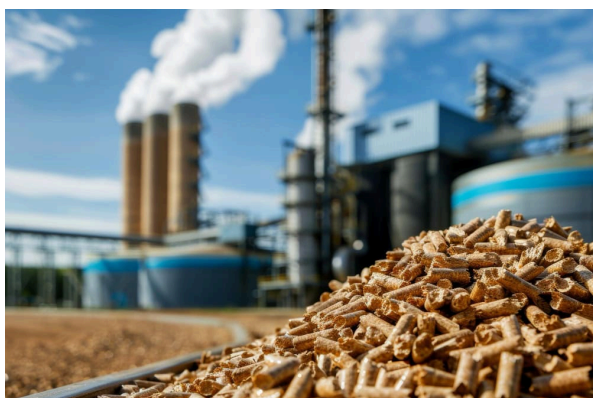




Energy Sector Skills Strategy - Namibia



International
Labour
Organization



NIPDB

Namibia Investment Promotion
& Development Board

Prepared by:

Namibia Investment Promotion & Development Board



Table of Contents

Energy Sector Skills Strategy - Namibia

1. Executive Summary	11
2. Introduction	24
2.2 Need for an Energy Sector Skills Strategy	25
2.3 Aims and Scope of the Sector Skills Strategy	26
2.4 Understanding the Report	27
3. Vision for the Future of the Energy Sector	29
 4. Oil & Gas Sector	31
4.1 Analysing Business Capability Gaps and Skills Implications for the Oil and Gas Industry in Namibia	33
4.1.1 Exploration and Appraisal	33
4.1.2 Extraction and Production	33
4.1.3 Processing and Refining	34
4.1.4 Transportation and Storage	34
4.1.5 Marketing and Sales	34
4.1.6 Support Services	34
4.1.7 Decommissioning	35
4.2 Business Capability Gaps & Skills Implications	36
4.3 Skills in Demand in Oil and Gas	39
4.3.1 Skills Demand during Exploration and Appraisal	40
4.3.2 Skills Demand during Engineering & Construction	42
4.3.3 Skills Demand during Production	44
4.3.4 Skills Demand during Decommissioning	47
4.4 Skills Supply in Oil & Gas	52
4.4.1 Current Skills Supply from Namibian Institutions	54
 5. Biomass Sector	68
5.1 Dominant and Emerging Value Chains	69
5.1.1 Charcoal Production and Export	69
5.1.2 Biomass for Energy: Thermal and Power Generation	70
5.1.3 Animal Feed from Bush (Boskos)	71
5.1.4 Biochar: Soil Enhancement and Carbon Sequestration	72
5.2 Analysing Business Capability Implications for the Biomass Industry	73
5.2.1 Charcoal- Mapping the Value Chain: From Bush to Export	73
5.2.2 Business Capability Gaps & Skills Implications	75
5.2.3 Thermal and Power Generation- Biomass-to-Energy Value Chain	78
5.2.4 Business Capability Gaps & Skills Implications	81
5.2.5 Animal Feed (Boskos)- From Bush to Feed Value Chain	85
5.2.6 Business Capability Gaps & Skills Implications	87
5.2.7 Biochar Value Chain	95
5.2.8 Business Capability Gaps & Skills Implications	97
5.3 Skills in Demand in the Biomass Sub-Sector	101
5.3.1 Charcoal	101
5.3.2 Power Generation	104
5.3.3 Animal Feed from Bush	108

5.3.4 Biochar	111
5.3.5 Common Technical Skills Across Bush Biomass Subsectors	114
5.4 Skills supply in Biomass	116
5.4.1 TVET Sector Provision	117
5.4.2 Higher Education Sector Provision (NUST & UNAM)	119
5.4.3 Analysis of Skills Gaps in the Namibian Biomass Sector	123
5.4.3 Strategic recommendations for bridging the gaps in the Biomass Sector	127
6. Green Hydrogen & Renewables Sub-sector	132
6.1 Dominant and Emerging Green Hydrogen & Renewables Value Chains	132
6.1.1 Renewable Energy Generation (Solar, Wind)	133
6.1.2 Green Hydrogen Production (Electrolysis Technologies)	134
6.1.3 Conversion and End-user Products	135
6.1.4 Storage and Transportation	137
6.2 Analysing Business Capability Implications for the Green Hydrogen Industry	139
6.2.1 Solar and Wind Energy for Green Hydrogen Production Value Chain	139
6.2.2 Cross-Cutting Business capability gaps & skills implications	148
6.2.3 Water Desalination Value Chain	154
6.2.4 Business Capability Gaps and Skills Implications	161
6.2.5 Green Hydrogen Production (Electrolysis Technologies) Value Chain	165
6.2.6 Business Capability Gaps and Skills Implications	174
6.2.7 Green Hydrogen Conversion Value Chains	177
6.2.8 Green Hydrogen Storage and Transportation Value Chain	192
6.2.9 Business Capability Gaps and Skills Implications	195
6.3 Skills in Demand in the Green Hydrogen Value Chain	197
6.4 Skills Supply in Green Hydrogen	218
6.4.1 Higher Education Landscape	218
6.4.2 Technical Vocational Education and Training (TVET) Sector	221
6.4.3 Specific Green Hydrogen Skills Initiatives	223
6.4.4 Analysis of Skills Gaps in the Namibian Green Hydrogen Sub-sector	225
6.4.5 Recommended Qualifications, Courses, and Certifications for Namibia's GH2 Future	229
6.4.6 Strategic Recommendations for Bridging the Gaps in the Green Hydrogen Sub-Sector	236
6.5 High-Level Consolidated Implementation Plan	239
6.5.1 The Critical Need for Data	243
7. Annexures	247
Annexure 1: Oil & Gas Demand- Industry Skills Quantification	247
Annexure 2: Oil & Gas Engineering, Construction and Production- Quantification of skills	248

Acronyms and Abbreviations

AEC	Alkaline Electrolysis
AEM	Anion Exchange Membrane
AFCFTA	African Continental Free Trade Area
AI	Artificial Intelligence
BAM	Federal Institute for Materials Research and Testing
BCBU	Bush Control and Biomass Utilisation
BC	Bush Control
BMBF	German Federal Ministry of Education and Research
BoP	Balance of Plant
BPP	Bipolar Plates
BTDC	Biomass Technology Demonstration Centre
BU	Bush Utilisation
BUSH	Biomass Utilisation by Sustainable Harvest
CAoN	Charcoal Association of Namibia
CAPEX	Capital Expenditure
CCF	Cheetah Conservation Funds
CcH2	Cryo-compressed Hydrogen
CCM	Catalyst Coated Membrane
CCS	Carbon Capture Storage
CCUS	Carbon Capture, Utilisation and Storage
CHG	Compressed Hydrogen
CHP	Combined Heat and Power
CO2	Carbon Dioxide
CoP	Cessation of Production
CPD	Continuous Professional Development
CRCs	Carbon Dioxide Removal Certificates
CREEE	Centre for Renewable Energy and Energy Efficiency
CRMs	Critical Raw Materials
DARD	Directorate of Agricultural Research and Development
DCS	Distributed Control Systems
DPOs	Dynamic Positioning Operators
EBC	European Biochar Certificate
ECU	Electronic Control Unit
EDI	Electrodeionization
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan

EOl	End of Life
EOR	Expression of Interest
EPC	Engineering, Procurement and Construction
ERDs	Energy Recovery Devices
ESIAs	Environmental and Social Impact Assessments
EU	European Union
FAENS	Faculty of Agriculture, Engineering and Natural Sciences
FEBE	Faculty of Engineering and the Built Environment
FDI	Foreign Direct Investment
FHNRAS	Faculty of Health, Natural Resources and Applied Sciences
FLNG	Floating Liquefied Natural Gas
FPSO	Floating Production Storage and Offloading
FSC	Forest Stewardship Council
FTE	Full-Time Equivalent
GAC	Granular Activated Carbon
GDLs	Gas Diffusion Layers
GDP	Gross Domestic Product
GH2	Green Hydrogen
GHG	Greenhouse Gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
GRN	Government of Republic of Namibia
GW	Gigawatt
GWh	Gigawatt-hour
H2	Hydrogen
H2O	Water
HEI	Higher Education Institution
HPP2	Harambee Prosperity Plan II
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security and Environment
IBI	International Biochar Initiative
ICEs	Internal Combustion Engines
ICT	Information and Communication Technology
IEA	International Energy Agency
IFC	International Finance Corporation
ILO	International Labour Organization
IOCs	International Oil Companies

IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IT	Information and Technology
IUT	International University of Management
kWh	Kilowatt hour
LANCIS	National Laboratory of Sustainability Science
LH2	Cryogenic Liquid Hydrogen
LLPB	Livestock and Livestock Products Board of Namibia
LNG	Liquefied Natural Gas
LOHCs	Liquid Organic Hydrogen Carriers
LT-LEDS	Long Term Low-Emission Development Strategy
M&E	Monitoring and Evaluation
MAFWLR	Ministry of Agriculture, Fisheries, Water and Land Reform
MBA	Masters of Business Administration
MB-IX	Mixed-Bed Ion Exchange
MCFCs	Molten Carbonate Fuel Cells
MEA	Membrane Electrode Assembly
MED	Multi-Effect Distillation
MEFT	Ministry of Environment, Forestry and Tourism
MIT	Ministry of Industrialisation and Trade
MLD	Minimal Liquid Discharge
MME	Ministry of Mines and Energy
MMF	Multimedia Filtration
MODUs	Mobile Offshore Drilling Units
MoUs	Memoranda of Understanding
MSB	Modified Single Buyer
MSF	Multi-Stage Flash Distillation
MVR	Mechanical Vapor Recompression
MW	Megawatt
MWh	Megawatt hour
N-BiG	Namibia Biomass Industry Group
NAD	Namibian Dollar
NAMPOA	Namibia Petroleum Operators Association
NamPower	Namibia Power Corporation
NaOH	Sodium Hydroxide
NCA	Namibia Charcoal Association
NCA	Natural Capital Accounting
NCHE	National Council for Higher Education

NEI	Namibia Energy Institute
NDC	Nationally Determined Contribution
NDP	National Development Plans (NDP5 and 6)
NEI	Namibia Energy Institute
NERA	Namibia Energy Regulatory Authority
NGHRI	Namibia Green Hydrogen Research Institute
NHRP	National Human Resource Plan
NH3	Ammonia
NIMT	Namibia Institute of Mining and Technology
NPDB	Namibia Investment Promotion and Development Board
NOx	Nitrogen Oxide
NQA	Namibia Qualifications Authority
NQF	Namibia Qualifications Framework
NSFAF	Namibia Students Financial Assistance Fund
NSI	Namibia Standards Institute
NTA	Namibia Training Authority
NUST	Namibia University of Science and Technology
NVC	National Vocational Certificate
NYS	National Youth Services
NZF	Natzeo Filtration
O2	Oxygen
O&G	Oil and Gas
OBPS	Otjikoto Biomass Power Station
OEMs	Original Equipment Manufacturers
OH-	Hydroxide Ions
OIM	Offshore Installation Manager
OPITO	Offshore Petroleum Industry Training Organisation
OT	Operational Technology
PAFCs	Phosphoric Acid Fuel Cells
PAHs	Polycyclic Aromatic Hydrocarbons
PEG	Polyethylene Glycol
PEM	Proton Exchange Membrane
PEMFCs	Proton Exchange Membrane Fuel Cells
PETROFUND	Petroleum Training and Education Fund
PGMs	Platinum Group Metals
pH	Potential of Hydrogen
PPE	Personal Protective Equipment
PPP	Public-Private Partnership

PRI's	Perivoli Rangeland Institute
PtX	Power-to-X
PV	Photovoltaic (solar)
R&D	Research and Development
QA	Quality Assurance
REDS	Regional Power Distribution companies
REEs	Rare Earth Elements
REFIT	Renewable Energy Feed-In Tariff Programme
RO	Reverse Osmosis
ROV	Remote Operated Vehicle
RPL	Recognition of Prior Learning
SADC	Southern African Development Community
SCADA	Supervisory Control and Data Acquisition
SDI	Silt Density Index
SDPs	Skills Development Plan
SEC	Specific Energy Consumption
SEZ	Special Economic Zone
SLAs	Service Level Agreements
SME	Small Medium Enterprise
SMR	Steam Methane Reforming

SOEC	Solid Oxide Electrolysis Cell
SOFCs	Solid Oxide Fuel Cells
STED	Skills for Trade and Economic Diversification
SWRO	Seawater Reverse Osmosis
TJ	Terajoules
TOC	Total Organic Carbon
ToT	Training of Trainers
TVET	Technical and Vocational Education and Training
UF	Ultrafiltration
UK	United Kingdom
UN	United Nations
UNAM	University of Namibia
UPW	Ultra Pure Water
UV	Ultraviolet
VET	Vocational Education and Training
VOCs	Volatile Organic Compounds
VTCs	Vocational Training Centers
WVTC	Windhoek Vocational Training Centre
ZLD	Zero Liquid Discharge

LIST OF TABLES

Table 1: Business capability gaps and skills implications- Oil & Gas	36
Table 2: Skills demand - Oil & Gas Engineering & Construction	42
Table 3: Skills Demand- Oil & Gas Construction & Installation	43
Table 4: Skills Demand - Oil & Gas Production	44
Table 5: Oil and Gas Decommissioning– Key stages	47
Table 6: List of essential occupations and core tasks	48
Table 7: Key Skills in the O&G Value Chain	53
Table 8: Higher Education Institutions’ Offerings Relevant to Oil and Gas	54
Table 9: Technical Vocational Institutions’ Offerings Relevant to Oil and Gas	56
Table 10: Oil & Gas Value Chain and Skills Supplied in Namibia	58
Table 11: Business Capability Gaps and Skills Implications- Charcoal Value Chain	75
Table 12: Business Capability Gaps - Biomass Value Chain	81
Table 13: Skills Implications- Biomass Value Chain	83
Table 14: Business Capability Gaps- Bush to Feed Value Chain	88
Table 15: Skills implications- Bush to Feed value chain	92
Table 16: Business Capability Gap and Skills Implications- Biochar Value Chain	98
Table 17: Occupations and Skills in the Biomass to Charcoal Value Chain	102
Table 18: Occupations and Skills in the Biomass to Power Generation Value Chain	104
Table 19: Occupations and Skills in the Biomass to Animal Feed Value Chain	109
Table 20: Occupations and Skills in the Biomass to Biochar Value Chain	112
Table 21: Cross-Cutting Skills areas in Bush Biomass Sub-sectors	115
Table 22: Bush Biomass- Relevant TVET Qualifications and Specialisations	121
Table 23: Bush Biomass- Relevant Higher Education Degrees and Specialisations at NUST & UNAM	122
Table 24: Matrix Summarising the Identified Skills Gaps per Sub-sector, Differentiating between TVET and Higher Education	126
Table 25: Business Capability Gaps and Skills Implications- Solar & Wind Value Chains	151
Table 26: Business Capability Gaps and Skills Implications - Water Desalination	161
Table 27: Business Capability Gaps and Skills Implications-Electrolysis Value Chain	174
Table 28: Business Capability Gaps and Skills Implications - GH2 to Ammonia Conversion	180
Table 29: Business Capability Gaps and Skills Implication- GH2 to Electricity Production	190
Table 30: Business Capability Gaps - GH2 Transport & Storage	195
Table 31: Business Skills Implication- GH2 Transport & Storage	196
Table 32: Occupations, Skills, and Certifications for Engineering, Design, and Construction (Cross-Cutting)	199
Table 31: Occupations, Skills, and Certifications for Renewable Energy Generation (Solar & Wind) - Construction, Operation & Maintenance	201
Table 32: Occupations, Skills, and Certifications for Green Hydrogen Production - Construction, Operation & Maintenance	203
Table 33: Occupations, Skills, and Certifications for Hydrogen Storage and Conditioning - Construction, Operation & Maintenance	206

Table 34: Occupations, Skills, and Certifications for Hydrogen Transportation and Distribution - Design, Construction, Operation & Maintenance	208
Table 35: Occupations, Skills, and Certifications for Green Ammonia Production - Design, Construction, Operation & Maintenance	210
Table 36: Occupations, Skills, and Certifications for Electricity Production from Green Hydrogen (Fuel Cells & Turbines) - Design, Construction, Operation & Maintenance	211
Table 37: Occupations, Skills, and Certifications GH2 Production- Cross Cutting	214
Table 38: Occupations, Skills, and Certifications for End-of-Life Management of Renewable Energy Infrastructure	215
Table 39: Occupations, Skills, and Certifications for End-of-Life Management of H2 Production & Derivatives Plants	216
Table 40: Occupations, Skills, and Certifications for End-of-Life Management of H2 Storage & Transport Infrastructure	217
Table 41: Occupations, Skills, and Certifications for End-of-Life Management- General	218
Table 42: Current GH2 relevant programmes at UNAM and NUST	220
Table 43: Current GH2-Relevant TVET Qualifications in Namibia	222
Table 44: Recommended New/ Enhanced Qualifications for GH2 – Vocational and Higher Education	234
Table 45: Key Recommended Professional Certifications for the GH2 Sector in Namibia	235

LIST OF FIGURES

Figure 1: Oil and Gas Value Chain	39
Figure 2: Charcoal Value Chain	73
Figure 3: Power Generation Value Chain	78
Figure 4: Biomass to Animal Feed Value Chain	85
Figure 5: Biomass to Biochar Value Chain	95
Figure 6: GH2 End-User Products	135
Figure 7: Solar Energy Production Value Chain	139
Figure 8: Wind Energy Production Value Chain	144
Figure 9: Water desalination value chain	154
Figure 10: Water Electrolysis Process	165
Figure 11: Electrolysis Value Chain	168
Figure 12: Green Ammonia Production Process	177
Figure 13: GH2 to Electricity Value Chain	182
Figure 14: GH2 Transport & Storage Value Chain	192
Figure 15: Green Hydrogen Production Value Chain	197

01

Energy Sector Skills Strategy - Namibia

EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

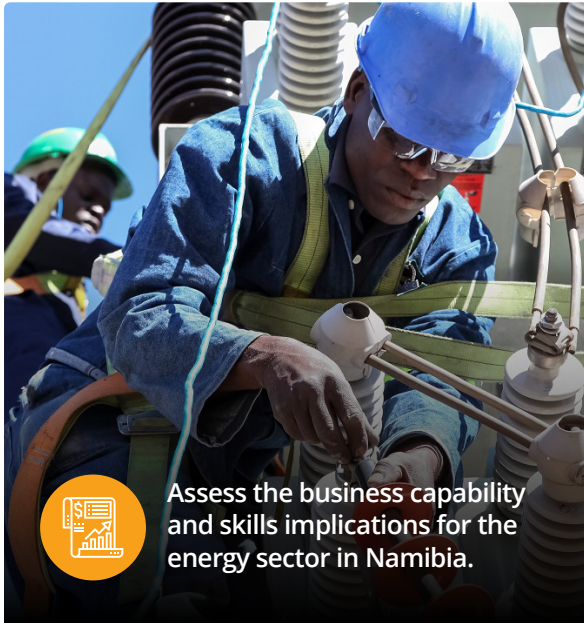


The core challenge identified across all energy sub-sectors is a fundamental mismatch between the existing supply of foundational skills from local institutions and the highly specialised, internationally certified, and experience-driven competencies demanded by these advanced industries. While Namibian universities and technical colleges produce graduates with solid general knowledge in engineering, trades, and sciences, there is a critical deficit in specialised programs and practical experience tailored to the specific technologies and standards of the oil and gas, biomass, green hydrogen and renewables value chains.

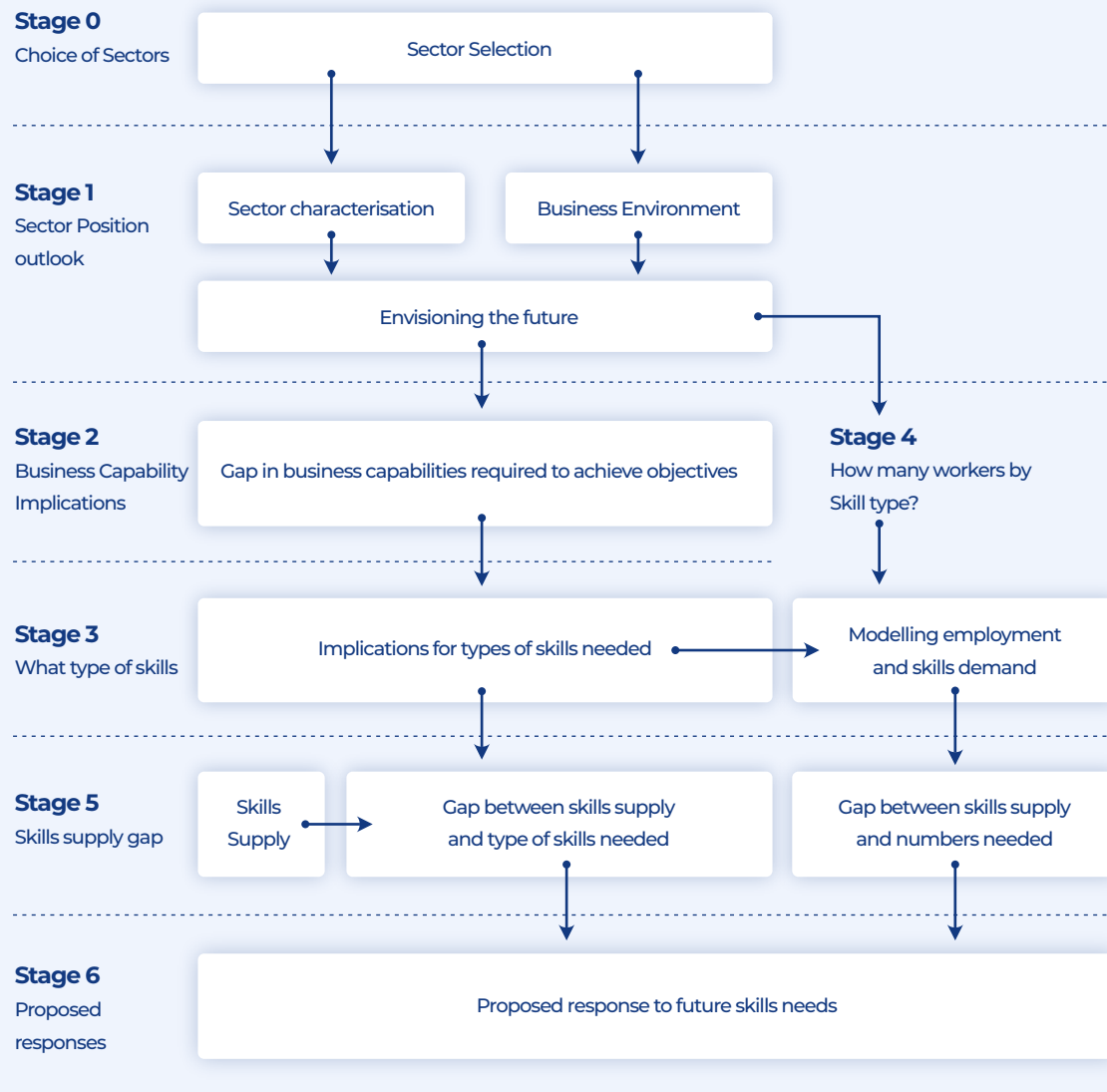
Namibia is at a critical juncture, with its burgeoning energy sector poised to be a primary driver of sustainable economic growth, industrial diversification, and significant job creation. A strategic approach to human capital development is paramount to capitalise on the vast potential of its renewable resources—including biomass, green hydrogen, solar, and wind—and recent offshore oil and gas discoveries. This report, a collaborative effort between the Namibia Investment Promotion and Development Board (NIPDB), the United Nations Resident Coordinators' Office (RCO) and the technical leadership of the International Labour Organisation (ILO), outlines a comprehensive skills strategy for the nation's energy sector. Employing the ILO's Skills for Trade and Economic Diversification (STED) methodology, the strategy aims to systematically identify and address skills gaps, ensuring that Namibia's workforce is prepared for the opportunities ahead and that the sector's growth translates into decent employment and a just transition for all Namibians.

Strategy Highlights

Objectives



STED Analytic / Diagnostic Framework



Namibia's Energy Sector

A Summary of Key Business Capability Gaps



Technological & Manufacturing Limitations

Namibia has an underdeveloped manufacturing base, leading to heavy reliance on imported technology for all energy sectors. There is limited local capacity for advanced production and a dependence on foreign expertise for large scale projects.



Infrastructure Deficiencies

Robust supporting infrastructure is lacking. This includes an undersized national power grid, inadequate road and rail networks for heavy transport, and ports that require significant upgrades for large-scale energy operations and exports.



Access to finance for Local Enterprises

A critical bottleneck, especially for SMEs. Local businesses struggle to secure affordable and appropriate financing, hindering their ability to participate meaningfully in energy value chains and limiting the realisation of local content goals.



Policy & Regulatory Effectiveness

While supportive policies exist, their success is hampered by historically poor implementation. Inconsistencies, administrative gaps, and delays create an uncertain investment climate and challenge the effective execution of local content targets.



Skills Shortages & Human Capital

A significant shortage of diverse skills across all levels, from entry level technicians to specialised engineers and managers. Developing local human capital to meet international standards is a critical challenge for all energy subsectors.



Market Development & Branding

Several sectors lack a distinct national brand and the capacity to negotiate effectively in global markets. Products are often sold under international labels, limiting market recognition and the potential for higher value capture.

Skills Demand



Occupations in Oil & Gas

Petroleum engineers	Crane operators	Production engineers	Cost estimators/controllers
Mechanical engineers	Offshore technicians	Reservoir engineers	Contract managers
Civil engineers	ROV technicians and supervisors	Geoscientists (geologists/geophysicists)	Regulatory compliance Officers/specialists
Electrical engineers	Saturation technicians	Drilling engineers	Well plugging and abandonment (P&A)
Naval architects	Marine officers/section leaders/supervisors	Mud engineers/loggers	Well site supervisors/company representatives
Subsea engineers	Heavy lift specialist	HSE officers/advisors/managers	P&A engineers
Offshore piping designers	HSE advisors/specialists	Medics/paramedics	Cementing operators/supervisors
Process engineers	Foremen & line supervisors	Safety engineers	Wireline/slickline operators
Architectural & civil drafters	Seatrax crane inspector	Logistics coordinators	Coiled tubing operators
Architectural & engineering managers	Production operators/technicians	Procurement officers/supply chain managers	Rig crews (drillers, derrickhands, floorhands)
Project managers and engineers	Control room operators	Administrative staff	Toolpushers
Cost control managers	Terminal operators:	Catering staff/stewards/camp boss	Offshore construction managers (OCMs)
HSE advisors/specialists	Pipeline technicians:	Roustabouts/Floorhands/Leasehands	Heavy lift supervisors/operators
Software developers	Maintenance technicians (Mechanical, electrical, instrument)	Offshore technicians	Crane operators
Construction managers/superintendents	Mechanics	ROV technicians	Riggers
Project managers and engineers	Electricians	Ballast control operators/dynamic positioning operators (DPOs)	Welders/cutters
Welders	Welders	Project managers (decommissioning)	Commercial divers (saturation, Air)
Pipe-fitters	Control systems/instrumentation technicians	Decommissioning Managers/engineers	ROV pilots/technicians
Riggers	Maintenance supervisors	Engineers (structural, civil, marine, environmental, wells P&A)	Marine crew: captains/masters
Medics/paramedics	Petroleum engineers	Planners/schedulers	Foremen
Logistics coordinators	Onshore dismantling/recycling yard workers	Surveyors	Environmental scientists/engineers
Procurement specialists	HSE advisors/managers	Safety engineers	Marine biologists
			Waste management Consultants/specialists



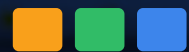
Occupations in Biomass

Bush harvester / cutter	Bush harvester / forestry worker	Forage harvester / bush collector / rangeland worker	Feedstock manager / technician
Harvesting supervisor / team leader	Fuel supply logistics coordinator / manager	Rangeland management advisor / extension officer	Pyrolysis plant operator / technician
Kiln operator / charcoal burner	Wood chipper / grinder operator	Feed mill operator / processing technician	Biochar processing technician
Charcoal sorter / grader / sieve	Pellet mill operator (if applicable)	Animal nutritionist / feed formulator	Biochar quality Analyst / Lab Technician
Briquette machine operator (where applicable)	Dryer operator (if applicable)	Quality control / laboratory technician (feed)	Packaging operator
Quality control technician / inspector	Boiler operator (biomass)	Packaging & warehouse operator	Marketing & sales specialist (biochar)
FSC auditor / certification manager	Gasifier operator	Marketing & sales representative (animal feed)	dMRV system operator / carbon project analyst
Packaging operator	Control room operator / plant Operator	Agricultural extension officer / farmer advisor	Carbon project manager
Marketing & sales personnel / exporter	Auxiliary plant operator / Field Operator	Farmer / small-scale feed Producer / cooperative manager	Health & safety officer / coordinator
Transport / logistics coordinator	Auxiliary plant operator / field operator		Agronomist / soil scientist / Agricultural advisor
Charcoal producer / farm owner / business manager	Electrical maintenance technician		Biochar plant / facility manager / director
	Instrumentation & control (I&C) technician		
	Electrical engineer (grid/substation)		
	Environmental compliance officer		
	Ash handler / material handler		
	Plant manager / operations manager		
	Project manager (construction phase)		



Occupations in Green Hydrogen and Renewables

Project development manager (GH2)	Solar PV installation technician	Hydrogen production technician / Electrolyser operator	Cryogenic systems engineer/technician (LH2)	Gaseous H2 pipelines	Ammonia plant operator
Civil/structural engineer	PV system designer	Process engineer (hydrogen)	High-pressure gas systems Technician/ engineer (compressed H2)	Road/rail transport (compressed gas / LH2 / ammonia)	Chemical engineer (Ammonia synthesis)
Mechanical engineer (plant & equipment design)	Solar project manager	Electrical engineer (electrolyser & power systems)	Materials engineer/ scientist (hydrogen service)	Maritime transport (ammonia / LH2)	Process control engineer (ammonia plant)
Electrical engineer (system design & construction)	Wind turbine technician (WTG technician)	Instrumentation & control (I&C) technician/engineer	LOHC (Liquid Organic Hydrogen Carrier) System Operator/ engineer	Cross-cutting (transport/ distribution)	Mechanical engineer (ammonia plant equipment)
Chemical/process design engineer	Renewable energy engineer (solar/wind/ grid)	Hydrogen safety specialist/engineer	Metal Hydride Storage System technician/engineer		Ammonia storage & handling specialist
Construction manager	SCADA/control room operator (renewables)	Plant manager (hydrogen production)	Hydrogen purification specialist		Environmental engineer (ammonia plant)
Procurement specialist/manager	Site assessor/ surveyor (solar/wind)	Water Treatment Specialist/Technician	Tank Farm Operator (H2/Ammonia)		Construction project engineer (ammonia plant)
HSE (Health, Safety, Environment) manager (construction)	Grid interconnection engineer	Mechanical maintenance technician (hydrogen plant)	Conditioning plant technician (compression/ liquefaction)		Hydrogen Fuel Cells (Power Generation)
CAD/BIM Technician/ Coordinator	Environmental consultant (renewables)	Quality control (QC) analyst/technician	Civil engineer (storage infrastructure)		Hydrogen Turbines (Power Generation)
Welding engineer/ inspector	Blade repair technician (wind)	Construction supervisor (H2 plant)			Construction manager (H2 Power Plant)
Commissioning engineer/technician	High voltage (HV) electrician/technician (renewables)				
	Construction site supervisor (renewables)				



Key Skills Development Recommendations Across the Energy Sub-sectors

Energy Sub-Sector

Oil & Gas

Context:

The recent major offshore oil and gas discoveries in Namibia's Orange Basin have positioned the country as a promising new frontier in the global energy market, with first oil production anticipated around 2029-2030. This development is expected to attract billions in foreign investment and present a significant economic growth and diversification opportunity. However, the nation currently possesses only an estimated 45% of the required skills, hindering local content development.

Identified Skills Gaps:

The most significant deficiencies lie in higher education, with a complete absence of dedicated degree programs in Petroleum Engineering, Reservoir Engineering, Drilling Engineering, and Subsea Engineering. At the vocational level, there is a critical shortage of technicians with certifications that meet international oil and gas standards, such as for coded welding (API/ASME), offshore safety (BOSIET), and hazardous environment operations (CompEx). Furthermore, there are gaps in specialised non-technical areas like Petroleum Law and O&G Project Finance.

Key Recommendations:

- **Establish a National Oil and Gas Institute:** Expedite the creation of a dedicated institute to serve as a hub for specialised training, curriculum development, and international certification.
- **Upgrade TVET Capacity:** Invest in equipping NIMT and select VTCs with industry-standard simulators and equipment, and align curricula with international standards (e.g., OPITO, API) to produce certified technicians.
- **Enhance Higher Education Specialisation:** Provide targeted funding to UNAM and NUST to develop specialised undergraduate tracks and postgraduate programs in Petroleum Engineering, Geophysics, and other critical upstream disciplines.
- **Mandate Skills Transfer:** Implement clear, enforceable policies requiring skills transfer plans from expatriate experts to Namibian nationals as a condition for work permits.

Energy Sub-Sector

Biomass

Context:

Namibia successfully transforms the ecological challenge of widespread bush encroachment (affecting an estimated 45 million hectares) into a diverse economic sector. The biomass industry encompasses an established charcoal export market. It rapidly expands into power generation (e.g., the 40 MW Otjikoto Biomass Power Station), animal feed production (Boskos), and innovative products like biochar for soil enhancement and carbon sequestration.

Identified Skills Gaps:

While foundational skills in agriculture and general trades exist, specialised expertise is lacking. There is a shortage of formal training in efficient and sustainable charcoal production (using modern retort kilns) and quality control for export markets. The power generation sector requires technicians and engineers with specific experience in biomass-fired boilers and gasifiers. The animal feed sector needs skills in the nutritional analysis of local bush species and formulating balanced, safe rations. The nascent biochar industry requires expertise in pyrolysis technology and the complex processes for carbon credit verification.

Key Recommendations:

- **Formalise and Scale TVET Qualifications:** Prioritise the registration and rollout of the N-BiG-developed National Vocational Certificates in Bush Control, Biomass Utilisation, and SME Management through the NTA and VTCs.
- **Develop New Specialised TVET Programs:** Create new qualifications for roles such as "Biomass Power Plant Technician" and "Biochar Production Technician" to address the "missing middle" of skilled technical personnel.
- **Strengthen Higher Education in Bio-economy:** Enhance university engineering and agriculture programs with in-depth modules on advanced biomass conversion technologies, biorefining, and circular economy principles.
- **Support Applied Research and Innovation:** Foster stronger collaboration between research institutions (e.g., NUST's ButoVal project) and industry to adapt technology to local conditions and develop new value-added products.

Energy Sub-Sector

Green Hydrogen (GH2) & Renewables

Context:

Namibia strategically positions itself as a global leader in the green hydrogen economy, leveraging its world-class solar and wind resources to drive green industrialisation. Large-scale projects are underway, with forecasts of massive investment and job creation across the entire value chain, from renewable energy generation to the production of derivatives like green ammonia.

Identified Skills Gaps:

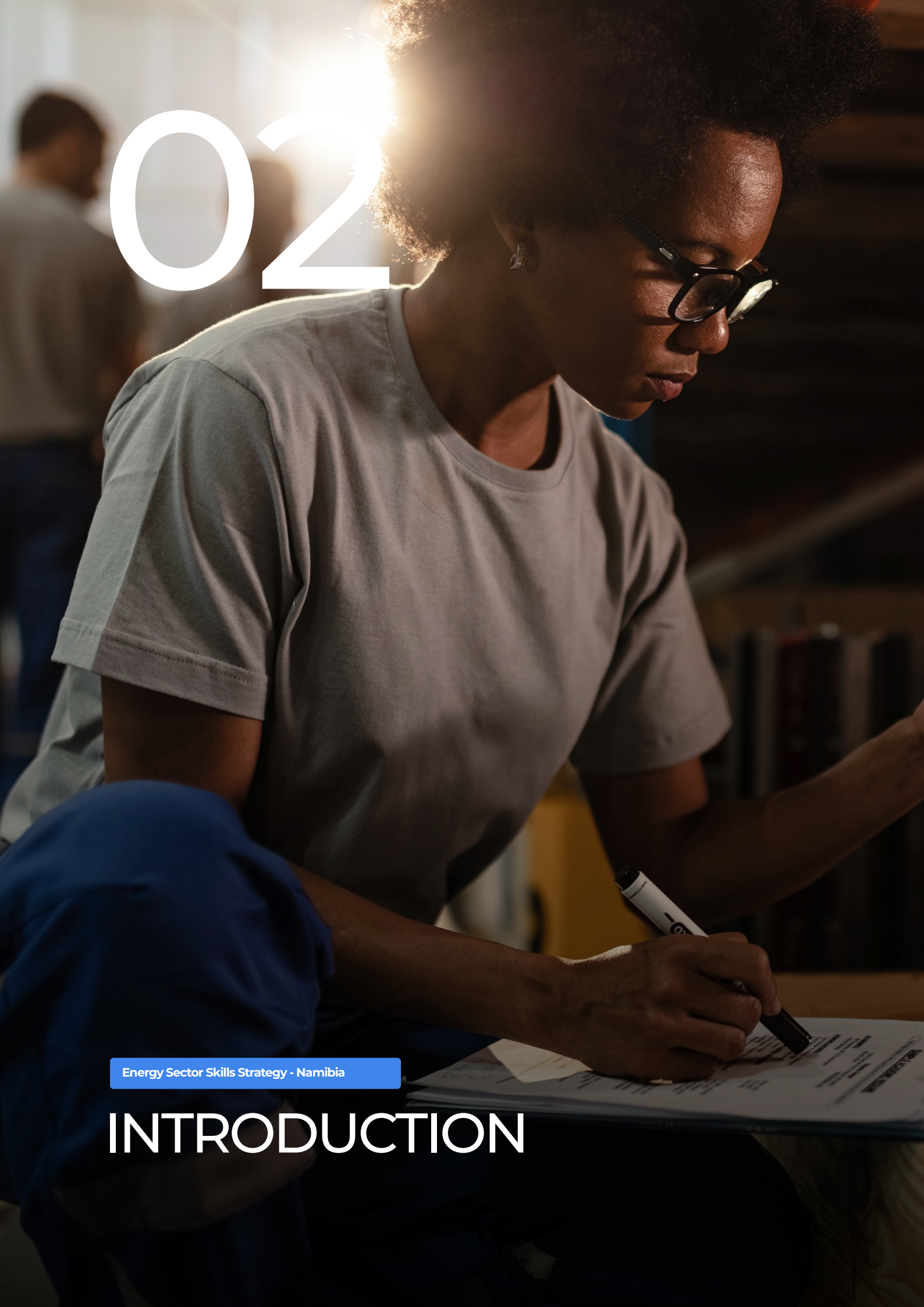
The scale and novelty of the GH2 industry create a comprehensive skills deficit. There is an urgent need for specialised technicians proficient in electrolyser operations, hydrogen storage and handling, and fuel cell systems. A significant shortage of engineers with expertise in Power-to-X (PtX) processes, cryogenics, process safety engineering for hydrogen, and advanced renewable energy integration is projected. Furthermore, there is a high demand for professionals skilled in managing mega-projects, navigating international regulations, and implementing robust safety and environmental protocols across the full project lifecycle, from construction to decommissioning and recycling.

Key Recommendations:

- **Establish a National PtX Skills Task Force:** Create a high-level coordinating body to oversee the national skills strategy for GH2, ensuring alignment between government, industry, and educational institutions.
- **Develop Specialised GH2 Vocational Qualifications:** Task the NTA with creating new, accredited programs for "Hydrogen Technicians," "GH2 Plant Safety Officers," and "Renewable Energy Decommissioning & Recycling Technicians," and integrate H2-specific safety modules into all relevant existing trades.
- **Introduce GH2 University Specialisations:** NUST and UNAM should launch specialised streams or dedicated degrees in green hydrogen technologies, focusing on process engineering, materials science, and renewable energy systems integration.
- **Build Institutional Capacity and Foster Collaboration:** Invest in upgrading the infrastructure and Faculty at NUST, UNAM (NGHRI), and VTCs. Promote international partnerships for knowledge transfer, curriculum development, and the adoption of internationally recognised safety and technical certifications.

Conclusion

Namibia stands on the precipice of an energy-led transformation. However, the nation's ability to fully harness the potential of its oil and gas, biomass, and green hydrogen resources is intrinsically linked to its capacity to develop a skilled, adaptable, and competitive local workforce. This strategy document provides a clear roadmap for bridging the critical gap between current skills supply and future industry demand. Success requires immediate, coordinated, and sustained action. By implementing these recommendations through a robust partnership between government, industry, and educational institutions, Namibia can build the human capital necessary to drive its energy revolution, ensuring that its natural resource wealth translates into lasting and inclusive prosperity for all its citizens.



02

Energy Sector Skills Strategy - Namibia

INTRODUCTION

2. INTRODUCTION

Namibia stands at a pivotal moment in its economic development, with the energy sector poised to play a significant role in driving sustainable economic growth, industrial diversification, social development and job creation. The country is strategically positioned to capitalise on its vast renewable energy potential, particularly in biomass, green hydrogen, solar and wind energy, and recent discoveries in oil and gas to reduce dependence on imported energy, enhance energy security, and contribute to global climate change mitigation efforts².

The government's commitment to energy security, sustainability and green transition is evident in its strategic plans and policies, such as the Namibia Vision 2030, the Draft National Development Plans (NDP6), the Harambee Prosperity Plan II (HPP2) and its updated Nationally Determined Contribution (NDC) for the Energy Sector³ (2023). These frameworks aim to ensure that the energy sector meets the current demand and supports long-term economic growth and environmental sustainability⁴. The country's commitment to achieving universal energy access by 2040 underscores its dedication to improving the quality of life for all its citizens. Simultaneously, the drive to reduce reliance on energy imports is strengthening energy security and shielding the nation from the volatility of global energy markets. This transition is underpinned by a strategic focus on renewable energy sources and developing a green hydrogen industry, positioning Namibia as a leader in the global movement toward clean energy.

Despite strong support from the government through sector policies and strategies, good education and training providers, and strong economic prospects, Namibia has yet to see the benefits of its energy sector labour force translate into increased employability and job creation. As the driver of the country's business investment and development agenda, the Namibia Investment and Promotion Development Board

(NIPDB) has partnered with the International Labour Organisation (ILO) to proactively address the skills needs arising from the sector's future growth.

This collaboration aims to anticipate and identify the challenges and opportunities of the energy sector's growth potential and their skills implications. Leveraging the ILO's Skills for Trade and Economic Diversification (STED) methodology ensures workforce development aligns with economic diversification goals⁵. This aligns with the United Nations (UN) sustainable goals for growth, with the main aim of creating decent jobs and supporting a just transition. It further promotes alignment with the UN's Global Accelerator on Jobs and Social Protection for Just Transitions, for which Namibia has been identified as a pathfinder country.

The Energy Sector Skills Strategy builds on Namibia's strategic plans and policies, and the Namibia Energy Sector Background Study⁶ and contains a detailed analysis of specific sector policies and trends in the economy, trade, employment, education, and other background information. The development of this strategy document was informed by participatory research involving sector stakeholders during a three-day foresight workshop convened by the NIPDB and the ILO.

Footnotes

² NAMPOWER 2024; Hyphen Hydrogen Energy (2022)

³ Nationally Determined Contribution (NDC) for the Energy Sector (2023), Ministry of Environment & Tourism

⁴ NamPower (2024)

⁵ ILO 2020

⁶ Sectoral Review Study and Drafting of a Sector Skills Strategy for the Energy Sector in Namibia, November 2024

Namibia is at a critical juncture in its economic evolution, with the energy sector poised to serve as a pivotal driver of sustainable economic expansion, industrial diversification, social progress, and employment generation. The nation is strategically positioned to harness its substantial renewable energy

capacity, particularly in biomass, green hydrogen, solar, and wind energy, as well as recently discovered oil and gas reserves, to diminish reliance on imported energy, augment energy security, and contribute to global climate change mitigation efforts.

2.1 Need for an Energy Sector Skills Strategy

The energy sector is experiencing rapid growth and holds considerable job creation, economic development, and energy security potential. A skilled workforce is vital for harnessing advanced technologies and maintaining competitiveness, particularly in renewable energy subsectors like biomass, solar, wind and green hydrogen, and the non-renewable oil and gas sub-sector.

The country's drive towards energy independence and transitioning to renewable energy sources necessitates a workforce equipped for this evolving landscape. Current energy training programmes often lack a practical focus and fail to address the specific skills needed in the industry adequately. This mismatch contributes to potential skills shortages and hinders the sector's growth.

Therefore, a dedicated strategy will enable Namibia to proactively and strategically identify and address these skills needs and gaps, ensuring a pipeline of qualified professionals to support the sector's expansion and drive the nation's energy-related goals. This strategic approach will ensure that education and training programmes are aligned with industry demands, fostering a resilient and self-sufficient energy sector that can effectively contribute to Namibia's long-term development goals.

The energy sector exhibits significant growth potential, presenting opportunities for job creation, economic advancement, and enhanced energy security. A highly skilled workforce is imperative for effectively utilising advanced technologies and maintaining competitive

advantage, particularly within renewable energy subsectors such as biomass, solar, wind, and green hydrogen, as well as the non-renewable oil and gas subsector.

The nation's ambition to achieve energy independence and transition towards renewable energy sources necessitates a labour force adept in this dynamic environment. Existing energy training programs often lack practical application and fail to adequately address the specialised skills demanded by the industry. This discrepancy contributes to potential workforce deficits and impedes sectoral expansion.

Consequently, a comprehensive strategic framework is essential for Namibia to systematically identify and address these skill requirements and deficiencies, securing a robust supply of qualified professionals to support sectoral growth and advance national energy objectives. Such a strategic approach ensures that educational and training initiatives are aligned with industry demands, fostering a sustainable and self-reliant energy sector that can effectively contribute to Namibia's long-term developmental aspirations.

2.2 Aims and Scope of the Sector Skills Strategy

The Energy Sector Skills Strategy will assist policymakers, key actors, and education and training institutions in developing a helpful tool for Namibia to unlock the full potential of its energy resources, drive sustainable economic growth, and create meaningful opportunities for its citizens.

The strategy aims to:

- Develop a skilled and adaptable national workforce
- Enhance local content and participation
- Bridge existing skills gaps
- Improve the quality and relevance of education and training
- Promote continuous learning and upskilling
- Foster collaboration and partnerships
- Support innovation and technological adoption
- Ensure safety and regulatory compliance
- Contribute to economic diversification and growth
- Advance a just energy transition

The study will focus on the following key focus areas, namely:

● Comprehensive coverage of the Namibian energy sector:

The strategy would address skills needs across all segments of the energy sector in Namibia, including:

- **Fossil fuels (Oil & Gas):** Exploration, extraction, processing, and distribution (including potential future oil and gas).
- **Green hydrogen and PtX:** Production, storage, transportation, and utilisation of green hydrogen and its derivatives (e.g., green ammonia, synthetic fuels). This will also include solar and wind energy technologies as key components of the production of green hydrogen.
- **Renewable energy:** Focus on solar and wind technologies, including manufacturing, installation, operation, and maintenance. This will be covered under the GH2 pillar.
- **Bioenergy:** Focus on biomass, biofuels and biogas technologies, including harvesting, manufacturing, installation, operations and maintenance.

● Addressing all levels of skills and occupations (direct employment), including:

- Low-skilled and semi-skilled workers (e.g., construction, plant support).
- Technicians and artisans (e.g., electricians, mechanics, renewable energy technicians).
- Engineers (various disciplines relevant to energy).
- Scientists and researchers.
- Management and administrative personnel with energy-specific knowledge.

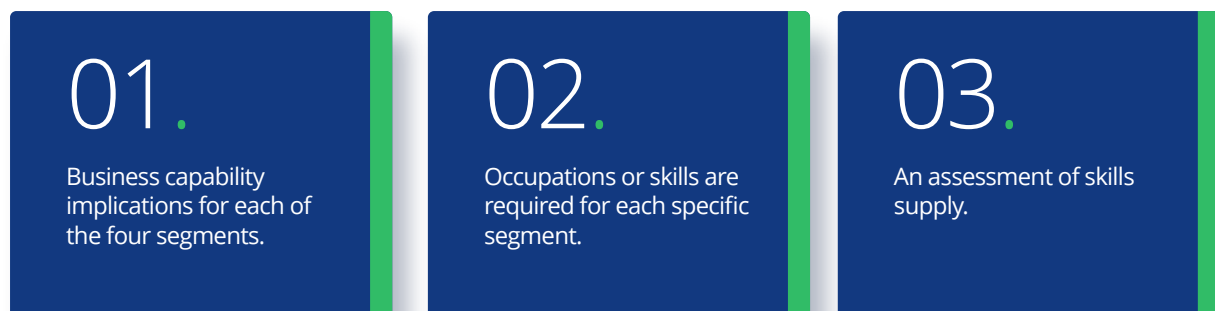
● **Encompassing the entire skills development lifecycle, including:**

- Skills needs assessment and forecasting: Identifying current and future skill demands.
- Curriculum development and reform: Ensuring training programs are relevant and up-to-date.
- Teacher and trainer development: Enhancing the capacity of educators in energy-related fields.
- Apprenticeships and internships: Facilitating practical, work-based learning opportunities.
- Recognition of prior learning (RPL): Allowing individuals with existing skills to gain formal qualifications.
- Upskilling and re-skilling: Allowing individuals to upgrade their existing skills, augment their existing skills with new skills and allow them to learn new relevant skills.
- Quality assurance and accreditation: Ensuring the quality and standards of training programs.

● **Policy and regulatory framework, providing recommendations for policy adjustments and regulatory support to facilitate skills development in the energy sector.**

2.3 Understanding the Strategy

Due to the energy sector's significant scope and the extensive information encompassed, this strategy is structured as follows for each energy segment/sub-sector, namely oil & gas, green hydrogen and PtX (including Renewable Energy) and Bioenergy:



Finally, the concluding section the strategy focuses on implementable recommendations at the policy, institutional, and enterprise levels. These recommendations aim to effectively address the skill gaps identified earlier and to provide substantial support for the sustained growth and advancement of the Namibian energy sector.

03

Energy Sector Skills Strategy Report - Namibia

VISION FOR THE FUTURE OF THE ENERGY SECTOR

3. VISION FOR THE FUTURE OF THE ENERGY SECTOR



Namibia envisions the establishment of a sustainable skills formation system for the energy sector, emphasising skills anticipation to address sector-specific demand and supply. This system aims to foster economic growth, promote equality, and generate decent employment opportunities within the sector. It is Namibia's aspiration to attain global leadership in energy sector expertise and skills, particularly in the realm of renewable energy, and meet the demands of both the African continent and the international community.

Namibia intends to utilise both renewable and non-renewable resources to develop a sustainable, diversified, and resilient energy sector. This development will ensure energy security, economic growth, and environmental sustainability.

The objective is to cultivate a highly skilled workforce through strategic investments, the implementation of innovative technologies, the formulation of robust policies, and the utilisation of accurate data-driven decision-making processes.

04

Energy Sector Skills Strategy - Namibia

OIL & GAS SECTOR

4. OIL & GAS SECTOR

Namibia's offshore Orange Basin has emerged as a highly promising frontier for oil and gas exploration, attracting significant global attention and investment following a series of substantial discoveries.⁷ The initial breakthrough came with Shell's discovery of light oil and associated natural gas at the Graff-1X exploration well in early 2022, followed shortly by TotalEnergies' announcement of a similar find at the Venus-1X well. The excitement surrounding these discoveries was further amplified by Galp Energia's announcement of the Mopane oil discovery in mid-2023.⁸ These initial successes have spurred further exploration activities, with Shell, TotalEnergies, and Galp reporting additional discoveries in subsequent wells, solidifying the Orange Basin's status as one of the world's top-rated areas for oil exploration. Beyond these key players, Eni has also confirmed preliminary results of an oil discovery in the offshore Orange Basin, indicating a growing interest and activity in the region.⁹ While the primary focus remains on the offshore potential, exploration activities have also been ongoing in Namibia's onshore basins for several decades.¹⁰

It is equally important to note that the discovery of oil and gas is not new to Namibia. In the 70s, the country discovered gas, which is known today as the Kudu Gas Discovery. With the open licensing system adopted in 1998/1999, Namibia witnessed exploration activities from 2008 to date. Some of the oil discovered in 2012, 2013, and 2014 confirmed that these wells have lower Cretaceous clastic and carbonate reservoirs¹¹. None of the above discoveries reached a Financial Investment Decision (FID). It is therefore reasonable to conclude that the oil and gas exploration thus far, in Namibia, has not progressed to the construction, production and decommissioning phases. This directly affects the demand and supply of skills in this sub-sector.

The Namibian government is actively facilitating the growth of its oil and gas sector through strategic initiatives, including the announcement of new offshore licensing opportunities planned for 2025.¹²

This proactive approach aims to attract further foreign investment and capitalise on the country's significant untapped hydrocarbon potential. With multiple drilling campaigns on the horizon, Namibia is setting the stage for substantial growth in its offshore oil and gas scene.¹³

As Namibia transitions from exploration to development, several key infrastructure projects are planned to facilitate the production and monetisation of its oil and gas resources. The country aims for first oil production around 2029 or 2030, with TotalEnergies' Venus project in Block 2913B making significant progress towards a final investment decision in 2026 and a targeted first oil in 2029.¹⁴

Footnotes

⁷ <https://africaoilgasreport.com/2025/01/oil-patch-sub-sahara/deepwater-namibia-despite-shells-write-down-theres-still-lots-of-life-left-in-the-basin/>

⁸ <https://worldoil.com/news/2024/9/22/digital-feature-unleashing-africa-s-next-big-play-namibia-s-emerging-oil-and-gas-sector/>

⁹ <https://www.euro-petrole.com/eni-confirms-oil-discovery-in-namibia-s-offshore-n-i-28353>

¹⁰ <https://www.upstreamonline.com/exploration/namibias-top-oil-and-gas-official-very-very-encouraged-by-latest-orange-basin-discovery/2-1-1810680>

¹¹ <https://www.namcor.com.na/history/#1668071916357-43234fab-4aef>

¹² <https://www.offshore-energy.biz/namibia-sets-the-stage-for-new-offshore-oil-gas-licensing-round-and-drilling-plays/>

¹³ <https://worldoil.com/news/2025/3/21/namibia-unveils-offshore-drilling-plans-new-licensing-opportunities/>

¹⁴ <https://african.business/2024/07/apo-newsfeed/namibias-minister-of-energy-and-mines-joins-angola-oil-gas-aog-2024-amid-surge-in-offshore-exploration>



The development of these deepwater fields will likely involve the deployment of floating production storage and offloading (FPSO) facilities, as envisioned for Venus' development, which could include up to seven such vessels operating in the Orange Basin.¹⁵ Additionally, Namibia is looking to develop its significant natural gas reserves, notably the Kudu Gas Field, which holds the potential to transform the country into a net electricity exporter through gas-to-power projects.¹⁶ BW Energy is actively pursuing the development of the Kudu license, with plans for further appraisal drilling.

The emergence of a robust oil and gas industry holds immense potential for Namibia's economic growth and diversification. Projections indicate that Namibia could become a major oil producer in Africa by the middle of the next decade, with production potentially reaching levels comparable to established oil-producing nations.¹⁷ This development is expected to attract billions of dollars in foreign direct investment, which could significantly boost the country's economy and potentially double its GDP by 2040.¹⁸

Furthermore, the growth of the oil and gas sector presents a crucial opportunity for Namibia to diversify its economy, reduce its reliance on imports of petroleum products, and potentially become a significant energy exporter. To ensure that these economic benefits accrue to Namibian citizens, the government is prioritising the implementation of local content policies aimed at promoting the participation of local businesses and the development of a skilled Namibian workforce.¹⁹

Currently, for Namibia, the respective skills supply studies indicate that the energy sector possesses a significant knowledge base but lacks the necessary experience, and specialisation and therefore the country faces a shortage of technical expertise within these sectors, which necessitates the involvement of foreign professionals in the short to medium term. It is essential to strike a balance between attracting foreign investment and expertise while simultaneously fostering the development of local talent.

Footnotes

¹⁵ <https://www.worldoil.com/news/2024/7/18/namibia-to-rival-guyana-as-world-s-newest-oil-and-gas-hotspot-following-massive-offshore-discoveries/>

¹⁶ <https://www.climatechangenews.com/2024/11/22/namibia-uses-cop29-climate-summit-to-push-for-oil-and-gas-investments/>

¹⁷ <https://www.globenewswire.com/news-release/2025/03/17/3043486/28124/en/Namibia-Energy-Market-Report-2025-Namibia-to-Become-Africa-s-5th-Largest-Oil-Producer-by-2035.html>

¹⁸ <https://africanminingmarket.com/namibia-emerging-oil-and-gas-sector/19700/>

¹⁹ <https://www.nipdb.com/priority-sectors-oil-and-gas>

4.1 Analysing Business Capability Gaps and Skills Implications for the Oil and Gas Industry in Namibia

The development of Namibia's oil and gas industry will necessitate a wide array of business capabilities across the entire value chain, from the initial stages of exploration to eventual decommissioning.

4.1.1 Exploration and Appraisal

This initial phase requires sophisticated capabilities in seabed surveying, utilising technologies such as seismic surveys to identify potential hydrocarbon reserves beneath the ocean floor.²⁰ It also involves the crucial capability of drilling exploratory and appraisal wells onshore and offshore using various types of drilling rigs suited to different environmental conditions and water depths.²¹

Furthermore, advanced reservoir evaluation and modelling capabilities are essential to assess the viability and potential of discovered resources, along with robust geological and geophysical analysis to understand the subsurface structures.

4.1.2 Extraction and Production

Once commercially viable reserves are confirmed, the focus shifts to extraction and production. This phase demands the capability to construct and operate various types of production platforms, including fixed platforms for shallower waters and floating production systems like FPSOs for ultra-deepwater environments.²³

Efficient well construction and completion techniques are critical, alongside the ongoing operation and maintenance of complex production facilities. Effective reservoir management and optimisation strategies are necessary to maximise hydrocarbon recovery, potentially involving artificial lift techniques to enhance production rates.²⁴

Footnotes

²⁰ <https://www.jouav.com/blog/offshore-oil-rig.html>

²¹ <https://www.murphyoilcorp.com/capabilities/>

²² <https://www.jouav.com/blog/offshore-oil-rig.html>

²³ <https://www.murphyoilcorp.com/capabilities/>

²⁴ <https://www.murphyoilcorp.com/capabilities/>

4.1.3 Processing and Refining

As crude oil and natural gas are extracted, capabilities in processing and refining become essential. This includes the ability to process crude oil to stabilise it and convert it into various petroleum products such as gasoline, diesel, and jet fuel. For natural gas discoveries, processing capabilities are needed to prepare the gas for distribution.²⁵

These processes require efficient logistics networks and the application of advanced supply chain technologies to ensure smooth operations.²⁶ Quality control and laboratory services are also vital to maintain product standards.

4.1.4 Transportation and Storage

The efficient movement of raw and processed hydrocarbons requires robust transportation and storage capabilities. This includes constructing and operating pipelines, both onshore and offshore, to transport crude oil and natural gas to processing facilities and markets.²⁷

The management of storage facilities at various points in the value chain is also crucial, along with capabilities in shipping and other logistical operations to distribute petroleum products.²⁸

4.1.5 Marketing and Sales

The efficient movement of raw and processed hydrocarbons requires robust transportation and storage capabilities. This includes constructing and operating pipelines, both onshore and offshore, to transport crude oil and natural gas to processing facilities and markets.

The management of storage facilities at various points in the value chain is also crucial, along with capabilities in shipping and other logistical operations to distribute petroleum products.²⁹

4.1.6 Support Services

A successful oil and gas industry relies heavily on a range of critical support services. Health, Safety, Security, and Environment (HSSE) management capabilities are paramount to ensure the safety of operations and minimise environmental impact.³⁰

Footnotes

²⁵ <https://www.capstera.com/business-architecture-in-oil-and-gas-industry/>

²⁶ <https://nextbillion.ai/blog/logistics-in-the-oil-and-gas-industry>

²⁷ <https://www.capstera.com/business-architecture-in-oil-and-gas-industry/>

²⁸ <https://flevy.com/blog/oil-gas-industry-value-chain-deep-dive/>

²⁹ <https://www.workrise.com/blog/understanding-the-oil-gas-supply-chain>

³⁰ <https://endeavormgmt.com/capabilities/advisory-services/eag/oil-and-gas-support-team>

Supply chain management and logistics capabilities are essential for the efficient flow of goods and services throughout the industry.³¹ Regulatory compliance capabilities are needed to navigate the complex legal and regulatory frameworks governing the oil and gas sector.³² Project management and engineering services are crucial for overseeing and executing various projects across the value chain.

With the increasing role of technology, data management and analytics capabilities are becoming vital for optimising operations and decision-making. Finally, strong stakeholder engagement and community liaison capabilities are necessary to build and maintain positive relationships with local communities and other stakeholders.

4.1.7 Decommissioning

While representing the final stage of the oil and gas project lifecycle, decommissioning requires careful planning and execution. This includes the capability to safely plug and abandon wells, remove offshore platforms and other infrastructure, and remediate the sites to restore the environment as much as possible. This phase demands project management skills, engineering expertise, and adherence to environmental regulations.³³

Footnotes

³¹ <https://nextbillion.ai/blog/logistics-in-the-oil-and-gas-industry>

³² <https://endeavormgmt.com/capabilities/advisory-services/eag/oil-and-gas-support-team>

³³ <https://thecommonwealth.org/oil-and-gas-decommissioning-toolkit>

4.2 Business Capability Gaps Skills Implications

The development of a thriving oil and gas industry in Namibia will require a diverse range of skills across all levels, from entry-level technicians to highly specialised engineers and experienced managers. These skills must be developed within the Namibian context, considering local content objectives and international industry standards

Table 1: Business capability gaps and skills implications- Oil & Gas

Business capability gaps skills implications - Oil & Gas			
● Technical Skills ³⁴			
Entry-Level Technicians	Skilled Technicians	Specialized Engineers	Managers
Entry-level technicians in the energy sector need foundational geological and engineering knowledge, familiarity with drilling and safety, and the ability to operate equipment under supervision. Basic welding and fabrication skills for routine tasks are also required	Experienced technicians require advanced technical knowledge in specific areas like drilling, production, or instrumentation. They must interpret technical drawings, operate complex equipment, and, for offshore roles, possess specialized skills such as FPSO maintenance and basic marine operations.	This level requires foundational knowledge in geological science, basic engineering principles, drilling methods, and safety regulations. Technicians operate specialized equipment under supervision and possess basic welding and fabrication skills for routine tasks.	Effective oil and gas management demands technical expertise alongside strong leadership, project oversight, team leadership, and strategic decision-making. Financial literacy for budgets and proficiency in contract negotiation are also crucial.
● Operational Skills ³⁵			
Entry-Level Technicians	Skilled Technicians	Specialized Engineers	Managers
Entry-level oil and gas technicians need a basic understanding of drilling and production, enabling them to follow procedures and operate basic equipment under supervision	Experienced technicians require advanced skills in operating and troubleshooting diverse drilling and production equipment, including critical well control procedures for safety and efficiency. Logistics roles necessitate basic material and equipment coordination skills	Operational engineers require expertise in reservoir optimization, drilling program design and oversight, and efficient and safe production management, including advanced hydrocarbon extraction methods	Effective energy sector management requires experience in leading teams, meeting production goals, and maintaining strict safety and efficiency

Footnotes

³⁴ <https://www.capstera.com/business-architecture-in-oil-and-gas-industry/>
<https://www.bk-engineering.in/post/roles-for-mechanical-engineers-in-the-oil-gas-industry>
<https://careers.seg.org/career/drilling-engineer/job-descriptions>
<https://targetjobs.co.uk/careers-advice/job-descriptions/petroleum-engineer-job-description>
<https://willeducation.com/media-detail/skills-you-need-to-conquer-the-oil-and-gas-industry/>

Business capability gaps and skills implications - Oil & Gas

● Management and Leadership Skills³⁶

Entry-Level Technicians	Skilled Technicians	Specialized Engineers	Managers
Entry-level personnel need effective teamwork and basic communication skills for successful collaboration	Technicians should develop leadership, guidance, and communication skills as they advance	Effective project management skills, including planning, execution, and monitoring, are crucial for engineers in the oil and gas sector. Collaboration and coordination with multidisciplinary professionals are also essential for complex projects.	Oil and gas leadership requires strong strategic thinking, financial management, negotiation skills, and the ability to manage diverse stakeholder relationships, including government, local communities, and international partners

● Health, Safety, Security, and Environment (HSSE) Skills³⁷

Entry-Level Technicians	Skilled Technicians	Specialized Engineers	Managers
Comprehensive safety training, including emergency response, first aid, and hazardous material handling, is fundamental for all oil and gas personnel. Adherence to environmental regulations is critical. Offshore workers require BOSIET and HUET certifications.			
			Management is responsible for creating and enforcing strong safety protocols, performing detailed risk evaluations, and guaranteeing the organization adheres to all pertinent safety and environmental laws

● Digital and Data Management Skills³⁸

Entry-Level Technicians	Skilled Technicians	Specialized Engineers	Managers
Basic computer skills and accurate data entry are required for many entry-level jobs	Skilled technicians increasingly need proficiency in industry-specific software and technologies for equipment and process monitoring and control	Energy engineers need expertise in specialized software (reservoir simulation, CAD, data analysis) and strong data management and interpretation skills (geological and production data)	Oil and gas managers require data analytics skills for strategic decisions and operational efficiency

● Supply Chain Management Skills³⁹

Entry-Level Technicians	Skilled Technicians	Specialized Engineers	Managers
Some entry-level supply chain roles necessitate a basic understanding of material and equipment handling procedures	Supply chain technicians require knowledge of inventory management and basic procurement	Energy engineers need skills in supply chain optimization and logistics planning for transporting materials and equipment	Effective management necessitates strategic supply chain practices, encompassing vendor negotiation, contract management, and supply chain risk assessment

Footnotes

³⁵ <https://www.ppmcore.com/blog/learn-about-project-management-in-the-oil-and-gas-industry/>
<https://willeducation.com/media-detail/skills-you-need-to-conquer-the-oil-and-gas-industry!/37>

³⁶ <https://www.bk-engineering.in/post/roles-for-mechanical-engineers-in-the-oil-gas-industry>
<https://www.ppmcore.com/blog/learn-about-project-management-in-the-oil-and-gas-industry/>
<https://willeducation.com/media-detail/skills-you-need-to-conquer-the-oil-and-gas-industry!/37>

³⁷ <https://altea-energy.com/sheets/hse-engineer/>
<https://www.wtsenergy.com/careers/hse-officer/>
<https://www.osha.gov/oil-and-gas-extraction/hazards>
<https://www.airswift.com/blog/offshore-oil-gas-certificates>

Business capability gaps and skills implications - Oil & Gas

● Project Management Skills⁴⁰

Entry-Level Technicians

Skilled Technicians

Specialized Engineers

Managers

A fundamental understanding of project timelines and management principles is beneficial for all personnel engaged in oil and gas projects

Engineers in the oil and gas sector plan projects and conduct risk assessments

Energy sector managers require comprehensive project management skills, including budget and cost control, stakeholder communication, and multidisciplinary team coordination

● Regulatory and Compliance Skills⁴¹

Entry-Level Technicians

Skilled Technicians

Specialized Engineers

Managers

All oil and gas industry employees should have a basic understanding of the relevant laws and regulations

Regulatory engineers require expertise in Namibian petroleum laws and environmental regulations for compliance

Managers are responsible for ensuring the organization's consistent adherence to all applicable regulatory requirements and industry standards

● Community Liaison and Stakeholder Engagement Skills⁴²

Entry-Level Technicians

Skilled Technicians

Specialized Engineers

Managers

Strong communication and interpersonal abilities are crucial for all staff, particularly those engaging with local communities

Community relations roles require strong communication, interpersonal, negotiation, and conflict resolution skills. Cultural awareness and trust-building with diverse stakeholders are crucial.

Effective stakeholder management and engagement are crucial for managers to build positive relationships and secure social license to operate

Footnotes

³⁸ [https://iyskillstech.com/sample-skills-profiles/fps-o-operation-\(floating-production-storage-and-offloading\)](https://iyskillstech.com/sample-skills-profiles/fps-o-operation-(floating-production-storage-and-offloading))

<https://www.analytixlabs.co.in/blog/data-analytics-in-oil-and-gas/>

<https://365datascience.com/career-advice/how-to-become-a-data-scientist-in-the-oil-and-gas-industry/>

<https://www.digitaloilandgas.solutions/what-we-do/data-management>

<https://www.mineralview.com/blogs/data-analytics-in-oil-and-gas-operations>

<https://www.analytixlabs.co.in/blog/data-analytics-in-oil-and-gas/>

³⁹ <https://www.edstellar.com/course/logistics-of-oil-gas-and-petroleum-products-training>

<https://blog.projectmaterials.com/role-of-supply-chain-management-in-oil-and-gas/>

⁴⁰ <https://www.ppmcore.com/blog/learn-about-project-management-in-the-oil-and-gas-industry/>

<https://willeducation.com/media-detail/skills-you-need-to-conquer-the-oil-and-gas-industry!/37>

⁴¹ <https://www.legal500.com/guides/chapter/namibia-energy-oil-gas/>

<https://altea-energy.com/sheets/hse-engineer/>

<https://www.wtsenergy.com/careers/hse-officer/>

<https://www.tealhq.com/skills/regulatory-affairs-specialist>

⁴² <https://www.boreal-is.com/infographics/stakeholder-engagement-best-practices-oil-gas/>

<https://petropartners.co.uk/stakeholder-management-in-oil-and-gas/>

4.3 Skills in Demand in Oil and Gas

Following the determination of necessary skill types, we now focus on quantifying the projected workforce demand for these specialised skill sets within the Oil and Gas (O&G) sector, predicated upon anticipated expansion and development.

This phase entails transforming projected skill requirements into corresponding labour demands across various occupational classifications, while considering the sector's existing occupational composition and the prospective transformations driven by growth and technological innovations. The data in this section has been sourced from data collected for the Oil & Gas Industry Baseline Study⁴³ conducted by Deloitte in 2023-24 and other numerous sources.

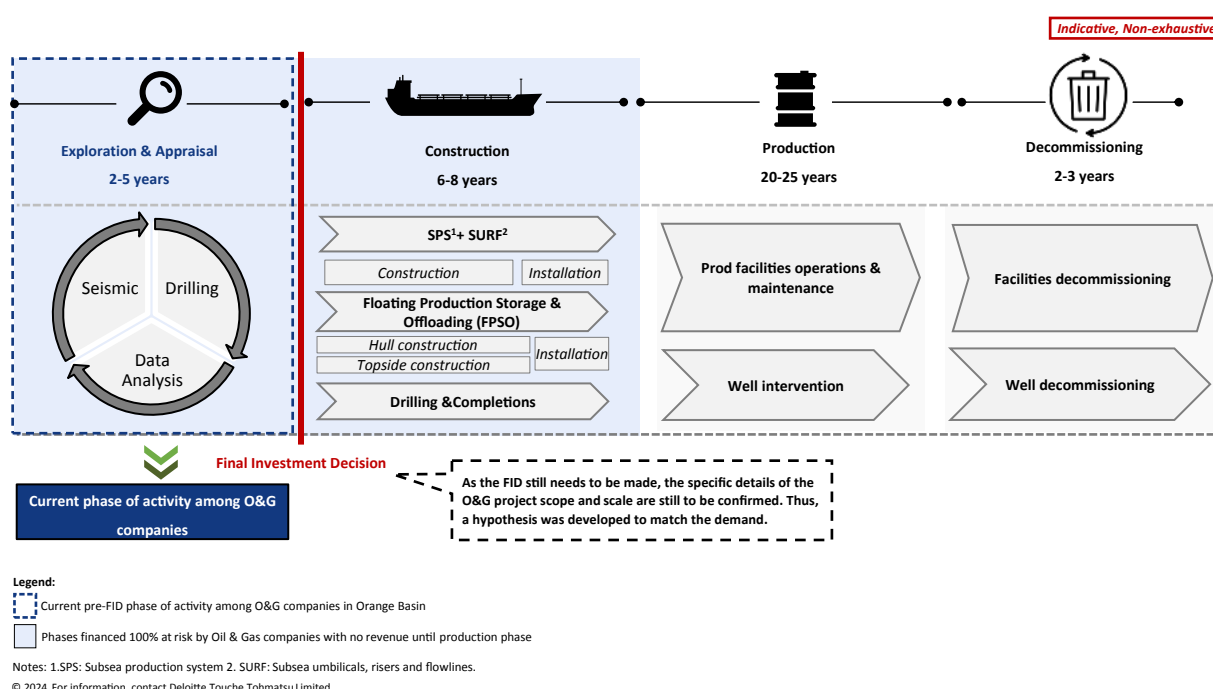


Figure 1: Oil and Gas Value Chain⁴⁴

Research indicates a significant skills gap in Namibia's oil and gas industry, with only 45% of the required skills.⁴⁵ This deficit hinders the growth and implementation of the local content policy. While there's a surplus in general support qualifications, there's a lack of technical skills, particularly in offshore operations and specialised catering.⁴⁶ Vocational training centres and universities lack the advanced equipment and specialised curricula needed for the oil and gas sector, with limited dedicated petroleum engineering programs.⁴⁷ The occupational/ skill areas indicated in this section may differ from those of International Oil Companies (IOCs), given the technicalities of the projects being undertaken. The numbers are typical for a stand-alone project.

Footnotes

⁴³ Oil & Gas Industrial Baseline Survey – Namibia, August 2024

⁴⁴ Sourced from the Oil & Gas Industrial Baseline Survey – Namibia, August 2024

⁴⁵ <https://www.namibian.com.na/namibia-only-has-45-capability-for-oil-sector-skills-demand/>

⁴⁶ <https://southernafricantimes.com/namibia-faces-skills-gap-in-offshore-catering/>

⁴⁷ <https://thebrief.com.na/2024/08/is-namibia-ready-for-the-oil-and-gas-revolution-assessing-the-role-of-vocational-training-centres/>

4.3.1 Skills Demand during Exploration and Appraisal

Exploration Phase (Offshore):

Offshore exploration involves specialised techniques and considerations due to the marine environment. Seismic surveys are a primary tool, utilising seismic vessels that tow airgun arrays to generate sound waves and hydrophone streamers to record the reflected signals.⁴⁸ These surveys can be 2D, providing a profile view, or 3D, offering a more comprehensive subsurface image. Exploration drilling is conducted from various offshore platforms or Mobile Offshore Drilling Units (MODUs) such as jack-up rigs for shallower waters and semi-submersibles or drillships for deeper waters.⁴⁹ These drilling operations aim to confirm the presence of hydrocarbons and gather initial data about the reservoir.

Required core disciplines for offshore exploration include geophysics, marine geology to understand seabed conditions, drilling engineering adapted for offshore environments, offshore operations expertise to manage the complexities of marine logistics and platform operations, HSE with a focus on offshore safety, and marine environmental science to address the unique ecological sensitivities of marine environments.⁵⁰

Essential technical skills for offshore exploration encompass seismic data acquisition and interpretation specific to the marine environment, offshore drilling techniques, well logging adapted for offshore conditions, remote sensing for oceanographic and seabed analysis, and marine environmental monitoring to assess and mitigate potential impacts.⁵¹ Non-technical skills are critical, with a strong emphasis on safety management due to the inherent risks of offshore operations, robust risk management strategies, clear communication among diverse teams often working in remote locations, effective teamwork, and meticulous logistics coordination to manage the movement of personnel and equipment.⁵²

A typical offshore exploration team can be larger and more specialised than an onshore team. It might include 3-7 geophysicists, 2-5 drilling engineers with offshore experience, an Offshore Installation Manager (OIM) responsible for overall platform operations, a Barge Master for managing marine aspects of MODUs, 2-3 HSE officers specialised in offshore safety, 2-4 Marine Mammal Observers to monitor and protect marine life during seismic surveys, and a seismic survey crew of 20-50 personnel depending on the vessel and technology used.⁵³

Appraisal Phase (Offshore):

The appraisal phase offshore mirrors onshore activities but with added complexities related to the marine setting. Appraisal drilling from offshore platforms or MODUs is conducted to delineate the discovered reservoir. Well testing is performed to evaluate reservoir characteristics and production potential in the offshore environment.⁵⁴

Reservoir evaluation involves analysing the gathered data to refine reservoir models and assess the commercial viability of the offshore discovery. A unique aspect of offshore appraisal is the consideration of subsea engineering for planning the infrastructure required for potential subsea well completion and production.⁵⁵ Comprehensive Environmental Impact Assessments (EIAs) are crucial to address the specific environmental risks associated with offshore development.

Footnotes

⁴⁸ <https://www.eia.gov/energyexplained/oil-and-petroleum-products/offshore-oil-and-gas-in-depth.php>

⁴⁹ <https://www.gmsthailand.com/blog/offshore-oil-and-gas/>

⁵⁰ <https://www.oil-gasportal.com/upstream/petroleum-exploration/>
<https://www.slb.com/resource-library/oilfield-review/defining-series/defining-exploration>

⁵¹ <https://www.element-staffing.com/2025/04/09/what-skills-are-employers-seeking-in-the-oil-gas-industry/>

⁵² <https://www.progasllc.com/work-skills-for-gas-industry/>

⁵³ <https://www.planete-energies.com/en/media/article/exploration-multi-stage-process>
<https://drillingforgas.com/en/planning/staffing-requirement-for-exploration-drilling-operations>

⁵⁴ <https://www.planete-energies.com/en/media/article/exploration-multi-stage-process>

⁵⁵ <https://www.oil-gasportal.com/upstream/field-appraisal-phase/>

The core disciplines required for offshore appraisal include reservoir engineering, drilling engineering, well testing, subsea engineering to design and manage underwater infrastructure, marine environmental science, and economics to assess the financial feasibility of offshore development.⁵⁶

Essential technical skills include reservoir simulation tailored for offshore reservoirs, advanced well test analysis, expertise in subsea equipment operation and maintenance, proficiency in offshore logistics to manage complex supply chains and personnel transport, and thorough knowledge of environmental impact assessment in marine ecosystems.⁵⁷ Non-technical skills remain paramount, encompassing strong decision-making capabilities for complex offshore scenarios, rigorous risk assessment and management, effective collaboration across multidisciplinary and often multinational teams, clear communication, and well-developed emergency response skills crucial for ensuring safety in remote offshore locations.⁵⁸

A typical offshore appraisal team might consist of 4-8 reservoir engineers, 3-6 drilling engineers with offshore expertise, 4-7 well test operators, 2-4 subsea engineers, an Offshore Installation Manager (OIM), 2-3 environmental specialists focused on marine environments, and 1-2 economists.⁵⁹ The exact team size and the number of personnel in each role will depend on the water depth, the complexity of the subsea environment, and the scale of the potential offshore field.

Impact of Project Scale and Complexity on Skill and Staffing Requirements

The scale and complexity of an oil and gas project significantly influence the skills and staffing levels required during exploration and appraisal.⁶⁰ Larger potential fields with substantial reserves typically necessitate more extensive exploration and appraisal programs, demanding larger teams and longer project durations across all disciplines. In offshore projects, water depth is a critical factor; deeper water environments introduce substantial complexities, requiring advanced technologies, specialised skills in subsea engineering and deepwater drilling, and larger, more sophisticated offshore installations with correspondingly larger crews.⁶¹ Projects located in environmentally sensitive areas demand greater expertise in marine or terrestrial environmental science, stricter adherence to regulatory requirements, and potentially larger teams focused on ecological monitoring, mitigation, and restoration.⁶² The type of hydrocarbon being targeted (oil versus gas) can also influence skill requirements, particularly in reservoir characterisation and production forecasting, due to the differing physical properties. Finally, the exploration and appraisal of unconventional resources like shale gas or tight oil necessitate specialised techniques such as hydraulic fracturing and horizontal drilling, requiring specific technical expertise and potentially different team compositions.⁶³

A list of provided occupational fields and indicative numbers is attached to the report as Annexures 1 and 2.

Footnotes

⁵⁶ <https://www.oil-gasportal.com/upstream/petroleum-exploration/>

⁵⁷ <https://www.mobilityoilandgas.com/petroleum-engineer-skills-salary-and-professional-development/>

⁵⁸ <https://getglobalgroup.com/training-and-skills-for-the-modern-upstream-oil-and-gas-professional/>

⁵⁹ <https://drillingforgas.com/en/planning/staffing-requirement-for-exploration-drilling-operations>

⁶⁰ <https://www.bain.com/insights/large-project-management-in-oil-and-gas/>

⁶¹ https://www.researchgate.net/publication/315375512_Complexity_for_Megaprojects_in_the_Energy_Sector

⁶² <https://www.noia.org/wp-content/uploads/2021/08/The-Gulf-of-Mexico-Oil-Gas-Project-Lifecycle.pdf>

⁶³ <https://jpt.spe.org/composite-results-project-complexity-study>

4.3.2 Skills Demand during Engineering & Construction

With confirmed reserves, the focus shifts to designing the offshore infrastructure needed for production. This has two phases: engineering and construction.

4.3.2.1 Engineering Phase

Table 2: Skills demand - Oil & Gas Engineering & Construction

Skills demand - Oil & Gas Engineering & Construction	
Occupation ⁶⁴	Tasks
Petroleum Engineers	Design drilling tools and techniques for production wells
Mechanical Engineers	Design machinery and equipment for extraction and processing
Civil Engineers	Design offshore structures (platforms, jackets)
Electrical Engineers	Design power generation and distribution systems
Naval Architects	Design floating production and storage facilities (FPSOs).
Subsea Engineers	Design subsea wellheads, pipelines, and control systems
Offshore Piping Designers	Design the complex network of pipes on platforms
Process Engineers	Design facilities for processing extracted oil and gas
Architectural & Civil Drafters	Create detailed engineering drawings
Architectural & Engineering Managers	Oversee the design teams
Project Managers and Engineers	Manage the overall engineering and design phase
Cost Control Managers	Manage the budget for the design phase
HSE Advisors/Specialists	Ensure safety and environmental considerations are integrated into the design.
Software Developers	Develop specialized software for modeling and analysis

For this stage, essential skills include engineering design (mechanical, civil, electrical, subsea, process, piping), structural analysis, risk assessment, project management, cost estimation, regulatory compliance, and CAD software proficiency. A small platform development might require a core engineering team of 15-30 engineers and designers for 1-2 years. A large, complex deepwater project could involve 50-100 or more specialists over 2-4 years.

⁶⁵

Footnotes

⁶⁴ <https://getglobalgroup.com/gy/career-opportunities-oil-gas-industry/>

⁶⁵ <https://www.noia.org/gulfanchor/>

4.3.2.1 Engineering Phase

The final stage of development involves building and installing the designed infrastructure.

Table 3: Skills Demand- Oil & Gas Construction & Installation

Skills Demand- Oil & Gas Construction & Installation	
Occupation ⁶⁶	Tasks
Construction Managers/Superintendents	Oversee all construction and installation activities
Project Managers and Engineers	Manage the construction phase, ensuring adherence to timelines and budgets
Welders	Fabricate and repair steel structures and pipelines
Pipefitters	Install and connect piping systems
Riggers	Handle and move heavy equipment and materials.
Crane Operators	Lift and position materials and equipment.
Offshore Technicians	Perform maintenance and repair tasks during installation.
ROV Technicians and Supervisors	Operate remote underwater vehicles for inspection and installation support
Saturation Technicians	Perform specialized diving operations
Marine Officers/Section Leaders/Supervisors	Manage vessel operations involved in installation
Heavy Lift Specialist	Oversee the lifting and movement of large modules
HSE Advisors/Specialists	Ensure safety and environmental protection during construction
Foremen & Line Supervisors	Lead and organize construction crews
Seatrax Crane Inspector	Inspect and certify offshore cranes

Essential skills include construction management, welding, pipefitting, rigging, crane operation, offshore construction techniques, subsea installation, heavy lifting operations, safety management, and marine operations. This stage is the most labour-intensive. A small platform installation might involve 100-200 workers offshore for several months. Large projects, especially deepwater developments or FPSO installations, can require several hundred to thousands of personnel offshore and onshore (fabrication yards) over 1-3 years or more.⁶⁷

Footnotes

⁶⁶ <https://www.orientalent.com/oil-and-gas-industry-careers/position-types/>
<https://www.noia.org/gulfanchor/>

⁶⁷ <https://www.noia.org/gulfanchor/>

4.3.3 Skills Demand during Production

The production phase commences after the successful drilling and completion of wells and continues until the economic or technical limit of the reservoir is reached, leading to Cessation of Production (CoP).

The phase involves the extraction of oil and gas from reservoirs, processing the raw fluids, and transporting them to refineries or markets. Its primary objectives revolve around maximising resource recovery efficiently and safely, maintaining operational integrity, and ensuring continuous flow. While exploration and drilling are foundational, the production phase represents the longest operational period.

Table 4: Skills Demand - Oil & Gas Production

Skills Demand - Oil & Gas Production	
Operations	
Occupation ⁶⁸	Tasks
Production Operators/Technicians	Monitor and operate process equipment, take readings, perform routine checks
Control Room Operators	Monitor and control the overall process from a central control room using SCADA/DCS systems, respond to alarms
Terminal Operators:	Manage storage and loading/offloading operations at onshore terminals
Pipeline Technicians:	Monitor and maintain pipeline integrity and associated pump/compressor stations
Maintenance	
Maintenance Technicians (Mechanical, Electrical, Instrument)	Perform specialized maintenance and repair tasks within their discipline
Mechanics	Focus on rotating equipment (engines, pumps, compressors) and mechanical systems
Electricians	Install, maintain, and repair electrical power generation, distribution, and control systems
Welders	Perform fabrication and repair welding tasks
Control Systems/Instrumentation Technicians	Install, calibrate, maintain, and troubleshoot process control instrumentation and systems
Maintenance Supervisors	Oversee maintenance teams and activities.

Footnotes

⁶⁸ <https://www.orientalent.com/oil-and-gas-industry-careers/position-types/>
<https://www.learntodrill.com/post/50-roles-in-oil-gas-company>

Skills Demand - Oil & Gas Production

● Technical / Engineering

Petroleum Engineers	Involved in overall reservoir management, production optimization, and well integrity
Production Engineers	Focus specifically on optimizing production rates, designing surface facilities, and troubleshooting operational issues
Reservoir Engineers	Analyze reservoir performance, predict future production, and plan EOR strategies
Geoscientists (Geologists/Geophysicists)	Provide ongoing geological interpretation for reservoir management and well interventions
Drilling Engineers	Plan and supervise well intervention activities requiring drilling rigs or specialized equipment
Mud Engineers/Loggers	Involved during specific well interventions requiring fluid management or data logging

● Safety

HSE Officers/Advisors/Managers	Implement and monitor safety procedures, conduct audits, investigate incidents, ensure regulatory compliance
Medics/Paramedics	Provide onboard medical care, especially offshore.
Safety Engineers	Involved in the design and assessment of safety systems

● Support

Logistics Coordinators	Manage transport of personnel and materials
Procurement Officers/Supply Chain Managers	Manage purchasing and inventory
Administrative Staff	Provide general office support
Catering Staff/Stewards/Camp Boss	Manage accommodation and food services, crucial for offshore morale and well-being.
Roustabouts/Floorhands/Leasehands	Provide general labor support, cleaning, assisting trades

● Offshore Specific

Offshore Technicians	Often multi-skilled roles covering operations and maintenance duties on offshore platforms
ROV Technicians	Operate Remotely Operated Vehicles for subsea inspection and light intervention tasks
Ballast Control Operators/Dynamic Positioning Operators (DPOs)	Maintain stability and positioning for floating facilities (e.g., FPSOs, Semi-submersibles)

The integrated nature of modern production facilities often necessitates a cross-disciplinary understanding among technical and maintenance personnel. For instance, a pipeline technician may need operational, technical, electrical, and mechanical skills, while maintenance technicians frequently work across hydraulic, pneumatic, electrical, and mechanical systems. This blurring of traditional lines requires a broader skill base and adaptability, particularly within learner operational teams.⁶⁹

Success in production phase roles requires a combination of technical proficiency, soft skills, and a strong safety mindset. Essential skills include:

- **Technical skills:** Process operations, maintenance and repair, engineering and analysis, safety and compliance.
- **Soft Skills:** Problem-solving and critical thinking, communication, teamwork & collaboration, attention to detail, adaptability, decision-making, leadership and resilience.

The increasing trend towards digitalisation and automation within the oil and gas industry is reshaping skill requirements. Technologies like remote monitoring, advanced process control, digital twins, and data analytics are becoming more prevalent. This necessitates that operations and maintenance personnel develop stronger digital literacy, data interpretation skills, and the ability to manage and troubleshoot complex automated systems. While automation may reduce the need for some routine manual tasks, it increases the demand for specialised technicians proficient in instrumentation, control systems, and IT/OT (Operational Technology) integration, potentially shifting the workforce composition towards more highly skilled roles, including those based onshore providing remote support.⁷⁰

Determining a single "typical" workforce size for the production phase is challenging due to significant variations based on several factors. However, analysis of industry data provides indicative ranges. Offshore platforms, for example, can accommodate large numbers, potentially up to around 200 individuals at peak times. However, this figure often includes personnel involved in concurrent drilling, construction, or major maintenance campaigns, alongside core production crew and support staff (catering, medical, marine).⁷¹ Floating Production, Storage, and Offloading (FPSO) vessels' crew sizes are often comparable to large tankers, typically ranging from 20-25 essential marine and production personnel, potentially augmented by project or maintenance staff.⁷² Fixed Platforms, on the other hand, have generally decreased manning levels over time due to automation and efficiency drives. While older, larger platforms might have housed hundreds, modern fixed platforms often operate with crews closer to 100 or significantly fewer.⁷³

Footnotes

⁶⁹ <https://www.iogp.org/workstreams/engineering/>

<https://www.orientalent.com/oil-and-gas-industry-careers/position-types/>

⁷⁰ <https://www.iogp.org/workstreams/engineering/>

<https://www.orientalent.com/oil-and-gas-industry-careers/position-types/>

<https://dokumen.pub/offshore-risk-assessment-vol-2-principles-modelling-and-applications-of-qra-studies-4th-ed-2020-978-1-4471-7447-9-978-1-4471-7448-6.html>

⁷¹ <https://www.nesfircroft.com/resources/blog/oil-rig-life-whats-it-like-living-on-an-offshore-oil-platform/>

⁷² <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/dtl-er-challengeindustry-08072013.pdf>

⁷³ <https://dokumen.pub/offshore-risk-assessment-vol-2-principles-modelling-and-applications-of-qra-studies-4th-ed-2020-978-1-4471-7447-9-978-1-4471-7448-6.html>

4.3.4 Skills Demand during Decommissioning

Decommissioning represents the final phase of an oil and gas asset's lifecycle, encompassing the safe shutdown, removal or repurposing of infrastructure, and restoration of the operational site to a predetermined condition, often aiming for its original state. It is a legally mandated and highly complex undertaking, usually spanning several years from initial planning to final site clearance.⁷⁴

4.3.4.1 Key Stages within Decommissioning

While specific project plans vary, the decommissioning process typically involves the following key stages, often overlapping.⁷⁵

Table 5: Oil and Gas Decommissioning– Key stages

Oil and Gas Decommissioning – Key stages	
Key stages	Tasks
Planning & Engineering	This crucial phase commences well before production ceases, sometimes two to five years in advance. It involves developing the overall decommissioning strategy, conducting detailed engineering studies for removal and plugging and abandonment (P&A), performing environmental and risk assessments, estimating costs, selecting contractors, and preparing the formal Decommissioning Programme document for regulatory submission.
Permitting & Regulatory Compliance	Obtaining formal approval for the Decommissioning Programme from relevant regulatory bodies (e.g., OPRED and NSTA in the UK; BSEE and BOEM in the US) is mandatory before major offshore work begins. This involves extensive documentation and stakeholder engagement.
Platform Preparation / Making Safe (Post-CoP):	After production stops, the facility must be prepared for removal. This involves thoroughly flushing pipelines and process vessels to remove residual hydrocarbons, managing hazardous materials, isolating and disconnecting utility and process systems, and potentially installing structural reinforcements or padeyes needed for lifting operations.
Well Plugging & Abandonment (P&A):	Often the most significant cost component (around 50% of total decommissioning cost) and critical for long-term environmental protection. This stage involves permanently sealing the wells to prevent any future leakage. Key activities include cleaning the wellbore, setting multiple mechanical and/or cement plugs at specific depths to isolate hydrocarbon and water zones, pressure testing plug integrity, and removing the wellhead equipment. This can be done using a dedicated rig (rig-based P&A) or increasingly via specialized vessels or from the platform itself before removal (rigless P&A).
Conductor Removal:	The large pipes (conductors) running from the platform to the seabed must typically be severed and removed to a specified depth below the mudline. Techniques include internal or external cutting using explosives, mechanical cutters, abrasive water jets, or diamond wire saws, followed by pulling the sections.

Footnotes

⁷⁴ <https://oceanconservancy.org/wp-content/uploads/2024/09/Decommissioning-Report-Final.pdf>

<https://www.nesfircroft.com/resources/blog/everything-you-need-to-know-about-offshore-decommissioning/>

<https://www.gov.uk/government/publications/export-strategy-for-global-offshore-upstream-decommissioning/global-offshore-upstream-decommissioning-export-strategy>

⁷⁵ https://www.rigzone.com/training/insight?insight_id=3548

Oil and Gas Decommissioning – Key stages

Topside Removal:	The upper section of the platform (deck, modules, equipment) is dismantled and lifted off the substructure. This is typically performed using large crane vessels (Heavy Lift Vessels - HLVs or Derrick Barges). Removal can occur as a single large lift (for smaller topsides), module by module, or by cutting the topside into smaller sections (piece-small).
Substructure (Jacket/Base) Removal:	The supporting structure (e.g., steel jacket, concrete gravity base) is removed. For steel jackets, this involves severing the foundation piles below the seabed using divers, ROVs, or specialized internal/external cutting tools. The jacket is then lifted, either whole (for smaller structures) or in sections, and transported onshore. Alternatives permitted in some regions include partial removal (leaving the lower section in place) or toppling for Rigs-to-Reefs programs.
Pipeline & Subsea Infrastructure Decommissioning:	Associated pipelines, umbilicals, manifolds, protection structures, and stabilization materials (e.g., concrete mattresses) must be addressed. Options include complete removal or decommissioning-in-place, which involves flushing, cleaning, plugging, and potentially trenching/burying the pipeline if it poses no significant environmental or navigational hazard. Mattresses and other subsea hardware are typically removed.
Materials Disposal & Recycling:	All removed materials (steel, equipment, concrete, waste) are transported onshore to licensed facilities for processing. Emphasis is placed on maximizing reuse and recycling in line with circular economy principles and waste management regulations.
Site Remediation & Clearance	The final step involves verifying that the seabed is clear of decommissioning debris to the required standard. This is typically confirmed through side-scan sonar surveys, ROV visual inspection, and potentially test trawling. Any remaining debris must be removed. Depending on findings from environmental assessments, soil or water remediation might also be required.

Decommissioning projects require a diverse and often specialised workforce that shifts significantly throughout the project lifecycle.

Table 6: List of essential occupations and core tasks

List of essential occupations and core tasks

● Management and Planning

Occupation ⁷⁶	Tasks
Project Managers (Decommissioning)	Oversee entire project scope, schedule, budget, and interfaces
Decommissioning Managers/Engineers	Specialize in planning and executing decommissioning activities
Engineers (Structural, Civil, Marine, Environmental, Wells P&A)	Provide discipline-specific expertise for planning, design, and execution.
Planners/Schedulers	Develop detailed project schedules
Cost Estimators/Controllers	Manage project budget and costs
Contract Managers	Manage multiple contractor agreements
Regulatory Compliance Officers/Specialists	Ensure adherence to regulations and manage permit applications

Footnotes

⁷⁶ <https://www.nesfircroft.com/resources/blog/everything-you-need-to-know-about-offshore-decommissioning/>
<https://gcaplain.com/offshore-decommissioning-a-growing-industry-with-rising-risks/>
<https://oilfieldworkers.com/articles/transitioning-to-the-future-the-critical-role-of-decommissioning-in-the-oil-gas-sector/>

List of essential occupations and core tasks

● Well Plugging and Abandonment (P&A)

Well Site Supervisors/Company Representatives	Oversee P&A operations at the well site
P&A Engineers	Design detailed abandonment procedures.
Cementing Operators/Supervisors	Operate equipment to mix and pump cement plugs
Wireline/Slickline Operators	Run tools for logging, plug setting, perforating
Coiled Tubing Operators	Perform interventions using coiled tubing units
Rig Crews (Drillers, Derrickhands, Floorhands)	If rig-based P&A is used
Toolpushers	Supervise rig crews

● Removal Operations

Offshore Construction Managers (OCMs)	Manage offshore removal campaigns
Heavy Lift Supervisors/Operators	Plan and execute heavy lifts using crane vessels.
Crane Operators	Operate platform or vessel cranes
Riggers	Prepare loads for lifting.
Welders/Cutters	Perform structural cutting using various technologies (torches, abrasive jets, diamond wire)
Commercial Divers (Saturation, Air)	Perform subsea tasks like cutting, inspection, rigging.
ROV Pilots/Technicians	Operate ROVs for inspection, cutting tool deployment, monitoring, debris removal.
Marine Crew: Captains/Masters	Dynamic Positioning Operators (DPOs), engineers, deckhands operating support vessels, barges
Foremen	Supervise specific work crews (e.g., cutting, rigging)

● Environmental/ Safety

Environmental Scientists/Engineers	Conduct impact assessments, monitor environmental conditions, plan remediation, ensure compliance
Marine Biologists	Assess impacts on marine ecosystems, conduct surveys
Waste Management Consultants/Specialists	Plan and oversee compliant disposal and recycling of materials
HSE Advisors/Managers	Ensure safety protocols are followed during high-risk operations
Safety Engineers	Analyze risks and design safe procedures
Medics/Paramedics	Provide medical support, often required offshore

● Onshore Support

Logistics Coordinators	Manage complex logistics for vessels, personnel, and materials
Procurement Specialists	Source specialized equipment and services
Onshore Dismantling/Recycling Yard Workers	Process materials received from offshore
Surveyors	Conduct pre- and post-decommissioning site surveys

A key characteristic of the decommissioning workforce is its dynamic nature. The project begins with a concentration of planning, engineering, and regulatory personnel, often office-based.

The P&A phase requires mobilising specialised well crews and equipment. The peak workforce demand typically occurs during the intensive offshore removal phase, involving large numbers of marine crew, construction trades (welders, cutters, riggers), heavy lift specialists, divers, and ROV teams. Finally, environmental and survey teams play a crucial role in the site clearance and close-out stages. This fluctuation necessitates highly flexible workforce planning, mobilisation, and management capabilities from both operators and contractors.⁷⁷

Decommissioning demands a unique blend of skills, combining traditional oil and gas expertise with capabilities from heavy construction, demolition, and environmental services, alongside stringent safety certifications. Additional skills include:

Technical Skills:	Project Management, Structural Engineering & Analysis, Cutting & Severance Techniques, Heavy Lifting Operations, Marine Operations, Well P&A Techniques, ROV Operations & Tooling, Diving Operations, Environmental Science & Engineering, Hazardous Materials Management, Regulatory Knowledge and Surveying.
Soft Skills:	Risk management, problem-solving, collaboration & communication, planning & organisation, adaptability, safety and leadership. These are soft skills and must not be capped.
Safety Certifications:	Standard offshore survival training (BOSIET/FOET/HUET) is typically required for offshore personnel. Additionally, specialised certifications are necessary for roles involving diving, ROV operation, crane operation, welding, rigging, handling explosives, and managing hazardous waste. Adherence to rigorous safety protocols and permit-to-work systems is non-negotiable due to the elevated risks associated with dismantling ageing structures and handling potentially hazardous materials. ⁷⁸

The nature of decommissioning work requires drawing expertise from multiple sectors. While foundational knowledge from oil and gas operations (like well engineering, offshore logistics, marine operations) is vital, it must be complemented by specialised skills typically found in heavy construction (structural demolition, heavy lifting), civil engineering (structural analysis), and environmental services (remediation, waste management, ecological assessment). This creates a unique, multi-disciplinary workforce profile distinct from that of the production phase.

79

Estimating workforce size for decommissioning is highly dependent on the specific project's phase, scale, complexity, location, and chosen methodologies. Generalisations are difficult, but available data and project examples offer some insights:

Footnotes

⁷⁷ <https://www.nesfircroft.com/resources/blog/everything-you-need-to-know-about-offshore-decommissioning/>

⁷⁸ <https://gcaptain.com/offshore-decommissioning-a-growing-industry-with-rising-risks/>

⁷⁹ <https://www.nesfircroft.com/resources/blog/everything-you-need-to-know-about-offshore-decommissioning/>
<https://oilfieldworkers.com/articles/transitioning-to-the-future-the-critical-role-of-decommissioning-in-the-oil-gas-sector/>
<https://decommission.net/wp-content/uploads/2023/08/proserv.pdf>

**UK Continental Shelf
Decommissioning (UKCS
Focus):**

The UK Continental Shelf (UKCS) decommissioning market is substantial and growing. Forecast expenditure for the next decade (from 2023/2024) is estimated at £21-£24.6 billion⁸⁰. UKCS forecasts for 2024 included 187 wells and 14 topsides removals. Over the next decade (to 2033), over 2,000 wells and numerous platforms/subsea structures are slated for decommissioning in the UKCS. However, actual work often lags forecasts. In 2023, only 126 wells and three topsides were decommissioned in the UKCS, compared to higher forecasts, indicating challenges in execution and potential backlogs⁸¹.

Internationally, activity is also high. In the Netherlands, eight platforms were removed in 2023. Globally, thousands of platforms are ageing and will require decommissioning in the coming years⁸².

Project-Specific Workforce Examples:

ExxonMobil Bass Strait (Australia): A multi-year P&A campaign engaged approximately 600 workers (likely rotating crews across multiple assets like rigs and support vessels). An additional ~40 contract staff managed ongoing care and preservation of non-producing facilities. This illustrates that large-scale P&A campaigns require substantial, sustained workforces⁸³. Individual P&A operations typically utilise teams ranging from 5 personnel (for 12-hour operations) up to 10-12 personnel plus supervisors (for 24-hour operations), depending on the complexity and method (rigless vs. rig-based). A campaign involving multiple simultaneous operations would scale this number significantly⁸⁴. While direct numbers per removal aren't readily available, the complexity and cost (e.g., >\$100M for some California platforms) imply large project teams, especially during the offshore heavy lift phase involving specialised vessels and extensive marine and construction crews⁸⁵.

The highly variable, project-based nature of decommissioning, coupled with the dependence on specialised, high-cost assets (like HLVs, specialised P&A vessels, dive support vessels) and personnel, makes efficient resource scheduling paramount. Industry initiatives promoting campaign-based approaches, where multiple wells or structures are decommissioned sequentially or in parallel by a dedicated team and vessel spread, aim to improve efficiency and reduce costs. The observed challenges in meeting planned decommissioning schedules and the rising cost estimates suggest that optimising this complex logistical puzzle remains a critical hurdle for the industry. Effective collaboration between operators and the supply chain, along with greater visibility of future work scopes, is essential to smooth workflow and maintain a capable domestic supply chain⁸⁶.

Last but not least, there is considerable potential for skill transfer between the production and decommissioning phases, and increasingly, into the broader energy transition landscape:

Footnotes

⁸⁰ <https://www.nstauthority.co.uk/media/lnmhq2l/decom-cost-report-2023-final-accessible-1.pdf>

⁸¹ <https://oeuk.org.uk/wp-content/uploads/2024/11/OEUK-Decommissioning-Report-2024.pdf>
<https://eeegr.com/wp-content/uploads/2024/07/ukcs-decom-cost-and-performance-update-01.pdf>

⁸² <https://www.nextstep.nl/wp-content/uploads/2024/06/NEXSTEP-Re-use-Decommissioning-report-2024.pdf>
<https://specialty.ajg.com/energy/decommissioning-strategy-in-the-age-of-the-energy-transition>

⁸³ <https://corporate.exxonmobil.com/locations/australia/our-operations/bass-strait/decommissioning-in-the-bass-strait>

⁸⁴ <https://www.bsee.gov/sites/bsee.gov/files/tap-technical-assessment-program/738aa.pdf>

⁸⁵ <https://ccst.us/wp-content/uploads/CCST-Orphan-Wells-in-California-An-Initial-Assessment.pdf>

⁸⁶ https://www.rigzone.com/training/insight?insight_id=354&c_id=
<https://www.nstauthority.co.uk/regulatory-information/decommissioning/overview/>
<https://www.decomreghub.org.uk/resources/preparation-for-decom-and-late-life-operations/>
<https://www.nextstep.nl/wp-content/uploads/2024/06/NEXSTEP-Re-use-Decommissioning-report-2024.pdf>
<https://eeegr.com/wp-content/uploads/2024/07/ukcs-decom-cost-and-performance-update-01.pdf>
<https://oeuk.org.uk/wp-content/uploads/2024/11/OEUK-Decommissioning-Report-2024.pdf>

High Transferability:	Roles like project managers, HSE professionals, logistics coordinators, marine crew (masters, DPOs, engineers), and specific trades (e.g., welders, electricians, mechanics involved in maintaining support equipment) possess skills readily applicable in both contexts. Core engineering disciplines also provide a strong foundation, though specialisation may be required. Job roles without names are not capped.
Retraining/Upskilling Needed:	Transitioning from certain production-focused roles to decommissioning requires significant adaptation. For example, a production operator's skills in process control are less relevant to structural dismantling than skills in cutting or rigging. A reservoir engineer focused on EOR needs expertise that is different from that of a P&A engineer designing permanent well barriers. Retraining programs are necessary to bridge these gaps.
Energy Transition Linkages	Decommissioning is a crucial bridge to the future energy system. Many skills honed during offshore decommissioning – complex project management, offshore logistics and installation, subsea engineering, handling large structures, working in challenging marine environments – are directly transferable to offshore wind farms' installation, maintenance, and eventual decommissioning. Furthermore, assessing and potentially repurposing existing infrastructure (pipelines, platforms) for Carbon Capture, Utilisation, and Storage (CCUS) or hydrogen production creates further opportunities for workforce transition, leveraging existing asset knowledge and offshore expertise. ⁸⁷

4.4 Skills Supply in Oil & Gas

The recent confirmation of substantial offshore oil and gas reserves positions Namibia on the cusp of becoming a significant player in the regional and global energy landscape.

These discoveries hold the promise of substantial economic growth, diversification, and improved public services. The Namibian government has clearly articulated its intention to transition from discovery to production efficiently yet responsibly, ensuring that the nation's resource wealth translates into tangible, long-term benefits for its citizens⁸⁸.

Central to achieving this vision is the development of robust human capital. The ability of Namibians to participate meaningfully across the complex O&G value chain – from the initial search for resources to their final processing and eventual site restoration – is paramount. This aligns directly with national strategic priorities emphasising local content development and the beneficiation of natural resources, ensuring that economic opportunities are inclusive and fostering sustainable domestic capacity. As stated by the government, Namibia seeks partners committed not just to capital investment but also to skills development, infrastructure support, and knowledge transfer aligned with the country's long-term goals⁸⁹.

Footnotes

⁸⁸ <https://worldoil.com/news/2025/4/24/namibia-s-oil-and-gas-success-hinges-on-smart-policy-partnerships-aec-says/>

⁸⁹ <https://theextractormagazine.com/2025/04/23/namibia-is-ready-for-collaboration-technical-capability-and-strong-governance-in-oil-gas-sector/>
<https://namibiaoilandgas.com/2025/03/03/hyphen-signs-memorandum-of-understanding-for-local-skills-development-and-capacity-building/>
<https://www.observer24.com.na/petrofund-sbm-offshore-launch-graduate-programme/>

Successfully navigating the O&G value chain demands a wide spectrum of skills, ranging from highly specialised technical expertise to essential operational, managerial, and support competencies. These can be broadly categorised and summarised as follows:

Table 7: Key Skills in the O&G Value Chain

Key Skills in the O&G Value Chain				
Value Chain Stage ⁹⁰	Key Technical Skills (HEI)	Key Technical Skills (TVET)	Key Operational & Managerial Skills	Key Support Skills
Exploration	Geology, Geophysics, Geomatics/Surveying, Data Science	Drilling support (basic), surveying assistants	Project management, risk management, contract management (Seismic/Drilling)	HSE management, legal (exploration licenses), IT (Data Management), community relations
Appraisal	Geology, Geophysics, Reservoir Engineering, Drilling Engineering, Petrophysics	Drilling support (roustabout, floorman), NDT technicians, mud logging technicians	Project management, drilling operations management, financial analysis (viability assessment)	HSE management, environmental permitting, logistics (rig Mobilisation), IT
Development	Petroleum Eng., Reservoir Eng., Drilling Eng., Completion Eng., Mechanical Eng., Electrical Eng., Civil/Structural Eng., Process Eng., Materials Science, Geomatics/Surveying	Welding (structural, piping), pipefitting, boiler making, electrical installation, instrumentation, mechanical fitting, scaffolding, rigging, construction trades, NDT, diving (offshore)	Project management (major projects), construction management, contract & procurement management, supply chain management, financial management (budgeting/cost control), drilling operations management.	HSE management, environmental permitting & assurance/control, logistics, IT, HR management
Production	Production Eng., Reservoir Eng., Process Eng., Mechanical Eng., Electrical Eng., Chemical Eng., Environmental Eng.	Production operations technicians, mechanical maintenance technicians, electrical technicians, instrumentation technicians, well servicing crew, laboratory technicians, NDT	Operations management, maintenance planning & management, production optimisation, asset integrity management, supply chain management, risk management	HSE management, environmental monitoring & compliance, logistics (product transport), IT (process control), security, HR management
Processing	Chemical/Process Eng., Mechanical Eng., Electrical Eng.	process operators, laboratory technicians, maintenance technicians (mech, elec, instrument)	Plant management, operations management, quality control	HSE management, IT (process control), logistics
Transportation	Mechanical Eng. (Pipelines), Civil Eng. (Pipelines), Marine Eng. (Tankers)	pipeline maintenance crew, truck drivers, vessel crew (deck officers, engineers), logistics coordinators	Logistics management, fleet management, pipeline operations management, contract management (shipping)	HSE management, legal (transport regulations, maritime law), IT (tracking systems)
Storage	Mechanical Eng., Civil Eng.	Tank farm operators, maintenance technicians	Terminal management, inventory management	HSE management, security
Marketing & Trading	Petroleum Economics	Administrative support	Trading operations, market analysis, contract management	Legal (trading contracts), finance

Footnotes

⁹⁰ <https://www.skillcatapp.com/post/technical-skills-required-in-oil-and-gas-industry>
<https://www.ifptraining.com/e-031-exploration-production-overview.html>
<https://flevy.com/blog/oil-gas-industry-value-chain-deep-dive/>

Key Skills in the O&G Value Chain

Value Chain Stage ⁹⁰	Key Technical Skills (HEI)	Key Technical Skills (TVET)	Key Operational & Managerial Skills	Key Support Skills
Refining/ Downstream	Chemical/Process Eng., Mechanical Eng., Electrical Eng.	Refinery operators, laboratory technicians, maintenance technicians	Refinery management, operations management, supply chain management (feedstock/product)	HSE management, quality control, logistics (product distribution), IT
Decommissioning	Environmental Eng., Civil/Structural Eng., Mechanical Eng., Project Management (Specialised), Marine Biology (Offshore)	Specialised well P&A crew, demolition/cutting specialists, hazardous waste handling technicians, heavy lift operators (riggers), divers (offshore), site remediation technicians	Decommissioning project management, waste management planning, contract management (demolition/waste), regulatory compliance management	HSE management (demolition/remediation specific), environmental monitoring (post-closure), legal (liability, regulations), community relations

4.4.1 Current Skills Supply from Namibian Institutions

An examination of Namibia's current offerings from its key HEIs and TVET institutions reveals a landscape with existing strengths in foundational areas but significant specialisation gaps in the O&G industry.

4.4.1.1 Higher Education Institutions' Offerings Relevant to Oil & Gas

Table 8: Higher Education Institutions' Offerings Relevant to Oil and Gas

Higher Education Institutions' Offerings Relevant to Oil and Gas⁹¹

Institution	Program Area	Specific Degree/Qualification Examples	NQF Level(s)	Potential O&G Relevance
UNAM	Geosciences	BSc Geology (Hons)	8	Exploration, Appraisal, Development, Production (Foundation)
UNAM	Environmental Science	BSc Environmental Biology (Hons), BSc Geo-Information Science - Geography & Environmental Studies (Hons), BSc Geo-Information Science - Environmental Biology (Hons)	8	Environmental Management, EIA, Permitting, Decommissioning (Foundation)

Footnotes

⁹¹ <https://unam-na.libguides.com/c.php?g=1074922&p=7828986>
<https://www.bachelorsportal.com/studies/195711/geology.html>
<https://llm-guide.com/schools/africa/namibia/university-of-namibia-faculty-of-law>
<https://www.nust.na/undergraduate-programmes>
<https://www.nust.na/programmes>
<https://ium.edu.na/master-of-science-in-transport-and-logistics/>
<http://www.nche.org.na/quality-assurance/institutions>
<https://namqa.org/wp-content/uploads/2024/07/Namibian-accredited-Institutions-as-at-27-June-2024-1.pdf>
<http://www.ecn.org.na/ecn/accredited-bodies/>

Higher Education Institutions' Offerings Relevant to Oil and Gas

Institution	Program Area	Specific Degree/Qualification Examples	NQF Level(s)	Potential O&G Relevance
UNAM	Engineering	BSc Mechanical Engineering (Hons)	8	Development, Production, Midstream, Downstream, Decommissioning (Foundation)
UNAM	Law	LLB (Hons)	8	Legal Support, Contracts, Regulation (General - requires specialization)
UNAM	Economics/ Management	B.Econ (Hons), B.Com (Accounting, etc.)	7, 8	Financial Analysis, Accounting, Business Support
UNAM	Engineering	BSc Civil Engineering (Hons), BSc Electrical Engineering (Hons), BSc Metallurgical Engineering (Hons), BSc Mining Engineering (Hons).	8	Development, Production, Midstream, Downstream, Decommissioning (Strong Foundation)
UNAM	Engineering	MSc Mechanical Engineering, MSc Civil Engineering, MSc Electrical Engineering, MSc Metallurgical Engineering, MSc Manufacturing Engineering (specialisation in Welding).	9	Development, Production, Midstream, Downstream, Decommissioning (Strong Foundation)
NUST	Engineering (Mechanical)	B.Eng Mechanical Engineering, B.Tech Mechanical Engineering	7, 8	Development, Production, Midstream, Downstream, Decommissioning (Strong Foundation)
NUST	Engineering (Electrical)	B.Eng Electrical Power Engineering, B.Eng Electronics & Telecommunication Engineering, B.Tech Power Engineering, B.Tech Electronic Engineering	7, 8	Development, Production, Midstream, Downstream, Decommissioning (Strong Foundation)
NUST	Engineering (Civil)	B.Eng Civil Engineering, B.Tech Civil Engineering	7, 8	Infrastructure Development (Onshore/ Offshore), Pipelines, Decommissioning (Foundation)
NUST	Engineering (Chemical)	B.Eng Chemical Engineering	8	Processing, Refining, Production Support, Environmental Management (Foundation)
NUST	Engineering (Mining/ Metallurgy)	B.Eng Mining Engineering, B.Eng Metallurgy, M.Eng Mining, M.Eng Metallurgy	8, 9	Potential overlap in materials science, extraction principles (Mining less direct)
NUST	Engineering (Postgraduate)	M.Eng (Civil, Mining, Metallurgy), Master of Environmental Engineering, Master of Sustainable Energy Systems, MSc Integrated Water Resource Management, MSc Natural & Applied Sciences (Green Hydrogen focus)	9	Specialization in Environment, Energy Systems, Water Management; Research capacity
NUST	Geosciences (Spatial)	Diploma Geomatics, B.Geomatics, B.Geoinformation Technology, B.Geomatics (Hons), B.Geoinformation Technology (Hons), Master of Geoinformation Science & Earth Observation	6, 7, 8, 9	Surveying, Mapping, GIS, Site Selection, Pipeline Routing
NUST	Environmental Health	BSc Environmental Health Sciences	8	Occupational Health, Community Health, Environmental Monitoring
NUST	Logistics & Supply Chain Mgmt	B.Logistics & Supply Chain Management, B.Logistics & SCM (Hons), Master of Logistics & SCM	7, 8, 9	Procurement, Materials Management, Transport Logistics (Personnel & Equipment), Distribution
NUST	Management/ Business	B.Business Management, B.Accounting (Hons), B.Marketing, B.HRM, etc.	7, 8	Business Support, Finance, HR, Administration
IUM	Logistics & Transport	Certificate in Transport & Logistics Management, Bachelor (various), Master of Science in Transport & Logistics Management	5, 7, 8, 9	Transport Management, Logistics Operations
IUM	ICT / Management	Various Certificates, Diplomas, Bachelors, Masters in ICT, Business Admin, Finance, etc.	5-9	IT Support, Business Support, Administration

4.4.1.2 Relevant TVET Trades/Courses in Namibia for Oil & Gas

A key consideration for the TVET sector is the distinction between the breadth of foundational trades offered and the specialised depth required by the O&G industry. While NIMT and VTCs produce graduates with qualifications in welding, electrical installation, or mechanical fitting, these standard curricula may not cover the specific codes, standards (e.g., API, ASME, IECEx), materials, and safety protocols (e.g., offshore survival, H2S awareness) mandated in the O&G sector, particularly for international operations. A Level 3 certificate in welding, for instance, does not automatically qualify a graduate for high-pressure pipeline welding or complex structural welding on an offshore platform without additional, industry-specific training and certification. This highlights a potential gap not just in the types of programs offered but also in the content and certification level of existing trades training relative to O&G industry requirements.

Table 9: Technical Vocational Institutions' Offerings Relevant to Oil and Gas

Technical Vocational Institutions' Offerings Relevant to Oil and Gas ⁹²				
Institution	Program Area	Specific Qualification Examples	NQF Level(s)	Potential O&G Relevance
NIMT	Fitting & Turning / Mechanical Fitting	Formal Apprenticeship (Levels 1-3 + Job Attachment)	1-3+	Maintenance & Installation of Mechanical Equipment (Pumps, Valves, etc.)
NIMT, VTCs	Boilermaking / Metal Fabrication	National Vocational Certificate (Levels 1-4), NIMT Apprenticeship (Levels 1-3+)	1-4+	Structural Steel Fabrication, Pressure Vessel Fabrication/Repair (Requires specific O&G codes/certs)
NIMT, VTCs	Welding	National Vocational Certificate (Levels 2-4), NIMT Apprenticeship (Levels 1-3+), NIMT Special Training	1-4+	Structural & Pipe Welding (Requires specific O&G codes/certs like API 1104, ASME IX)
NIMT, VTCs	Electrical (General)	National Vocational Certificate (Levels 2-5), NIMT Apprenticeship (Levels 1-3+)	1-5+	Electrical Installation & Maintenance (Requires specialized hazardous area training - CompEx - for many O&G environments)
NIMT	Instrumentation	Formal Apprenticeship (Levels 1-3 + Job Attachment)	1-3+	Installation, Calibration & Maintenance of Process Control Instruments (Crucial for operations)
NIMT, VTCs	Automotive Mechanics / Mechatronics	National Vocational Certificate (Levels 1-5), NIMT Apprenticeship (Levels 1-3+)	1-5+	Maintenance of Vehicles, Generators, Heavy Equipment
NIMT, VTCs	Airconditioning & Refrigeration	National Vocational Certificate (Levels 1-4), NIMT Apprenticeship (Levels 1-3+)	1-4+	HVAC systems maintenance (Accommodation modules, control rooms)
NIMT, VTCs	Plumbing & Pipefitting / Sheetmetal	National Vocational Certificate (Levels 1-4), NIMT Apprenticeship (Levels 1-3+), NIMT Special Training	1-4+	Utility Piping, Basic Pipefitting (High-pressure O&G pipefitting requires specialization)
NIMT, VTCs	Carpentry & Joinery	National Vocational Certificate (Levels 1-4), NIMT Apprenticeship (Levels 1-3+), NIMT Special Training	1-4+	Construction Support, Temporary Works, Accommodation Fit-out

Footnotes

⁹² <https://www.nimtnam.com/trades>

<https://www.nta.com.na/training-services/>

https://trainingproviders.nta.com.na/training_providers/

<http://www.nche.org.na/quality-assurance/institutions>

<https://namqa.org/wp-content/uploads/2024/07/Namibian-accredited-Institutions-as-at-27-June-2024-1.pdf>

Higher Education Institutions' Offerings Relevant to Oil and Gas

Institution	Program Area	Specific Degree/Qualification Examples	NQF Level(s)	Potential O&G Relevance
VTCs	Bricklaying & Plastering	National Vocational Certificate (Levels 1-4)	1-4	Onshore Construction
VTCs	Business Services (Office Admin)	National Vocational Certificate (Levels 1-4)	1-4	Administrative Support
VTCs	Information Communication Technology (ICT)	National Vocational Certificate (Levels 1-5, various specializations like Computing Fundamentals, System Support, Networking)	1-5	Basic IT Support, Network Assistance
VTCs (Nakayale)	Transport & Logistics (Freight Handling)	National Vocational Certificate (Levels 2-3)	2-3	Basic Logistics Operations Support
VTCs (Gobabis)	Water Care	National Vocational Certificate (Level 3)	3	Water treatment operations (relevant for camp facilities, potentially production water treatment)
NAMFI	Maritime Trades	Various vocational maritime qualifications Diploma in Marine Navigation (Fishing Vessel Operations) Diploma in Marine Engineering (Fishing Vessel Operations) Deck Officer Training/Nautical Studies (not accredited) Basic Safety and Familiarisation Training, Proficiency in Survival Craft (PISC), Advanced Firefighting, Medical First Aid and Medical Care (short courses)	5	Offshore Support Vessel Crewing, Maritime Safety
Private Providers	Occupational Health & Safety	Various Certificates/Diplomas (e.g., W.N. Occupational Health & Safety Academy)	Various	Site Safety Officers, HSE Support (Requires O&G context and potentially international certs like NEBOSH/IOSH)

4.4.1.3 Analysis of Skills Supply vs. Industry Demand

Mapping the identified educational offerings from Namibian HEIs and TVETs against the specific skill requirements of the O&G value chain reveals areas of foundational strength alongside critical deficiencies in specialised competencies. The overarching challenge is one of specialisation. Namibia's institutions can produce competent general engineers, geologists, lawyers, logisticians, and technicians. However, the O&G industry demands petroleum engineers, petroleum geologists, energy lawyers, O&G logisticians, and coded welders certified to rigorous international standards. Bridging this gap requires more than simply increasing enrolment in existing programs; it necessitates fundamental curriculum reform, developing or recruiting specialised Faculty, significant investment in industry-standard training equipment (like simulators and specialised labs), and establishing pathways to achieve internationally recognised certifications.

Compounding the specialisation gap is the experience gap. Namibia is a frontier O&G province lacking a large pool of experienced local professionals, particularly with offshore operational experience. Classroom learning and basic workshop practice, while necessary, are insufficient preparation for the complexities and hazards of the industry. This underscores the critical importance of practical exposure through well-structured Work-Integrated Learning (WIL), internships, graduate trainee programs, and potentially international secondments, as acknowledged by current initiatives sending Namibians abroad. However, securing sufficient high-quality, relevant practical placements presents a significant hurdle in the early stages of industry development⁹³.

The following table provides a systematic mapping of key O&G skills against the current supply from Namibian institutions, assessing the availability and potential limitations.

Table 10: Oil & Gas Value Chain and Skills Supplied in Namibia

Oil & Gas Value Chain and Skills Supplied in Namibia				
Key O&G Skill / Competency	Value Chain Stage(s)	Relevant HEI Program(s)	Relevant TVET Program(s)	Current Supply Status & Notes
Geology (Exploration & Production)	Exploration, Appraisal, Production	UNAM BSc Geology (Hons)	-	Available (Foundation): Core geology degree exists. Needs O&G specialization/modules (Petroleum Geology). UNAM Geology Dept has received some O&G software support
Geophysics (Interpretation)	Exploration, Appraisal	Limited/None (Possibly minor components in Geology/Geomatics)	-	Not Available: No dedicated Geophysics programs identified. Critical gap for exploration.
Reservoir Engineering	Appraisal, Development, Production	Limited/None (Potential minor overlap in NUST Chemical Eng?)	-	Not Available: No dedicated Reservoir or Petroleum Engineering degrees. Major gap for field development and production optimization.
Drilling Engineering	Appraisal, Development	Limited/None (Potential overlap in UNAM Mining Engineering Programme)	8	Not Available: No dedicated Drilling Engineering programs. Critical for well design and execution.
Production Engineering	Production	Limited/None (Potential overlap with NUST Mechanical/Chemical Eng)	-	Limited/Not Available: No dedicated Production Engineering program. Foundational engineering skills exist but lack specific focus on well performance, artificial lift, etc.
Petroleum Engineering (General)	Upstream (Multiple)	None Identified	-	Not Available: Absence of a comprehensive Petroleum Engineering degree covering reservoir, drilling, production is a major gap.

Footnotes

⁹³ <https://nbcnews.na/node/109477>

<https://thebrief.com.na/2025/02/20/petrofund-boosts-oil-gas-training-with-77-awarded-scholarships/>

<https://www.observer24.com.na/2025/02/20/petrofund-sbm-offshore-launch-graduate-programme/>

<https://worldoil.com/news/2025/4/24/namibia-s-oil-and-gas-success-hinges-on-smart-policy-partnerships-aec-says/>

Oil & Gas Value Chain and Skills Supplied in Namibia

Key O&G Skill / Competency	Value Chain Stage(s)	Relevant HEI Program(s)	Relevant TVET Program(s)	Current Supply Status & Notes
Chemical / Process Engineering	Development, Production, Midstream, Downstream	NUST B.Eng Chemical Engineering, NUST M.Eng Environmental Engineering	VTC Process Operators (basic), NIMT/VTC Instrumentation Techs	Available (Foundation): NUST B.Eng provides core principles. Needs O&G context (e.g., specific processing units, refining) and likely postgraduate specialization. TVET provides operator/technician level.
Mechanical Engineering	Development, Production, Midstream, Downstream, Decommissioning	NUST B.Eng/B.Tech Mechanical Eng., UNAM BSc Mechanical Eng. (Hons)	NIMT Fitting & Turning, VTC/ NIMT Automotive Mechanics	Available (Strong Foundation): Good availability of general mechanical engineering degrees and related trades. Specialization (e.g., rotating equipment, pipeline integrity, subsea) may be needed.
Electrical Engineering	Development, Production, Midstream, Downstream, Decommissioning	NUST B.Eng/B.Tech Electrical (Power, Electronics & Telecom), UNAM BSc Electrical Engineering	NIMT/VTC Electrical General, NIMT Millwright (Electrical)	Available (Strong Foundation): Good availability of general electrical engineering degrees and trades. Specialization needed (e.g., high voltage, hazardous areas - CompEx, control systems).
Civil / Structural Engineering	Development, Midstream, Decommissioning	NUST B.Eng/B.Tech Civil Eng, UNAM BSc Civil Engineering	VTC Bricklaying/ Plastering, NIMT/ VTC Carpentry	Available (Foundation): General civil engineering degrees and construction trades available. Needs specialization for offshore structures, pipeline construction, decommissioning.
Instrumentation & Control	Development, Production, Processing	NUST Electrical Eng. (Control Systems aspects), UNAM BSc Electrical and Electronics Engineering	NIMT Instrumentation, VTC Electrical (Electronics)	Available (Technician Level Strong): NIMT provides dedicated Instrumentation training. HEI coverage within Electrical Eng. Needs O&G specific systems knowledge.
Welding (O&G Standards)	Development, Midstream, Decommissioning	UNAM MSc Manufacturing Engineering (Specialisation in Welding).	NIMT/VTC Welding (Levels 1-4)	Partially Available: Foundational welding skills taught. Critical gaps in training/certification to specific O&G codes (API 1104, ASME IX, offshore structural) likely exist.
Pipefitting (High Pressure)	Development, Midstream	-	NIMT/VTC Plumbing & Pipefitting	Partially Available: Basic plumbing/ pipefitting taught. High-pressure O&G pipefitting requires specialized skills and likely certification, representing a gap.
Offshore Operations (e.g., FPSO)	Production	Limited/None (NUST Marine Eng. B.Tech exists but focus unclear)	NAMFI (Maritime Trades)	Limited/Not Available: Highly specialized area. NAMFI provides maritime basics. Need for specialized FPSO/offshore platform operations training noted
Subsea Engineering	Development, Production, Decommissioning	None Identified	Diving (potentially NAMFI or private)	Not Available: Major gap for offshore development, particularly deepwater.
HSE Management (O&G Specific)	All Stages	NUST BSc Environmental Health Sciences, UNAM Environmental Science programs	TVET HSE Officer (basic), Private providers (e.g., W.N. Occ. Health & Safety Acad.)	Partially Available: Foundational environmental/health degrees exist. Need for O&G-specific HSE management systems, risk assessment, and international certifications (NEBOSH, IOSH, BOSIET) is a likely gap.
Environmental Science (O&G Focus)	All Stages	UNAM Environmental Biology/GIS, NUST Environmental Health/ Eng.	-	Available (Foundation): Relevant degrees exist. Need specialization in O&G impacts (EIAs for drilling/ production/pipelines, oil spill response, decommissioning remediation).

Oil & Gas Value Chain and Skills Supplied in Namibia

Key O&G Skill / Competency	Value Chain Stage(s)	Relevant HEI Program(s)	Relevant TVET Program(s)	Current Supply Status & Notes
Logistics & Supply Chain Management	All Stages	NUST B.Logistics & SCM (Hons), Master IUM Cert/Bachelor/ Master Transport & Logistics	VTC Transport & Logistics (Freight Handling)	Available (Strong Foundation): Good availability at HEI level. Needs O&G context (e.g., managing offshore logistics, complex project procurement, international supply chains).
Petroleum Law / Energy Law	All Stages	UNAM LLB (Hons)	-	Limited/Not Available: General law degree available. Critical lack of specialization in petroleum contracts (PSAs), energy regulation, maritime law relevant to offshore
Petroleum Economics / Finance	All Stages	UNAM/NUST Economics/Finance/ Accounting degrees	-	Available (Foundation): General economics/finance degrees exist. Need specialization in O&G project economics, fiscal regimes, investment analysis.
Project Management (O&G/ Decomm.)	Development, Decommissioning	Possible components within NUST Eng/ Business programs?	-	Limited/Not Available: General PM principles likely taught. Lack of specialized programs focusing on large O&G capital projects or complex decommissioning projects
Decommissioning Expertise	Decommissioning	Limited/None (Overlap with NUST Env. Eng?)	Specialized trades (cutting, waste handling) likely missing	Not Available: Significant gap across engineering, project management, environmental remediation, and specialized trades for end-of-life phase.

4.4.1.4 Summary of Identified Areas of Skills Supply Available

The mapping confirms that Namibia possesses a commendable base of human capital potential relevant to the O&G sector, primarily in foundational academic disciplines and core vocational trades.

Foundational HEI Skills:	Namibian universities, particularly NUST, provide a strong supply of graduates in essential engineering fields, including mechanical, electrical, civil, and chemical engineering. UNAM contributes significantly to geology, environmental sciences, mechanical, civil, welding and Mining Engineering, while NUST and IUM offer robust logistics and supply chain management programs. General degrees in Law (UNAM) and various business, management, finance, and accounting disciplines (UNAM, NUST, IUM) are also readily available, providing a pool of graduates for various support and administrative functions.
Core TVET Trades:	The TVET sector, through NIMT and the NTA VTC network, effectively supplies artisans in fundamental trades crucial for construction and maintenance. These include welding, fitting/turning, boiler making, electrical installation, mechanical maintenance (including diesel/automotive mechanics), plumbing, carpentry, and bricklaying. Additionally, skills in office administration and basic ICT support are widely available from VTCs.
Support Functions:	Basic Health, Safety, and Environment (HSE) awareness is often incorporated into TVET induction programs, such as at NIMT, providing a rudimentary understanding. General IT skills and administrative capabilities are produced by both HEIs and TVET institutions.

This existing capacity provides a valuable starting point. Graduates from these programs possess the fundamental knowledge and skills upon which industry-specific competencies can be built through further training, specialisation, and practical experience.

4.4.1.5 Summary of Critical Skills Gaps (Supply Not Available / Limited)

Despite the available foundational skills, the analysis reveals critical gaps in the specialised competencies required to fully operate and manage the O&G value chain, particularly in the technically demanding upstream and offshore segments, as well as the end-of-life decommissioning phase.

Exploration & Appraisal:	There is a distinct lack of specialised programs in geophysics, particularly seismic interpretation, which is fundamental for identifying potential drilling targets. While UNAM offers geology, advanced specialisations in petroleum geology are likely needed. Crucially, dedicated degree programs in reservoir engineering and modelling, essential for accurately assessing discoveries and planning optimal recovery, are absent. Specialised drilling engineering programs focused on deepwater environments and complex well designs are also not available locally.
Development & Production:	The most significant gap is the absence of dedicated bachelor's or master's degrees in petroleum engineering, encompassing the core disciplines of reservoir, drilling, completion, and production engineering. Expertise in subsea engineering, critical for Namibia's offshore fields, is not offered. Similarly, specialised knowledge for designing and operating complex offshore facilities like FPSOs or potential FLNG units is lacking, necessitating overseas training for initial capacity building. Advanced process control and optimisation skills beyond basic chemical engineering, specialised well completion and intervention techniques, and Asset Integrity Management programs are also missing from the local educational landscape.
Midstream:	While general mechanical and civil engineering programs exist, specialised pipeline engineering programs focusing on design, construction, and integrity management are not available. If Liquefied Natural Gas (LNG) becomes relevant, specialised LNG plant operations and engineering skills would also represent a gap. Existing logistics programs may need further specialisation for complex O&G maritime and international logistics management.
Downstream:	While NUST offers chemical Engineering, advanced specialisation in complex refining processes or specific petrochemical engineering fields might be required if Namibia pursues significant downstream value addition beyond basic fuel production.
Decommissioning:	This area represents a major gap across the board. There are no dedicated Decommissioning Engineering or Management programs. Specialised expertise in Well & Abandonment, Hazardous Waste Management specific to O&G (including NORM), Offshore Structure Removal Engineering, and Long-term Environmental Monitoring and Remediation Techniques are not covered in existing curricula.
Cross-cutting Technical Gaps:	A critical deficiency lies in the availability of TVET graduates certified to internationally recognised O&G standards. This includes specific welding procedure qualifications (e.g., 6G pipe welding to API/ASME codes), electrical certifications for hazardous environments (e.g., CompEx), offshore-specific safety training (e.g., BOSIET - Basic Offshore Safety Induction and Emergency Training, HUET - Helicopter Underwater Escape Training), and advanced Non-Destructive Testing (NDT) techniques. Furthermore, postgraduate research capacity specifically addressing Namibia's unique O&G context (e.g., geological challenges, environmental sensitivities) appears limited.
Cross-cutting Non-Technical Gaps:	While general law degrees exist, specialisation in Petroleum Law (including production sharing agreement negotiation), Energy Law, and Maritime Law (vital for offshore activities) is absent. Similarly, specialised programs in O&G economics, project finance, and advanced O&G-specific Contract and procurement management are not offered.

4.4.1.6 Current Skills Development Initiatives and Partnerships

There is clear recognition among key stakeholders in Namibia – including government bodies, educational institutions, and incoming industry players – of the urgent need to address the identified skills gaps to support the burgeoning O&G sector. A range of initiatives and partnerships are emerging, reflecting a collaborative approach to building local capacity.

Government & State-Owned Enterprise (SOE) Roles:

Proposed Oil and Gas Institute:	The Ministry of Industries, Mines and Energy has proposed the establishment of a dedicated Oil and Gas Institute in partnership with industry stakeholders. This initiative aims to centralise training efforts, equip Namibians with foundational and intermediate technical skills, address critical gaps identified in surveys, and support local entrepreneurs seeking to participate in the sector. ⁹⁴
Petroleum Training and Education Fund (Petrofund):	Petrofund is playing a proactive role in funding and facilitating skills development. Its activities include awarding a growing number of scholarships for both HEI and TVET studies (currently 77 beneficiaries, with 38 new awards in 2025), specifically targeting TVET programs at the NIMT campus in Keetmanshoop. Petrofund has also deployed 17 Namibians for specialised O&G training overseas (France, Malaysia, Angola), provided institutional support to UNAM's Geology Department with drilling software and infrastructure, and facilitated specialised O&G and offshore survival training for government officials. ⁹⁵
National Petroleum Corporation of Namibia (NAMCOR):	As the national oil company, NAMCOR is actively involved in all phases, emphasising knowledge and technology exchange with international partners. It has entered into partnerships, such as an MoU with Subsea7 to strengthen offshore energy development capabilities and a collaboration with Moneda Invest focused on skills development, knowledge sharing, and investment opportunities for local Micro, Small, and Medium Enterprises (MSMEs). ⁹⁶

Industry Partnerships:

Collaboration between industry and local entities is a growing feature of the skills development landscape:

Petrofund & SBM Offshore:	A significant MoU has been signed to launch a graduate trainee program. This partnership aims to provide young Namibian graduates with hands-on industry experience, exposure to advanced technologies, and skills specific to the offshore energy sector, aligning with local content objectives. ⁹⁷
Hyphen Hydrogen Energy & Hardap Regional Council:	While focused on Green Hydrogen, the MoU signed emphasises local skills development and capacity building, particularly at the TVET level, potentially creating transferable skills relevant to the broader energy sector. ⁹⁸
Operator Initiatives (e.g., Galp):	Companies like Galp are implementing nationalisation plans, employing Namibians (reportedly 25% of their local workforce, including female managers), training personnel abroad for specialised roles like FPSO operations, and collaborating with local entities like Namport on capacity building. ⁹⁹

Footnotes

⁹⁴ <https://miningandenergy.com.na/namibia-proposes-oil-and-gas-institute-to-bridge-sector-skill-gaps/>

⁹⁵ <https://thebrief.com.na/2025/02/petrofund-boosts-oil-gas-training-with-77-awarded-scholarships/>
<https://nbcnews.na/node/109477>

⁹⁶ <https://worldoil.com/news/2025/4/24/namibia-s-oil-and-gas-success-hinges-on-smart-policy-partnerships-aec-says/>

<https://www.aerweek.com/moneda-invest-supports-msme-skills-development-in-oil-gas-joins-aew-2024-as-partner/>

⁹⁷ <https://www.observer24.com.na/petrofund-sbm-offshore-launch-graduate-programme/>

⁹⁸ <https://namibiaoilandgas.com/2025/03/03/hyphen-signs-memorandum-of-understanding-for-local-skills-development-and-capacity-building/>

⁹⁹ <https://worldoil.com/news/2025/4/24/namibia-s-oil-and-gas-success-hinges-on-smart-policy-partnerships-aec-says/>

Financial & Service Sector Support (e.g., Moneda Invest, Workforce Staffing):	Financial institutions like Moneda Invest provide virtual training to MSMEs on O&G fundamentals and contracting strategies, alongside financial support ¹⁰⁰ . Organisations like Workforce Staffing Namibia are expanding their local talent databases, implementing on-the-job training, artisan and leadership development programs, facilitating skills transfer from expatriates, and supporting local informal vendors through ESG initiatives. ¹⁰¹
--	--

Higher Education and TVET Institutions' Involvement:

UNAM:	Benefitting from institutional support (Geology software from Petrofund)
NUST:	Actively engaged, with existing relevant postgraduate programs (Sustainable Energy Systems, Environmental Engineering) and plans to introduce optional O&G programs. However, it faces challenges regarding specialised faculty, equipment, and securing sufficient WIL placements. ¹⁰²
NIMT:	Positioned as a key TVET partner, receiving Petrofund scholarship students at its Keetmanshoop campus and identified as crucial for TVET-level skills needed for projects like Hyphen's.

While these initiatives demonstrate positive momentum and a commitment to local capacity building, many appear to be developing in reaction to the recent discoveries and identified needs. Establishing the proposed Oil and Gas Institute could signify a shift towards a more proactive, centralised, and strategically planned approach. A sustained, long-term national strategy that integrates efforts across government, industry, and the entire education system (HEI and TVET) will be essential. Short-term measures like scholarships and overseas training are valuable but insufficient on their own. Systemic changes – embedding specialised O&G content into local curricula, developing domestic faculty expertise, investing in industry-standard training facilities, and ensuring alignment with international certification requirements – are necessary to build a truly self-sufficient and competitive local workforce before peak industry activity levels are reached.¹⁰³

The prevalence of Memoranda of Understanding (MoUs) and partnerships highlights a crucial reality: bridging Namibia's O&G skills gap requires extensive collaboration. No single entity possesses all the necessary resources, expertise, and infrastructure. The government relies on industry for technical input, funding, and practical training opportunities. Industry requires supportive government policies and a pipeline of appropriately skilled local talent from educational institutions. Academia needs resources, research direction, and industry engagement from both government and private sector partners to ensure program relevance and provide essential practical experience for students. The success of Namibia's skills development efforts will therefore depend significantly on the effective coordination, shared commitment, and sustained investment of all these stakeholders working in concert.¹⁰⁴

Footnotes

¹⁰¹ <https://africanminingmarket.com/workforce-staffing-namibia-strengthens-operations-to-support-growth-in-oil-gas-energy-mining-and-construction-sectors/20403/>

¹⁰² <https://febe.nust.na/>

https://ptx-hub.org/wp-content/uploads/2023/08/International-PtX-Hub_202308_Namibia-PtX-skills-needs-assessment.pdf

<https://thebrief.com.na/2025/02/ptrofund-boosts-oil-gas-training-with-77-awarded-scholarships/>

¹⁰³ <https://miningandenergy.com.na/namibia-proposes-oil-and-gas-institute-to-bridge-sector-skill-gaps/>

¹⁰⁴ <https://worldoil.com/news/2025/4/24/namibia-s-oil-and-gas-success-hinges-on-smart-policy-partnerships-aec-says/>

<https://theextractormagazine.com/2025/04/23/namibia-is-ready-for-collaboration-technical-capability-and-strong-governance-in-oil-gas-sector/>

4.4.1.7 Specific O&G Recommendations

To effectively address the identified skills gaps and build a competent Namibian workforce for the O&G sector, the following actionable recommendations are proposed:

For Government (Ministries of Education, Energy, Labour, NTA, NQA, Petrofund):

National O&G Skills Strategy:	Develop and urgently implement a comprehensive, long-term National Oil and Gas Skills Development Strategy. This strategy must clearly define priority skills, integrate HEI and TVET pathways with clear articulation routes, set targets for local workforce participation, and establish robust monitoring and evaluation mechanisms.
Establish O&G Institute:	Expedite the establishment of the proposed national Oil and Gas Institute. Ensure it has strong industry governance, adequate funding, and a mandate to coordinate specialised training, curriculum development support, and potentially as a hub for international certification and research relevant to Namibia's context.
Upgrade TVET Capacity:	Invest significantly in upgrading infrastructure at NIMT and selected VTCs, including workshops, industry-standard equipment (e.g., welding booths for specific codes, process simulators, instrumentation labs), and safety training facilities (potentially including offshore survival elements). Mandate and fund the alignment of relevant TVET curricula and assessment practices with required international O&G standards (e.g., OPITO for safety/operations, API/ASME for trades, CompEx for electrical).
Enhance HEI Specialisation:	Provide targeted funding and incentives for UNAM and NUST to develop and launch specialised O&G programs and modules within existing faculties (e.g., petroleum engineering options/minors within mechanical/chemical engineering, petroleum geology tracks, Energy Law specialisations, decommissioning management modules). Support the recruitment and development of specialised faculty through international partnerships, industry secondments, and PhD funding.
Strengthen Quality Assurance:	Ensure NQA, NCHE, and NTA have the capacity and frameworks to effectively accredit and monitor the quality of new O&G-specific programs and certifications, ensuring they meet international benchmarks.
Expand Targeted Funding:	Increase and strategically focus scholarship and financial aid programs (like Petrofund) on the most critical skill gap areas identified in this report, including specialised engineering disciplines, geophysics, and internationally certified trades.
Skills Transfer Mechanisms:	Implement clear policies requiring skills transfer plans as a condition for work permits for expatriate experts, ensuring measurable outcomes and linking these plans to local training initiatives.

For Higher Education Institutions (UNAM, NUST, IUM):

Industry Collaboration for Curricula:	Proactively collaborate with industry operators, service companies, and the proposed O&G Institute to design and update curricula, ensuring relevance to sector needs. Develop specialised undergraduate tracks/minors and postgraduate programs (Masters/Diplomas) in areas like petroleum engineering, reservoir management, O&G law, environmental management, and decommissioning.
Integrate Industry Tools:	Incorporate industry-standard software (e.g., reservoir simulation, seismic interpretation, process modelling software), case studies from Namibian or analogous contexts, and guest lectures from industry professionals into teaching.
Focused Research:	Establish dedicated research groups or centres focusing on challenges and opportunities specific to Namibia's O&G sector (e.g., understanding Orange Basin geology, optimising production in local conditions, developing cost-effective decommissioning strategies, assessing environmental impacts).
Enhance Work-Integrated Learning (WIL) and National Youth Tax Incentive:	Strengthen partnerships with industry to secure sufficient, high-quality WIL placements, internships, and capstone project opportunities for students, addressing current challenges. Ensure these placements have clear learning objectives and supervision. A recent government-backed incentive, the National Internship Programme and Youth Tax Allowance, encourages employers to employ interns in lieu of paying lower corporate taxes.

For TVET Institutions (NIMT, NTA VTCs):

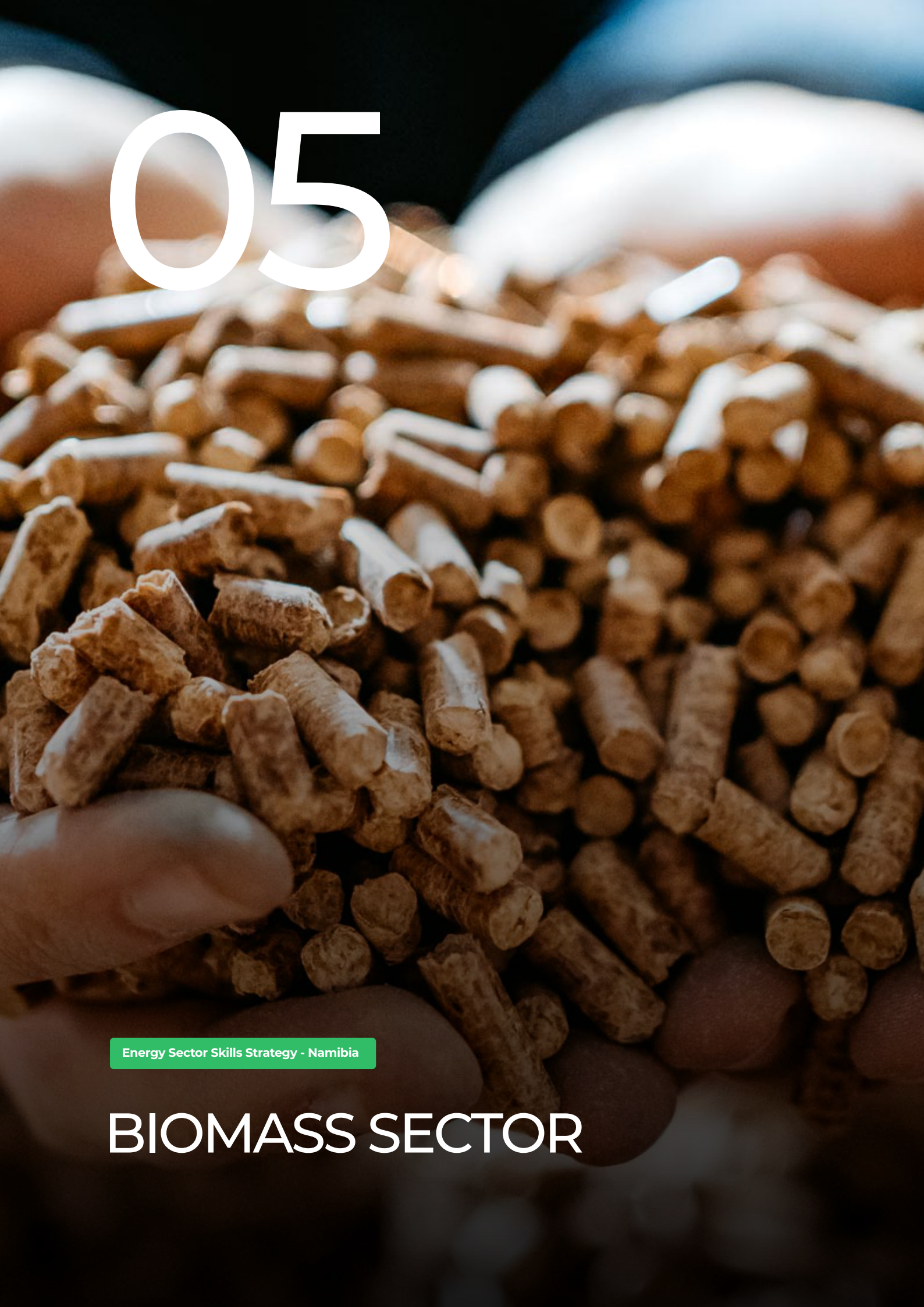
Develop Specialised Certifications:	Partner with industry and international certification bodies (e.g., OPITO, City & Guilds, AWS, CompEx boards) to develop and offer specialised, internationally recognised certifications for O&G trades (e.g., coded welding, offshore rigging, instrumentation for hazardous areas, process operations, BOSIET/HUET).
Invest in Specialised Equipment:	Seek funding (government, industry partnerships, NTF) to acquire specialised training equipment, including advanced welding simulators, process control training units, NDT equipment, and safety training mock-ups.
Create Articulation Pathways:	Work with NUST and UNAM to establish clear pathways for TVET graduates (e.g., Level 5 technicians) to gain advanced standing or entry into related HEI engineering or technology programs.

For Oil & Gas Industry Operators and Service Companies:

Active Curriculum Input:	Participate actively in curriculum advisory committees at HEIs and TVETs to ensure programs align with current and future industry needs.
Support Educational Institutions:	Provide substantial and sustained support (financial contributions, technical expertise for curriculum development/lecturing, donation of equipment, software licenses) to the proposed O&G Institute, NUST, UNAM, NIMT, and relevant VTCs.
Offer Quality Practical Training:	Create and offer a significant number of structured internships, apprenticeships, and graduate trainee positions with clear development plans, mentorship, and exposure to diverse operational aspects.

Invest in Local Suppliers:	Implement robust local supplier development programs that include skills upgrading components, helping Namibian businesses meet industry standards for quality and capacity.
Transparency:	Commit to transparently reporting on local content achievements, skills development investments, and workforce nationalisation progress.

Namibia possesses the potential to build a skilled and competitive local workforce for its emerging oil and gas sector. However, realising this potential requires immediate, strategic, and sustained investment in human capital development. Through coordinated action, strong partnerships, and a clear focus on developing specialised, internationally benchmarked skills, Namibia can ensure that its natural resource wealth translates into lasting prosperity and opportunity for its people.



05

Energy Sector Skills Strategy - Namibia

BIOMASS SECTOR

5. BIOMASS SECTOR

Namibia's biomass industry presents a compelling narrative of transforming a severe ecological crisis—widespread bush encroachment—into a diverse and burgeoning economic sector. Originating from the urgent need to restore vast tracts of degraded rangeland, the industry has evolved significantly from its early focus on charcoal production to encompass a sophisticated array of value chains, including thermal energy, large-scale electricity generation, animal feed, and innovative products like biochar. A substantial, renewable biomass resource is affected by an estimated 45 million hectares of land, which is affected by bush encroachment.¹⁰⁵

The Namibian biomass industry is fundamentally rooted in the nation's struggle against a pervasive environmental challenge: bush encroachment. This ecological issue, with its severe economic and social consequences, inadvertently laid the foundation for a sector that now turns this liability into a valuable resource. Bush encroachment in Namibia is characterised by the undesirable thickening and spread of indigenous woody plant species across savanna rangelands, fundamentally altering ecosystem structure and function. This phenomenon affects an estimated 45 million hectares, which constitutes over 60% of Namibia's savanna rangelands¹⁰⁶.

Other estimates place the affected area between 260,000 and 300,000 square kilometres, impacting 9 of the country's 14 regions. The sheer scale of this issue implies not only a significant ecological problem but also the existence of a vast, renewable biomass resource if managed sustainably. The total harvestable biomass from this encroached land is estimated at approximately 450 million metric tons, assuming an average yield of 10 tons per hectare. Furthermore, this resource exhibits considerable renewability, with encroacher bush regenerating naturally within 5 to 15 years and a conservative annual regrowth rate of 3%, adding an estimated 13.5 million tons of biomass each year¹⁰⁷.

The primary drivers of bush encroachment are multifaceted and often interlinked. Poor rangeland management practices, particularly overgrazing by livestock, which reduces grass cover and competition for woody seedlings, are considered a major factor.

The suppression of natural fire regimes, which historically controlled bush density, and the exclusion of browsing wildlife have also contributed significantly. Climate change acts as an accelerating factor, with increased atmospheric carbon dioxide levels favouring the growth of woody vegetation over grasses¹⁰⁸.

The future growth potential of Namibia's biomass industry is considerable. The available biomass from annual regrowth far exceeds current utilisation rates, offering extensive opportunities for expansion and diversification. Innovations in processing technologies, the development of strategic infrastructure by both public and private players such as the planned Biomass Industrial Park, and the increasing global demand for sustainable products and carbon sequestration solutions further bolster this potential.

The exploration of the contribution of 'green industrialized economy' and of the potential of the biomass sector to creating new jobs as part of economic diversification and exploring potential sources of "new growth", beyond mining and prioritizing labour-intensive sectors. The biomass sector presents an opportunity for diversifying the renewable energy mix, integrating waste management, forestry and other sectors, enhancing the agri-systems value chain. Namibia has through the 2019 Strategic Action Plan for Sustainable Bush Value Chains in Namibia identified potential fifteen viable bush-processing value chains to be explored and scaled.

Footnotes

¹⁰⁵ <https://www.developmentaid.org/organizations/view/426924/n-big-namibia-biomass-industry>
<https://voiconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹⁰⁶ <https://voiconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>
https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia

¹⁰⁷ https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia

¹⁰⁸ <https://voiconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>
https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia
<https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>

However, realising this future is conditional upon addressing persistent challenges, including scaling up sustainable harvesting practices, securing long-term investment, overcoming logistical hurdles, and ensuring effective policy implementation. The industry's trajectory demonstrates a viable model for sustainable development, offering valuable lessons in resource management and climate resilience¹⁰⁹.

5.1 Dominant and Emerging Value Chains

The Namibian biomass industry has cultivated several key value chains, with charcoal being the most established and energy generation rapidly gaining prominence.

Alongside these, animal feed and biochar are emerging as significant contributors with unique benefits. There are four distinct sub-industries in biomass, namely charcoal, energy, biochar and animal feed. These are going to be explored in depth, reviewing each industry value chain.

5.1.1 Charcoal Production and Export

The charcoal sector remains the most developed component of Namibia's biomass industry, producing over 200,000 tons annually. It is a major export commodity, with primary markets in Europe (which received approximately 100,000 tons in 2020) and South Africa (around 80,000 tons in 2020). Namibia holds a notable position as the fifth-largest international supplier of charcoal¹¹⁰.

Economically, the charcoal value chain is a significant contributor. Between 2009 and 2020, it generated over NAD 4.1 billion (approximately EUR 280 million) in foreign exchange earnings. Employment in this sub-sector is substantial, having grown from around 6,000 workers in 2016/17 to between 10,000 and 11,000 workers in more recent years¹¹¹.

A critical aspect of the Namibian charcoal industry's success and market acceptance is its increasing focus on sustainability. The adoption of Forest Stewardship Council (FSC) certification has become widespread, with certified production areas tripling in the three years leading up to 2020. FSC certification ensures that charcoal is produced according to stringent environmental and social labour standards, which is often a prerequisite for accessing premium European markets and enhances Namibian charcoal's overall credibility. Companies like UNIFOODS Charcoal are taking sustainability further by integrating advanced frameworks such as Natural Capital Accounting (NCA) to evaluate and manage the interplay between their business activities and ecosystem health. This proactive adoption of rigorous sustainability standards signals a mature understanding of international market demands and a commitment to responsible practices, potentially setting new benchmarks for the industry¹¹².

Key players in the charcoal sector include a multitude of local producers, many of whom are small and medium-sized enterprises (SMEs) and individual farmers operating in rural areas. Export market leaders such as Jumbo Charcoal and Namchar play a crucial role in connecting these producers to international markets. Industry bodies like the Charcoal Association of Namibia (CAoN), also referred to as the Namibia Charcoal Association (NCA), are instrumental in advocating for best practices, providing training, and facilitating market access¹¹³.

Footnotes

¹⁰⁹ <https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹¹⁰ https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia

<https://chrisoncc.com/pages/charcoal-business-in-namibia-a-guide-to-growth-challenges-and-sustainability>
<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹¹¹ <https://www.n-big.org/unlocking-namibias-biomass-potential-for-sustainable-growth/>

<https://www.developmentaid.org/organizations/view/426924/n-big-namibia-biomass-industry>
<https://chrisoncc.com/pages/charcoal-business-in-namibia-a-guide-to-growth-challenges-and-sustainability>

¹¹² <https://chrisoncc.com/pages/charcoal-business-in-namibia-a-guide-to-growth-challenges-and-sustainability>
<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

<https://www.n-big.org/unlocking-namibias-biomass-potential-for-sustainable-growth/>
<https://unu.edu/flores/blog-post/how-unifoods-charcoal-namibia-turns-invasive-bush-species-wealth>

¹¹³ <https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>
<https://chrisoncc.com/pages/charcoal-business-in-namibia-a-guide-to-growth-challenges-and-sustainability>

5.1.2 Biomass for Energy: Thermal and Power Generation

The use of encroacher bush for energy generation is a rapidly expanding frontier for the Namibian biomass industry, encompassing both thermal energy for industrial processes and electricity generation for the national grid.

Thermal Energy:

Several Namibian industries have successfully transitioned to using encroacher bush wood chips for their thermal energy needs, thereby substituting imported fossil fuels with a locally sourced, renewable alternative¹¹⁴.

- Ohorongo Cement, located near Otavi, is a prime example of utilising encroacher bush wood chips to cover almost all its thermal energy requirements. This creates a significant local market for approximately 80,000 tonnes of wood chips per annum, valued at around N\$65 million annually¹¹⁵.
- Namibia Breweries has also adopted biomass, with a dedicated boiler at its Windhoek plant converting roughly 7,500 tonnes of encroacher bush wood chips each year into thermal energy for its operations. These pioneering industrial applications have demonstrated the technical viability and economic benefits of using biomass for thermal energy, likely de-risking and building confidence for larger-scale power generation projects¹¹⁶.

Power Generation:

The conversion of biomass into electricity is recognised as a strategic imperative for Namibia to enhance its energy security and utilise its abundant bush resource. Initial studies confirmed the technical feasibility and economic viability of biomass-fuelled power plants up to a 20 MW scale. Theoretically, Namibia's existing encroaching bush resource could support 1,400 MW of power generation for 30 years, or more realistically, 200 MW over 220 years, not accounting for regrowth¹¹⁷.

The flagship project in this domain is the Otjikoto Biomass Power Station (OBPS), currently under development by NamPower, the national electricity utility¹¹⁸.

- **Capacity and Location:** The plant will have a 40 MW capacity and is situated near Tsumeb in the Oshikoto Region¹¹⁹.
- **Feedstock:** It is designed to use wood chips derived from encroacher bush, requiring an estimated 205,000 to 245,000 tonnes per annum. This will necessitate harvesting an area of approximately 16,200 hectares annually¹²⁰.
- **Investment and Funding:** The project's development cost is estimated at over N\$2 billion (approximately US\$152 million). Funding has been secured from a consortium of sources, including a significant loan from the French Development Agency (AFD), grants from the Mitigation Action Facility and the French Fund for Global Environment, and contributions from the Namibian Government¹²¹.

Footnotes

¹¹⁴ https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia

¹¹⁵ https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia
<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹¹⁶ https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia
<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹¹⁷ https://energypedia.info/wiki/Solid_Biomass_Energy_in_Namibia

¹¹⁸ <https://www.observer24.com.na/nampower-set-to-launch-n2-billion-biomass-power-plant/>

¹¹⁹ https://en.wikipedia.org/wiki/Otjikoto_Biomass_Power_Station

¹²⁰ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf
<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹²¹ <https://www.observer24.com.na/nampower-set-to-launch-n2-billion-biomass-power-plant/>
https://en.wikipedia.org/wiki/Otjikoto_Biomass_Power_Station

- **Timeline:** Construction officially commenced in 2024, with a ground-breaking ceremony held in November 2024. Commercial commissioning is anticipated in the first quarter of 2027¹²².
- **Economic and Strategic Impact:** The OBPS is projected to yield substantial economic benefits, estimated at around N\$21 billion over its lifetime, stemming from commercial activity along the fuel supply chain and improved ecosystem services such as increased groundwater recharge and enhanced agricultural productivity in harvested areas. NamPower is expected to inject N\$200-245 million annually into the Oshikoto region through the procurement of woodchips from local farmers and contractors. Strategically, the plant will provide much-needed baseload power, enhance Namibia's energy security by reducing dependence on imported electricity, support the objectives of the sixth National Development Plan (NDP6), and contribute to the country's ambition of becoming a net energy exporter by 2030¹²³.
- **Environmental Considerations:** An environmental impact assessment (EIA) and environmental management plan (EMP) conforming to International Finance Corporation (IFC) standards have been completed. A greenhouse gas (GHG) assessment indicated that the project has the potential to offset approximately 0.308 million tonnes of CO2 equivalent per year¹²⁴.
- **Key Partners:** Several joint ventures and organisations are involved as suppliers and partners, including Nexus Civils and Africa Biomass Company, Sactos Investment and Forestry Plant and Equipment Sales, and the Namibia Biomass Industry Group (N-BiG) in partnership with Ultra Special Supermarket and the Namibia Nature Foundation for ecological and social support measures¹²⁵.

The Otjikoto Power Station represents a major strategic pivot for the biomass industry, elevating it from primarily an export-oriented commodity sector (charcoal) to a critical component of national energy infrastructure. This project will create substantial, consistent local demand for wood chips, which is expected to stabilise and formalise the harvesting sector, providing significant opportunities for SMEs and local communities in the feedstock supply chain.

5.1.3 Animal Feed from Bush (Boskos)

The production of animal feed from encroacher bush, locally known as "Boskos," is another important value chain, particularly for enhancing agricultural resilience in Namibia's arid environment. Milled fibre from various encroacher bush species is mixed with molasses and other supplements to create a nutritious fodder, which is especially valuable during droughts when conventional grazing is scarce.¹²⁶

A key advantage of Bosko's production is its accessibility. It can be manufactured with relatively low capital outlay using simple tools like axes and hammer mills, making it feasible for small-scale farmers. Larger commercial operations also exist, employing wood chippers and pelting machines for more efficient production.

Footnotes

¹²² <https://www.observer24.com.na/nampower-set-to-launch-n2-billion-biomass-power-plant/>

https://en.wikipedia.org/wiki/Otjikoto_Biomass_Power_Station

¹²³ <https://www.observer24.com.na/nampower-set-to-launch-n2-billion-biomass-power-plant/>

https://en.wikipedia.org/wiki/Otjikoto_Biomass_Power_Station

¹²⁴ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

¹²⁵ <https://www.observer24.com.na/nampower-set-to-launch-n2-billion-biomass-power-plant/>

https://en.wikipedia.org/wiki/Otjikoto_Biomass_Power_Station

¹²⁶ <https://www.marketwatch.com.na/business/biomass-industry-going-from-strength-to-strength2025-04-16154170>

<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

This value chain directly addresses food security at the local level by providing an affordable and locally sourced feed alternative, reducing reliance on expensive imported feeds that may have to be transported over long distances (up to 800-900 km for some northern communal areas). The GIZ, in partnership with the Namibian government, has supported projects aimed at transforming invasive bush into nutrient-rich animal feed, empowering farmers and contributing to rural livelihoods. The low barrier to entry for basic Boskos production offers significant potential for decentralised, small-scale enterprise development, particularly benefiting unemployed individuals and smallholder farmers¹²⁷.

5.1.4 Biochar: Soil Enhancement and Carbon Sequestration

Biochar is an emerging and innovative product within Namibia's biomass sector, recognised for its multifaceted benefits, including soil improvement, carbon sequestration, and contributions to climate change adaptation. It is produced through the pyrolysis of encroacher bush material (often twigs and small branches) at high temperatures (typically above 500°C) in an oxygen-limited environment.¹²⁸

The applications and advantages of biochar are numerous:

Soil Amendment:	When added to soil, biochar can significantly improve its quality by enhancing water retention, increasing nutrient availability, promoting beneficial microbial activity, and moderating soil pH. This is particularly beneficial for Namibia's often nutrient-poor soils and irregular rainfall patterns, promoting sustainable agricultural practices and improving food security. It also offers an alternative to the intensive use of chemical fertilisers. ¹²⁹
Carbon Sequestration:	Biochar is a highly stable form of carbon that resists decomposition for hundreds to thousands of years, effectively sequestering carbon that would otherwise be released into the atmosphere through the natural decay of biomass. This makes biochar production a valuable climate change mitigation strategy. For example, the industrial biochar plant established by Atmosfair and PyroNam in the Otjozondjupa region, using FSC-certified encroacher bush, is designed to process approximately 2,900 tons of biomass into biochar annually, thereby permanently removing more than 2,000 tons of CO ₂ equivalent from the atmosphere each year. ¹³⁰
Animal Feed Additive:	Biochar can also be used as an additive in animal feed, and it has been reported to promote fodder digestion. ¹³¹

The quality of Namibian biochar is gaining recognition, with some products meeting standards such as the European Biochar Certificate (EBC) for feed char. Projects are also pursuing certification under schemes like the Carbon Standards International (CSI) to validate carbon removal claims.

Footnotes

¹²⁷ https://www.youtube.com/watch?v=8XGYdl_yh6k

<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹²⁸ <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>

<https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>

<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹²⁹ <https://www.coalitionforsoilhealth.org/soil-solutions/land-restoration-and-sustainable-agriculture-with-biochar-namibia>

<https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>

<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹³⁰ <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>

<https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

¹³¹ <https://voconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>

Key initiatives in this space include Sakeus Kafula's "Prime Biochar," focusing on soil health and restoration, and the aforementioned industrial-scale PyroNam facility. Biochar production also offers potential for job creation and skills transfer, particularly for youth and women in rural communities.¹³²

The development of biochar in Namibia appears to be following a dual track: high-tech, industrial-scale production targeting certified carbon removal and specialised markets, alongside smaller, potentially artisanal efforts focused on local agricultural needs. This unique combination of environmental restoration (through bush control), climate change mitigation (via carbon sequestration), and agricultural enhancement gives biochar a compelling multi-layered value proposition. Its carbon sequestration properties could also make a significant contribution to Namibia's Nationally Determined Contributions (NDCs) under the Paris Agreement.¹³³

5.2 Analysing Business Capability Implications for the Biomass Industry

5.2.1 Charcoal- Mapping the Value Chain: From Bush to Export



Figure 2: Charcoal Value Chain

A thorough understanding of the Namibian charcoal value chain, its constituent parts, key actors, economic significance, and prevailing market dynamics is essential for identifying business capability implications.

The Namibian charcoal value chain is a multi-stage process involving diverse actors and activities:

Footnotes

¹³² <https://www.coalitionforsoilhealth.org/soil-solutions/land-restoration-and-sustainable-agriculture-with-biochar-namibia>
<https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://voiconsulting.net/wp-content/uploads/2022/05/Encroacher-Bush-Biomass-in-Namibia-Detlof-von-Oertzen-2020.pdf>
<https://www.coalitionforsoilhealth.org/soil-solutions/land-restoration-and-sustainable-agriculture-with-biochar-namibia>

¹³³ https://unfccc.int/sites/default/files/resource/Namibia%27s%20BTR1_NC5%20Consolidated%20FINAL.pdf
<https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>

Input Supply & Harvesting:	The primary raw material for Namibian charcoal is invasive bush species, most notably <i>Acacia mellifera</i> , which encroaches upon extensive areas of rangeland. Harvesting is undertaken by a range of actors, including commercial farmers and, increasingly, small-scale and communal producers. Sustainable harvesting practices are critical, with growing adherence to standards such as those set by the Forest Stewardship Council (FSC) to ensure environmental integrity and market access. The Ministry of Environment, Forestry and Tourism (MEFT) provides regulatory oversight through permits and guidelines for harvesting operations. ¹³⁴
Production:	The carbonisation process, which converts wood into charcoal, predominantly utilises traditional kiln methods. However, there is an emerging trend towards the adoption of more efficient and environmentally friendlier technologies. Production often occurs on farms, where the initial cooling and weathering of the charcoal also take place. ¹³⁵
Processing & Quality Management:	Post-production, charcoal undergoes sorting and grading, although a significant portion is reportedly exported in an ungraded state, which can affect its market value. Further processing steps include sieving to remove fines and impurities, and additional weathering, often at centralised factory locations, to ensure stability and safety. Packaging is tailored for both local consumption and the specific requirements of export markets. ¹³⁶
Logistics & Transport:	The logistical chain involves the transportation of raw charcoal from farms to processing facilities and, subsequently, the movement of packaged charcoal to ports, primarily Walvis Bay, for export. This segment of the value chain is characterised by challenges related to infrastructure limitations and significant transport costs, which can erode Namibian charcoal's competitiveness in international markets. The cost of freight, in some instances, reportedly exceeds the product's actual price, posing a substantial economic hurdle. ¹³⁷
Marketing & Export:	Namibia exports charcoal to various international markets, with South Africa and several European nations (including Germany, the United Kingdom, the Netherlands, Poland, and Greece) being key destinations. Prominent export market leaders, such as Jumbo Charcoal, Namchar, and UNIFOODS Charcoal, play a significant role in connecting Namibian supply with global demand. However, the sector faces challenges related to branding, with Namibian charcoal often sold under international buyers' labels, and a perceived dominance of international buyers in price negotiations. ¹³⁸

The value chain involves a diverse set of stakeholders. These include primary producers (ranging from large commercial farms to small-scale communal operations), processors, and exporters. Industry associations, notably the Charcoal Association of Namibia (CAoN), play a crucial role in advocacy, standard-setting, and training. Government bodies, particularly the Ministry of Industrialisation and Trade (MIT) and MEFT, are involved in policy, regulation, and strategic development.

Footnotes

¹³⁴ <https://chrisoncc.com/pages/charcoal-business-in-namibia-a-guide-to-growth-challenges-and-sustainability>
<https://thebrief.com.na/2024/11/charcoal-industry-creates-over-14000-jobs-in-namibia/>
<https://neweralive.na/harsh-lives-of-undocumented-charcoal-workers/>
<https://fsc.org/en/newscentre/general-news/from-bush-to-charcoal-the-greenest-charcoal-comes-from-namibia>

¹³⁵ <https://charcoalpackaging.com/environmental-sustainability/>
<https://charcoal-transparency.org/produit.php?idProduit=433>
<https://caon.com.na/wp-content/uploads/2024/04/CAoN-Weathering-Guidelines-for-Namibia.pdf>

¹³⁶ <https://thebrief.com.na/2024/11/charcoal-industry-creates-over-14000-jobs-in-namibia/>
<https://charcoal-transparency.org/produit.php?idProduit=433>
https://unu.edu/sites/default/files/2025-02/Case%20Study%20Green%20Minimalist%20Company%20Case%20Study_UNU-FLORES.pdf

¹³⁷ <https://neweralive.na/charcoal-brand-identity-crucial-for-namibias-competitiveness/>
<https://thebrief.com.na/2024/11/charcoal-industry-creates-over-14000-jobs-in-namibia/>

¹³⁸ https://unu.edu/sites/default/files/2025-02/Case%20Study%20Green%20Minimalist%20Company%20Case%20Study_UNU-FLORES.pdf
<https://oec.world/en/profile/bilateral-product/wood-wood-articles-and-charcoal/reporter/nam>
<https://wits.worldbank.org/trade/comtrade/en/country/NAM/year/2023/tradeflow/Exports/partner/ALL/product/440200>

International development partners, such as the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), UNIDO and the Finish Government have also contributed through technical assistance and capacity-building initiatives.

The structure of the value chain, with relatively fragmented harvesting capacities comprising numerous small producers and a more consolidated production and marketing segment of processors and exporters, often leads to power imbalances. These imbalances can influence price negotiations, the stringency of quality control measures, and the equitable distribution of economic benefits derived from the charcoal trade. Small-scale producers, in particular, often face difficulties in accessing capital and are compelled to export ungraded charcoal, limiting their potential returns.¹³⁹

5.2.2 Business Capability Gaps and Skills Implications

This section outlines the current business capabilities and performance along the value chain, as well as the identified business capability gaps and skills for future diversification.

Table 11: Business Capability Gaps and Skills Implications- Charcoal Value Chain

Business Capability Gaps and Skills Implications - Charcoal Value Chain			
● 1. Current Business Capabilities & Performance along the Value Chain ¹⁴⁰			
Focus Area	Specific Aspect	Current Capabilities (Summary)	Performance Issues / Gap Description (Summary)
Input Supply & Harvesting	Sustainable Harvesting, Raw Material Management, & Input Supply	- Widespread availability of encroacher bush as raw material - Growing adoption of FSC certification among some producers - Basic harvesting skills prevalent - Training initiatives by GIZ and CAoN	- Variable adherence to comprehensive sustainable harvesting practices - Presence of undocumented labour creates challenges for ensuring ethical sourcing capabilities
Production	Production Technologies, Processing Efficiency, & Quality Management	- Traditional earth or metal kilns are dominant; limited adoption of more efficient retort technology - Basic processing (sieving, bagging) is common - Several larger companies have FSC and BSCI certifications - CAoN provides guidelines on charcoal weathering	- Inconsistent product quality; significant volume exported ungraded - Traditional kilns generally result in lower charcoal yields - Challenges in consistent application of weathering and grading standards - Lack of sufficient local processing facilities constrains value addition
Logistics and Marketing	Logistics & Export Infrastructure	- Established export channels to key international markets (e.g., Europe, South Africa) - Some larger, integrated companies manage their own export logistics effectively	- Sector competitiveness is significantly hampered by high freight costs - Inadequate domestic logistics infrastructure exacerbates costs and leads to inefficiencies
	Branding & Market Access	Access to key international markets	- Namibian charcoal often lacks a distinct national brand identity; frequently sold under international buyers' labels - Limited capacity to negotiate prices effectively

Footnotes

¹³⁹ <https://neweralive.na/charcoal-brand-identity-crucial-for-namibias-competitiveness/>
<https://thebrief.com.na/2024/11/charcoal-industry-creates-over-14000-jobs-in-namibia/>
¹³⁹ <https://thebrief.com.na/2024/11/charcoal-industry-creates-over-14000-jobs-in-namibia/>
<https://neweralive.na/harsh-lives-of-undocumented-charcoal-workers/>

Business Capability Gaps and Skills Implications - Charcoal Value Chain

Focus Area	Specific Aspect	Current Capabilities (Summary)	Performance Issues / Gap Description (Summary)
Cross-Cutting Functions	Regulatory Compliance	General awareness among producers of the need for MEFT harvesting permits	- Regulatory environment perceived by some as complex or outdated 500-tonne annual production threshold cited as a barrier to growth for smaller producers
	Financial Management & Entrepreneurship	Entrepreneurial activity is evident	- Access to finance remains a critical constraint, particularly for SMEs - Many small-scale producers face significant operational and financial hurdles
	Labor Management	Some businesses demonstrate compliance with labour laws and social security obligations	- Significant issues related to undocumented workers - Substandard labour conditions prevalent in parts of the sector; severe performance deficit in ethical labour management

2. Current Business Capabilities and Performance along the Value Chain¹⁴¹

Technological Capability Gaps	Adoption of Advanced Technology & Local Value Addition	- Marked gap in widespread adoption and proficient operation of advanced, cleaner production technologies (e.g., retort kilns), leading to lower efficiency, higher emissions, and missed quality/yield opportunities - Limited capacity for significant local value-added processing (briquetting, biochar)
Quality Management & Standardization Gaps	Consistent Quality & Certification	- Systemic inability to consistently produce, certify, and supply high-quality, well-graded charcoal across the sector - Results in lower prices or foreign entities performing value-adding functions - Lack of universal adherence to agreed quality standards
Market Development & Branding Gaps	Brand Strength & Market Negotiation	- Insufficient collective capacity to develop and promote strong, recognisable Namibian charcoal brands internationally - Limited ability to independently negotiate favourable terms and diversify export markets - High cost of establishing international distribution channels
Supply Chain Management & Logistics Gaps	Domestic Efficiency & Cost	- Inefficiencies within the domestic supply chain (transport from remote sites to processing/ports) - High overall logistics costs and inadequate infrastructure impact cost-competitiveness and reliability
Sustainable & Ethical Operations Gaps	Adherence to Environmental & Labor Standards	Critical gap in ensuring universal adherence to both environmentally sustainable harvesting practices and fair/ethical labour practices (formalisation, working conditions, labour law compliance).
Financial & Business Management Gaps (especially for SMEs)	Access to Finance & Management Skills	- SMEs often lack access to appropriate finance - Deficiencies in financial planning, business development skills, and general managerial acumen hinder growth, investment, and operational improvements
Regulatory Navigation & Advocacy Gaps	Understanding Regulations & Policy Influence	- Difficulty for many producers (especially small-scale) in navigating the complex regulatory landscape - Underdeveloped collective industry capability to advocate for a more streamlined and enabling policy environment (e.g., regarding the 500-tonne limit)

Footnotes

¹⁴¹ <https://charcoalpackaging.com/environmental-sustainability/>
<https://www.unido.org/sites/default/files/files/2020-02/Namibia.pdf>
<https://thebrief.com.na/2024/11/charcoal-industry-creates-over-14000-jobs-in-namibia/>
<https://newerative.na/charcoal-brand-identity-crucial-for-namibias-competitiveness/>
<https://caon.com.na/wp-content/uploads/2024/04/CAoN-Weathering-Guidelines-for-Namibia.pdf>

Business Capability Gaps and Skills Implications - Charcoal Value Chain

● 3. Skills Required¹⁴²

Identified Business Capability Gap	Implied Current Skills Shortage (Technical, Managerial, Soft, etc.)	Anticipated Future Skills Need (for competitiveness & diversification)	Potential Target Groups for Skills Development
Slow adoption of advanced/cleaner production technologies	Technical: Operation/maintenance of basic kilns	Technical: Retort/briquetting operation & maintenance, process optimization	Kiln Operators, SME Owners, Production Managers, Technicians
	Managerial: Limited investment appraisal for new tech.	Managerial: Technology assessment, project management for upgrades	
Inconsistent quality management and standardization	Technical: Variable grading/weathering skills.	Technical: Advanced QA/QC techniques, lab testing, certification procedures.	Producers (all scales), Quality Control Staff, Factory Supervisors.
	Managerial: Weak quality control system implementation.	Managerial: Implementing ISO/HACCP-like systems.	
Insufficient Namibian market development and branding	Managerial: Weak international marketing, branding, negotiation skills.	Managerial: Strategic brand management, digital marketing, export market research, international contract negotiation.	Export Managers, SME Owners, Marketing Professionals, CAoN staff.
	Soft skills: Limited cross-cultural communication for export.		
Inefficient supply chain and logistics	Managerial: Basic logistics coordination.	Managerial: Supply chain optimization, logistics software use.	Logistics Managers, Transporters, Processors.
	Analytical: Limited cost analysis of logistics.	Analytical: Transport economics, route planning.	
Non-universal adherence to sustainable and ethical operations	Technical: Inconsistent sustainable harvesting.	Technical: Advanced sustainable forestry management.	Harvesters, Farm Owners/Managers, HR Staff, All Employers.
	Managerial: Weak labor management, HR compliance	Managerial: Ethical sourcing, labor law expertise, social auditing.	
	Ethical: Low awareness of labor rights among some.	Ethical: Corporate social responsibility.	
Limited financial and business management (SMEs)	Managerial: Poor financial literacy, business planning.	Managerial: Advanced financial management, investment planning.	SME Owners, Emerging Entrepreneurs, Cooperative Leaders.
	Entrepreneurial: Difficulty accessing finance.	Entrepreneurial: Business model innovation, proposal writing.	

Footnotes

¹⁴² <https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>
https://unu.edu/sites/default/files/2025-02/Case%20Study%20Green%20Minimalist%20Company%20Case%20Study_UNU-FLORES.pdf
<https://unu.edu/flores/blog-post/how-unifoods-charcoal-namibia-turns-invasive-bush-species-wealth>
<https://caon.com.na/about/>
<https://www.giz.de/en/workingwithgiz/91230.html>

Business Capability Gaps and Skills Implications - Charcoal Value Chain

Identified Business Capability Gap	Implied Current Skills Shortage (Technical, Managerial, Soft, etc.)	Anticipated Future Skills Need (for competitiveness & diversification)	Potential Target Groups for Skills Development
Difficulty in regulatory navigation and advocacy	Managerial: Limited understanding of complex regulations.	Managerial: Regulatory compliance expertise.	Producers, CAoN leadership, Industry Representatives.
	Institutional: Weak collective advocacy on specific issues.	Institutional: Policy analysis, lobbying, stakeholder engagement.	
Nascent innovation and value addition	Technical: Basic charcoal production.	Technical: Biochar/activated carbon production, by-product utilization.	Researchers, Entrepreneurs, Technical staff in processing plants.
	Research & Development: Limited capacity for new product development.	Research & Development: Applied research skills, product innovation.	

5.2.3 Thermal and Power Generation- Biomass-to-Energy Value Chain

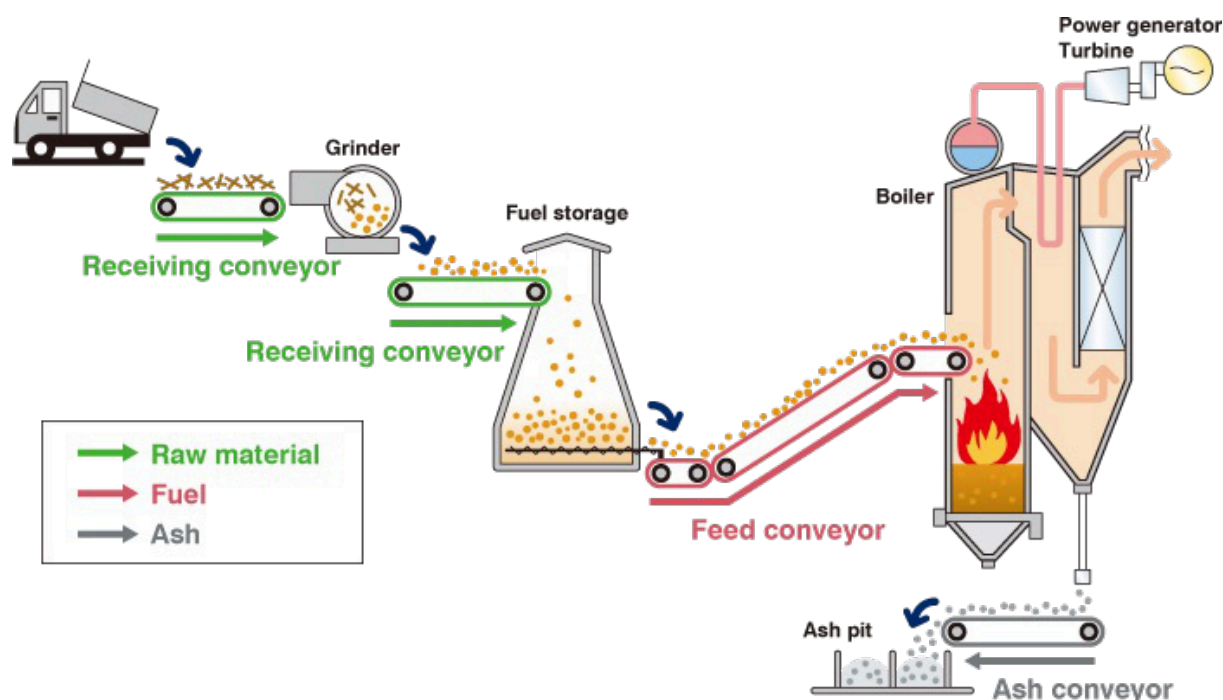


Figure 3: Power Generation Value Chain

The development of a viable biomass-to-power sector in Namibia, primarily utilising encroacher bush, involves a sequence of interconnected stages, from sustainable feedstock sourcing to electricity distribution. Although there are examples such as the Namibia Breweries Biomass Plant, the 40 MW Otjikoto Biomass Power Station (OBPS) project serves as a prominent and practical example for mapping this value chain.¹⁴³

5.2.3.1 Feedstock Sourcing and Sustainable Harvesting

The primary feedstock for Namibia's biomass energy ambitions is encroacher bush, an abundant resource resulting from land degradation. The sustainability of its harvesting is paramount for the long-term ecological and economic viability of the sector. The OBPS plans to utilise fully mechanised harvesting systems operated by contracted long-term fuel suppliers. A critical aspect of this operation is the adherence to Forest Stewardship Council (FSC) guidelines and regulations, ensuring responsible and sustainable land management practices. Organisations like the GIZ have also been active in promoting sustainable harvesting techniques and providing training to farmers and small businesses.¹⁴⁴

The integrity of the entire biomass value chain hinges on sustainable sourcing. Achieving FSC certification, as planned for OBPS feedstock and demonstrated by initiatives like the Cheetah Conservation Fund's (CCF) BUSHBLOK®, can significantly enhance market acceptance, ensure environmentally sound practices, and contribute to positive social outcomes.¹⁴⁵

5.2.3.2 Logistics and Transportation

This stage encompasses the movement of harvested biomass from the field to processing facilities or directly to the power plant. For the Otjikoto project, the contracted long-term fuel suppliers will be responsible for the transportation and delivery of biomass to the power station. The harvesting area for the OBPS is extensive, potentially extending beyond a 100 km radius from the plant.

Efficiently managing the logistics of large volumes of biomass presents inherent challenges. These include the condition of rural road infrastructure, the need for cost-effective transport solutions, particularly from remote harvesting sites, and the complexities of fleet management. The Namibia Biomass Industry Group (N-BiG) has also produced resources that touch upon transportation methods for biomass. Effective and efficient logistics are crucial for controlling operational costs and ensuring a consistent and reliable fuel supply to the power generation facility.¹⁴⁶

Footnotes

¹⁴³ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

¹⁴⁴ <https://mitigation-action.org/projects/namibia-biomass/>

https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

<https://www.giz.de/en/workingwithgiz/91230.html>

¹⁴⁵ <https://cheetah.org/wp-content/uploads/2021/10/BTDC-Fact-Sheet-2023.pdf>

¹⁴⁶ https://panorama.solutions/sites/default/files/n-big_harvesting_and_processing_encroacher_bush_booklet_2023_0.pdf

https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

5.2.3.3 Processing and Pre-treatment

Raw harvested bush must be processed and pre-treated to convert it into a fuel suitable for energy conversion technologies. The Otjikoto power plant will utilise wood chips as its primary fuel. These chips must meet specific quality standards, designated as P100 according to ISO 17225 for solid biofuels. NamPower also has provisions to process semi-processed biomass delivered by ad-hoc suppliers to meet the final required specifications.¹⁴⁷

Beyond wood chips for power generation, encroaching bush can be processed into a variety of other valuable products. These include charcoal (an established export product for Namibia), wood pellets, wood gas, animal feed, and soil-enhancing biochar. N-BiG actively promotes the development of these diverse product streams, and CCF's Biomass Technology Demonstration Centre (BTDC) is involved in research and demonstration of technologies for producing briquettes, charcoal, and energy through pyrolysis.¹⁴⁸

The processing stage is critical as it determines the quality of the fuel, which directly impacts combustion efficiency and emissions. Furthermore, diversifying the range of processed products enhances the overall economic viability and resilience of the biomass industry.

5.2.3.4 Energy Conversion Technologies

This stage involves the conversion of processed biomass into usable energy, primarily electricity, in the context of this report. The Otjikoto plant will have a 40 MW generation capacity. It will employ a grate-fired boiler technology where biomass wood chips are combusted to produce steam, which in turn drives a steam turbine connected to an electrical generator. The plant is expected to produce approximately 300,000 MWh of electricity annually.¹⁴⁹

While direct combustion for steam generation is the focus for OBPS, other energy conversion pathways for biomass exist. Wood gasification for electricity generation has been mentioned as being at an experimental stage in Namibia. Pyrolysis-based electrical generation is another area being explored, for instance, by the CCF's BTDC.¹⁵⁰

The choice of energy conversion technology significantly influences the overall efficiency of the power plant, its environmental performance (emissions), and its capital and operational costs. The OBPS will serve as a large-scale demonstration of biomass combustion technology in the Namibian context.¹⁵¹

Effective integration into the national grid is essential to realise the benefits of new generation capacity. The provision of baseload power from biomass can enhance overall grid stability and reliability, facilitating the integration of larger shares of variable renewable energy sources.

Footnotes

¹⁴⁷ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

¹⁴⁸ https://www.idos-research.de/uploads/media/Conference_Paper_Wageningen_Namibia_Bioenergy_MB_RH_final.pdf
<https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>
https://www.researchgate.net/publication/334382786_5_Bush-to-energy_Value_Chains_in_Namibia
<https://www.youtube.com/watch?v=epe3Plb12jo>

¹⁴⁹ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

¹⁵⁰ <https://cheetah.org/wp-content/uploads/2021/10/BTDC-Fact-Sheet-2023.pdf>
https://www.researchgate.net/publication/334382786_5_Bush-to-energy_Value_Chains_in_Namibia

¹⁵¹ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

The Otjikoto project stands as a central catalyst and a critical testbed for Namibia's ambitions in the biomass-to-power sector. As a large-scale initiative backed by the state utility (NamPower), with significant government support and international funding and technical assistance, it is positioned to be a "proof of concept" for biomass energy in the country. The project encompasses nearly all stages of the encroacher bush-to-electricity value chain, from establishing fuel sourcing agreements to power generation and grid feed-in. Consequently, the capabilities developed, challenges encountered, and gaps identified within the OBPS framework will offer highly indicative lessons for the broader Namibian biomass sector. Its success, or the lessons learned from its implementation, will profoundly influence future private sector investment and the development of IPP models for biomass energy.¹⁵²

5.2.4 Business Capability Gaps and Skills Implications

These identified capability gaps have significant implications for the overall competitiveness of Namibia's biomass sector and its potential to contribute to economic diversification.

Table 12: Business Capability Gaps - Biomass Value Chain

Business Capability Gaps - Biomass Value Chain				
Value Chain Stage ¹⁵³	Key Business Capability Area	Current Status or Strength	Identified Gap	Potential Impact on Sector Development/Competitiveness
1. Feedstock Sourcing & Harvesting	Technological	- Emergence of mechanized harvesting (OBPS); - GIZ training on machines	- Access to/maintenance of advanced/appropriate machinery; - Scalability	Inefficient harvesting, higher costs, slow expansion of sustainable practices.
	Operational	- FSC standards planned for OBPS; - Some sustainable practice awareness	- Widespread adoption/monitoring of sustainable practices (FSC, aftercare); - Integration of SMEs.	Resource degradation, inconsistent supply, ecological damage, loss of certification.
2. Logistics & Transportation	Operational	- Existing charcoal logistics; - OBPS suppliers manage logistics	- Optimized routing for large volumes; - Cost-effective solutions for remote areas; - Infrastructure limits; - Specialized fleet.	High transport costs, unreliable supply, bottlenecks.
3. Processing & Pre-treatment	Technological	- Charcoal tech established; - OBPS chipping; - R&D on diverse products	- Access to/maintenance of diverse advanced processing tech (pelletizers, gasifiers); - Local manufacturing of equipment.	Limited value addition, reliance on imported tech, higher costs.
	Operational	Quality specs for OBPS (ISO 17225)	- Consistent quality control systems across suppliers; - Efficient operation of diverse processing units.	Inconsistent fuel quality impacting conversion, operational inefficiencies.

Footnotes

¹⁵² <https://energycapitalpower.com/nampower-40-mw-biomass-power-plant/>

<https://na.ambafrance.org/groundbreaking-ceremony-of-the-otjikoto-biomass-power-station-in-tsumeb>

<https://mitigation-action.org/projects/namibia-biomass/>

https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

¹⁵³ https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

<https://www.giz.de/en/workingwithgiz/91230.html>

https://panorama.solutions/sites/default/files/n-big_harvesting_and_processing_encroacher_bush_booklet_2023_0.pdf <https://www.hamburg.de/resource/blob/157068/46bcc585cd8b47811c931d93ae0352a0/d-giz-debushing-bush-harvesting-guidelines-2017-data.pdf>

Business Capability Gaps - Biomass Value Chain

4. Energy Conversion (Operations & Maintenance)	Technological & Operational	NamPower experience with other thermal plants	- Specific expertise in large-scale biomass plant operations and maintenance; - Managing fuel variability; Local specialized operations and maintenance services.	Lower plant efficiency/availability, higher operations and maintenance costs, reliance on expatriate expertise.
All Stages	Managerial	- N-BiG support; - MIT SME programs	- Biomass-specific project/supply chain management; - Entrepreneurial skills for new ventures; - Contract management.	- Poor project execution, inefficient supply chains, slow SME growth, missed opportunities. - General shortage of managers/professionals in Namibia
	Financial	- Government contribution to OBPS - General SME finance schemes	Access to appropriate/affordable finance for biomass SMEs (esp. capital equipment).	Under-capitalization of businesses, slow adoption of better technology, limited scaling.
	Research, Development & Innovation	University and industry collaborative initiatives (NUST BUSH); CCF BTDC; GIZ-NUST collaboration	- Dedicated biomass R&D at scale; - Strong industry-research linkage; - Tech adaptation/localization capacity.	Slow innovation, continued tech import dependency, missed opportunities for optimizing local resources.
Overarching	Institutional & Policy	- National Integrated Resource Plan, National Energy Policy, Renewable Energy Policy support Renewable Energy Modified Single Buyer model; - OBPS shows collaboration.	- Consistent, coordinated national strategy; - Streamlined IPP facilitation; - Long-term institutional support beyond projects.	- Policy uncertainty deterring investment, fragmented efforts, slow overall sector development. - Historical coordination issues noted.

The business capability gaps identified above directly translate into specific skills requirements and deficiencies within the Namibian workforce. A growing and diversifying biomass sector in Namibia will necessitate a workforce equipped with a range of technical, operational, managerial, and innovation-related competencies. These are highlighted below:

Table 13: Skills Implications- Biomass Value Chain

Skills Implications - Biomass Value Chain		
Main Skill Category ¹⁵³	Specific Skill Area	Detailed Skills & Requirements
Technical and Operational Skills	Harvesting Operations	• Skilled operators for mechanized harvesting equipment (chainsaws, mobile chippers, tractors, feller bunchers, forwarders). • Maintenance technicians for mechanized harvesting equipment. • Skills in sustainable harvesting techniques such as FSC standards, selective thinning methodologies, Planning for effective aftercare for rangeland health, Conducting basic resource assessments and inventories.
	Logistics and Transport	• Fleet management • Route optimization (potentially using GPS and logistics software) • Maintenance of transport vehicles (heavy-duty trucks).
	Processing Operations	• Operators and maintenance personnel for industrial chippers, pellet mills, dryers, gasification/pyrolysis units. • Quality control and testing of biomass products (moisture content, ash content, calorific value, particle size distribution for standards like P100 for OBPS fuel). • Understanding of relevant ISO standards for solid biofuels.
	Power Plant Operation and Maintenance (O&M)	• Highly specialized skills for operating and maintaining biomass-specific boilers, steam turbines, generators, fuel handling systems (conveyors, silos), and emission control technologies. • Skills in predictive maintenance techniques. • Troubleshooting complex electro-mechanical systems unique to biomass power plants. • Managing fuel quality variations.
	General Trades and Artisan (including technician) Skills	• Qualified electricians, mechanics, fitters, and welders with industrial experience. • Adaptation of skills to specific requirements of biomass processing and power generation equipment. • Upskilling related to biomass technologies and safety protocols (note: high demand for technicians, artisans, and construction workers noted in PtX sector study, many roles transferable with specific upskilling).
Managerial and Entrepreneurial Skills (cross functional occupations) it can be utilised at any stage of the project	Supply Chain Management	• Expertise in managing complex biomass supply chains (sourcing strategies, inventory management, quality assurance). • Effective supplier relationship management (essential for OBPS fuel supply model).

Footnotes

¹⁵⁴ <https://ptx-hub.org/publication/study-skills-needs-assessment-in-namibias-ptx-sector-2/>

https://www.nampower.com.na/public/docs/projects/otjikoto/BIO_PFS_Biomass%20Project%20Fact%20Sheet_22May24_v6.2.pdf

<https://www.giz.de/en/workingwithgiz/91230.html>

https://panorama.solutions/sites/default/files/n-big_harvesting_and_processing_encroacher_bush_booklet_2023_0.pdf

<https://mit.gov.na/industrial-development>

<https://impact.dorsch.com/projects/detail/assessment-on-impact-of-bush-encroachment> [https://www.deginvest.de/DEG-Documents-in-English/About-us/What-is-our-impact/Case-Study_Ohorongo-Cement-\(Pty\)-Ltd_EN_2016-02.pdf](https://www.deginvest.de/DEG-Documents-in-English/About-us/What-is-our-impact/Case-Study_Ohorongo-Cement-(Pty)-Ltd_EN_2016-02.pdf)

Skills Implications - Biomass Value Chain

Main Skill Category ¹⁵³	Specific Skill Area	Detailed Skills & Requirements
Technical and Operational Skills	Project Management	Skills in planning, executing, and monitoring biomass projects at various scales.
	Business Development and Entrepreneurship	- Identifying new market opportunities for diverse biomass products. - Developing sound business plans. - Marketing and sales skills. - Securing finance (sector-specific business development acumen for biomass needed, beyond general SME support).
	Financial Management	Competencies in costing, budgeting, financial analysis, and investment appraisal.
	Contract Management	Ability to negotiate, draft, and manage various contracts (fuel supply agreements, land use agreements, technology procurement contracts, PPAs).
	Sustainability Management	Skills in implementing, monitoring, and reporting on environmental and social sustainability standards (FSC requirements, EIA conditions, occupational health and safety regulations).
Research, Development, and Innovation (RD&I) Skills	Applied Research & Development	- Expertise in managing complex biomass supply chains (sourcing strategies, inventory management, quality assurance). - Effective supplier relationship management (essential for OBPS fuel supply model).
	Assessment and Analysis	- Expertise in conducting thorough EIAs, socio-economic impact assessments, and lifecycle analyses specific to biomass projects. - Skills in data analysis, modeling, and GIS for resource assessment, sustainable land management planning, and climate impact assessment of biomass utilization.
Soft Skills	General Soft Skills	- Problem-solving. - Critical thinking. - Effective communication (written and verbal). - Teamwork. - Adaptability. - Strong work ethic

5.2.5 Animal Feed (Boskos)- From Bush to Feed Value Chain

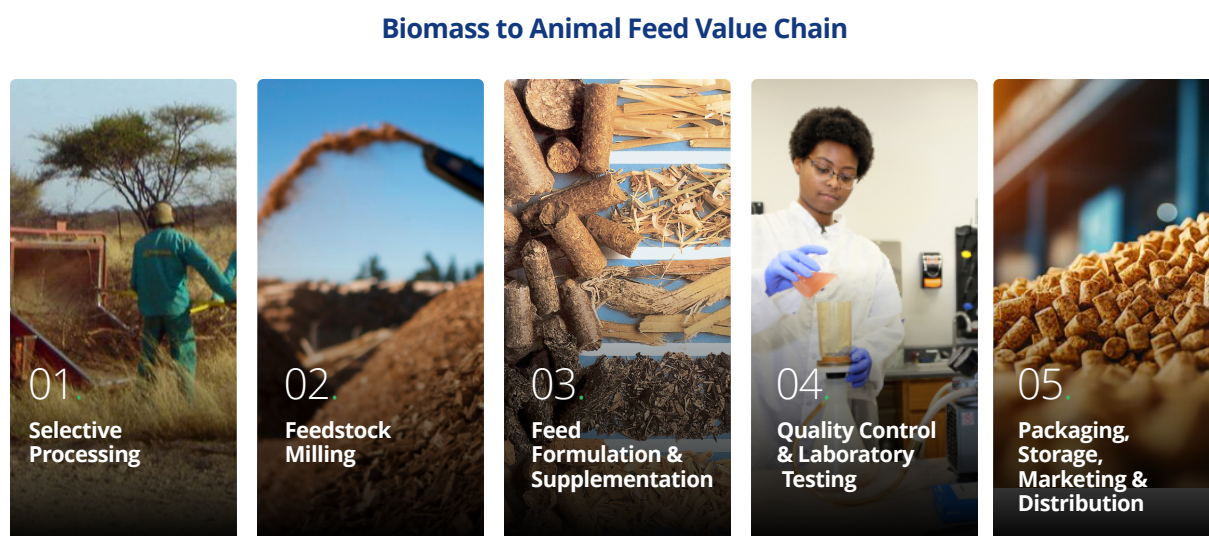


Figure 4: Biomass to Animal Feed Value Chain

The animal feed from the bush value chain in Namibia, while still developing, can be mapped across several key stages, each involving specific activities, technologies, and actors.

5.2.5.1 Sustainable Harvesting and Resource Management

The initial stage involves the felling and collection of encroaching bush. Harvesting methods range from manual techniques using hand tools, to semi-mechanical approaches employing equipment like the "Bosvreter" machine (a type of bush cutter), to more capital-intensive mechanical harvesters. The choice of method depends on factors such as the scale of operation, terrain, available capital, and desired efficiency. Cost, environmental impact (e.g. soil disturbance), and the need for subsequent aftercare to manage regrowth and promote rangeland recovery are critical considerations at this stage. Key actors involved in harvesting include individual farmers (both commercial and communal), community conservancies that may organise harvesting activities, and potentially specialised harvesting contractors, particularly for larger-scale operations.¹⁵⁵

5.2.5.2 Biomass Processing and Feed Formulation

Once harvested, the bush biomass undergoes primary processing to render it suitable for animal consumption. This typically involves chipping the branches using a wood chipper, followed by milling or grinding the chipped material into finer particles, often around 2mm in length, using a hammer mill. Specialised machinery, such as the "Bos-to-Kos" machine, has been developed and piloted in Namibia to integrate these steps – chipping, milling, and sometimes mixing – into a single operational unit.¹⁵⁶

Footnotes

¹⁵⁵ <http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>
<https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>
https://www.eld-initiative.org/fileadmin/pdf/ELD-CS_namibia_04_web_300dpi.pdf
https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf

¹⁵⁶ https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf
<http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>

The milled bush material forms the bulk of the animal feed, with proportions of up to 85% bush material and 15% supplements being reported as feasible, depending on the bush species and thickness. A variety of supplements are added to enhance palatability, nutritional value (particularly protein and energy, which can be low in raw bush), and digestibility. Commonly used supplements include molasses (for palatability and energy), urea (a non-protein nitrogen source for protein synthesis by ruminants), Polyethylene Glycol (PEG) (a tannin-binding agent to counteract anti-nutritional factors in some bush species), and sodium hydroxide (NaOH) (a chemical treatment to improve the digestibility of lignocellulosic material). Minerals and vitamins are also added to ensure a balanced diet. Additionally, natural supplements such as lucerne, maize meal, leguminous tree pods (e.g., from *Vachellia erioloba* or *Prosopis*), and agricultural by-products like bran or oil cakes are sometimes incorporated. Actors in this stage include the feed producers themselves (farmers, SMEs, community enterprises), suppliers of supplements and other inputs, and research institutions like the MAFWLR's Directorate of Agricultural Research and Development (DARD), the University of Namibia (UNAM), and the Namibia University of Science and Technology (NUST), which can provide guidance on feed formulation and testing.¹⁵⁷

5.2.5.3 Storage, Logistics, and Quality Control

Proper post-processing handling is crucial for maintaining feed quality and preventing spoilage. If chemical treatments like sodium hydroxide are used, the treated biomass must be adequately dried before mixing with other supplements to prevent spoilage and reduce chemical odours that livestock may find unpalatable. Both the milled bush material and the final mixed feed need to be dried to a moisture content of 12% or less and stored in cool, dry, well-ventilated conditions, often in bags, to prevent mould growth and infestation by insects and rodents. Pelleting the feed is a technique employed by some producers to improve its durability, ease of handling, storage life (pellets can reportedly be stored for up to 9 months), and potentially palatability and digestibility.¹⁵⁸

Logistics involve the on-farm transport of harvested material to processing sites and the movement of the finished feed to storage areas or points of use. The establishment of fodder banks, particularly in communal areas, is being explored and piloted as a means to ensure feed availability throughout the year, especially during drought periods. Quality control is a critical aspect, encompassing nutritional analysis to ensure the feed meets the dietary requirements of the target animals, consistency in formulation, and safety (e.g., avoiding over-supplementation, which can be harmful, and managing risks associated with chemical treatments like sodium hydroxide). Actors include producers, transporters, potential fodder bank operators, and quality testing laboratories such as those at MAFWLR's DARD or NUST's analytical centre.¹⁵⁹

5.2.5.4 Market Linkages and Distribution

Currently, the primary market for bush-based animal feed in Namibia is for on-farm consumption, serving as an emergency or supplementary feed source, particularly during the frequent and often severe droughts that affect the country. The local demand for such emergency feed is reported to be tremendously high, especially considering Namibia's significant annual expenditure on imported fodder.

Potential for market expansion is considerable. This includes sales to other farmers within both commercial and communal areas who may lack the capacity or resources to produce their own bush feed. There is also the broader commercial animal feed market, where locally produced bush-based feed could act as an import substitute, contributing to foreign exchange savings and enhancing national food and feed security.

Footnotes

¹⁵⁸ <http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>

¹⁵⁹ https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf
<http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>

Marketing channels are currently informal, primarily involving direct sales from producers to users. The development of more formal channels could involve community-based enterprises, agricultural cooperatives, or partnerships with established commercial feed companies. Actors in this segment include the producers themselves, traders, cooperatives, and potentially larger feed manufacturing and distribution companies. Regulatory bodies like the Livestock and Livestock Products Board of Namibia (LLPB) may also play a role, particularly concerning the implications of feed ingredients (e.g., use of genetically modified supplements) on the export status of livestock products.¹⁶⁰

The current structure of the value chain, largely characterised by localised production for immediate on-farm needs, particularly as emergency fodder, highlights its fragmented nature. While this demonstrates resourcefulness and addresses urgent requirements, a significant transformation is needed to move towards commercialisation and broader market access. This transition would necessitate substantial advancements in areas such as product standardisation to ensure consistent quality and safety, the development of reliable quality assurance systems, more sophisticated logistical networks for wider distribution, and the establishment of market information systems to connect buyers and sellers effectively. Without these developments, the value chain will likely remain a collection of localised, subsistence-oriented or emergency-driven activities, rather than evolving into a robust, market-oriented industry capable of making a larger contribution to economic diversification.

5.2.6 Business Capability Gaps and Skills Implications



The animal feed from the bush value chain in Namibia is characterised by nascent but growing business activity, largely driven by the pressing need for drought mitigation and rangeland improvement. Currently, production is dominated by an estimated 50 producers, many of whom are operating on a "trial and error" basis as they explore the viability and techniques of converting encroacher bush into usable animal fodder. This pioneering spirit has yielded remarkable results in some instances, proving that bush-to-feed production can serve as effective emergency feed and a valuable supplement, even during rainy seasons.¹⁶¹

Despite the potential, the animal feed from the bush value chain in Namibia faces several critical business capability gaps that hinder its growth, efficiency, and ability to contribute more significantly to economic diversification.

Footnotes

¹⁶⁰ https://www.resakss.org/sites/default/files/2024_ator_individual_chapters/Chapter%2012_ReSAKSS_AW_ATOM_2024.pdf

https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf

<http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>

¹⁶¹ https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_8664094373132500265DraftFundingProp osalforOtjozondjupaHotspots.docx

https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf

Table 14: Business Capability Gaps- Bush to Feed Value Chain

Business Capability Gaps - Bush to Feed Value Chain			
Capability Area ¹⁶²	Specific Gap/Challenge	Detailed Skills & Requirements	Impact on Value Chain Development
Technological & Infrastructural Deficiencies	Lack of appropriate, affordable, locally adapted machinery	- Imported machines often struggle with Namibian conditions, leading to high operational costs & breakdowns. For example: Bos-to-Kos machine reportedly lacks Namibian-based service/support agent - Need for expert assessment to define/procure suitable technologies, especially for community-level operations.	- Reduced efficiency, higher operational costs. - Operational unreliability and risks. - Limits adoption of effective processing methods.
	Limited access to efficient equipment	High capital costs of harvesting and processing equipment are a major barrier, especially for SMEs and communal farmers.	- Restricts operations to smaller scales. - Leads to reliance on less efficient methods. - Limits overall productivity.
	Inadequate storage and logistical infrastructure	- Lack of proper storage facilities to prevent spoilage and maintain feed quality over time. - Constraints for commercial-scale operations or fodder banking initiatives.	- Post-harvest losses due to spoilage. - Inability to buffer supply or maintain feed quality. - Limits market reach and commercial viability.
	Insufficient local equipment maintenance capacity	Shortage of technicians skilled in maintaining and repairing biomass processing equipment, particularly imported or specialized machinery.	- Increased equipment downtime. - Higher operational costs due to reliance on external/foreign expertise. - Operational risks.
Operational Inefficiencies & Quality Management	Lack of standardized production protocols	- Current "trial and error" approach by many producers. - Animal feed production is complex; incorrect implementation can jeopardize animal health	- Significant variability in feed quality, nutritional content, and safety. - Potential animal health issues. - Inefficient resource utilization.
	Suboptimal feed formulation and supplement use	- Risk of nutritional imbalances or toxicity if formulations are incorrect or supplements are overdosed. - Expert advice on feed mixtures is often required but may not be accessible.	- Jeopardizes animal health and productivity. - Can negate the benefits of feed production. - Wasted resources on incorrect supplementation.

Footnotes

¹⁶² <https://allafrica.com/stories/202110250631.html>

https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc/15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf

<http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>

https://energypedia.info/images/b/be/Financing_Bush_Control_2016.pdf

<https://documents1.worldbank.org/curated/en/09985031112236455/pdf/IDU0ff2db1400403c046b2099a300571336f9a6d.pdf>

https://www.researchgate.net/publication/351739690_Determinants_of_Female_Entrepreneurship_Success_in_the_Agricultural_Sector_An_Examination_of_SMEs_in_South_Africa

<https://encyclopedia.pub/entry/35890>

<https://encyclopedia.pub/entry/35890>

Business Capability Gaps - Bush to Feed Value Chain

Capability Area	Specific Gap/Challenge	Detailed Skills & Requirements	Impact on Value Chain Development
Operational Inefficiencies & Quality Management	Inadequate quality control and testing mechanisms	Few producers have access to on-farm or affordable laboratory testing facilities to analyze nutritional content, digestibility, or potential contaminants.	- Inability to assure or prove product quality for commercial markets. - Potential health risks for animals. - Erodes buyer confidence.
	No specific national standards for bush-based feed	The Namibian Standards Institute (NSI) currently has no specific standard relating to animal feeds, let alone bush-based feeds.	- Hinders efforts to ensure consistent quality for a wider market. - Lack of a benchmark for producers. - Complicates trade and market development.
	Poor post-harvest handling and storage practices	Practices leading to spoilage, mold growth, or pest infestation.	- Significant economic losses. - Reduced feed availability and quality. - Erodes the economic viability of production.
Financial Access & Investment Barriers	Limited access to affordable finance	Characterized by high interest rates, stringent collateral requirements (often fixed assets, which SMEs/communal enterprises lack), and complex, lengthy application processes.	- Undercapitalization of businesses. - Inability to invest in necessary technology and operational upgrades. - Slows growth and excludes many potential actors.
	Mismatch between financial products and industry needs	Insufficient grace periods that don't align with cash flow cycles of enterprises needing time for harvesting, processing, and market development before revenue generation.	Financial products are not tailored to the specific operational and investment cycles of the biomass sector.
	High initial investment costs	- Prohibitive costs for suitable harvesting/processing equipment and necessary infrastructure. - Costs are often difficult to amortize solely through animal feed production, especially at smaller scales.	- Significant barrier to entry for new producers. - Limits scaling up of existing operations. - Makes ventures appear less viable.
	Lack of specific incentive schemes	Absence of tailored financial incentives to support the biomass or bush-feed sector specifically.	- Reduced motivation for investment and innovation. - Fails to de-risk pioneering efforts in the sector.
	Overall Financial Gap Impact	The financial gap is a critical bottleneck perpetuating other capability gaps (technology, operations, market development). It creates a cycle of undercapitalization, suboptimal methods, and limited productivity.	- Severely constrains growth potential of the entire value chain. - Limits its capacity to contribute meaningfully to economic diversification.

Business Capability Gaps - Bush to Feed Value Chain

Capability Area	Specific Gap/Challenge	Detailed Skills & Requirements	Impact on Value Chain Development
Managerial, Entrepreneurial & Business Development	Limited business management and financial literacy	Widespread need for enhanced skills in managing finances, developing sound business strategies, and understanding market dynamics, particularly at SME and community enterprise level.	- Poor business planning and decision-making. - Inefficient operations and resource management. - Low profitability and sustainability.
	Weak entrepreneurial skills	- Deficiencies in identifying/evaluating market opportunities, developing robust business plans, innovating, and effectively managing business risks. - External experts often needed to help communities develop basic business concepts.	- Limits sector dynamism and innovation. - Missed market opportunities. - Slow adaptation to changing market conditions.
	Insufficient business development, marketing & sales capacity	Production primarily focused on on-farm use; skills for reaching and serving external markets are underdeveloped.	- Over-reliance on localized or emergency-driven markets. - Inability to scale operations or access broader commercial channels.
	Challenges in community-based enterprise management	Specific difficulties in managing operations effectively, ensuring transparent governance, and developing equitable benefit distribution plans that maintain community engagement.	- Risk of internal conflicts and disillusionment. - Ineffective operations and potential failure of community projects.
Market Development & Access Limitations	Fragmented and underdeveloped market	- Demand is primarily localized and often driven by emergency needs during droughts. - Lack of established commercial channels for broader distribution.	- Difficulty for producers in reaching a consistent buyer base. - Price instability and unpredictability. - Inefficient supply chains.
	Limited market information	Producers lack readily available information on prevailing prices, specific quality requirements from different market segments, and overall demand trends.	- Difficult for producers to make informed decisions about production levels, quality targets, and target markets. - Increases market risk.
	Challenges in meeting consistent quality/volume standards	Without standardized production and quality assurance, producers struggle to meet requirements of larger, more formal markets.	- Significant barrier to entering formal commercial channels and securing contracts. - Erodes trust with potential large-scale buyers.
	Lack of branding and marketing strategies	Absence of cohesive branding or marketing for Namibian bush-based feed products.	- Products remain undifferentiated. - Missed opportunities for market recognition, building a reputation, or creating a niche (e.g., for sustainably produced feed).

Business Capability Gaps - Bush to Feed Value Chain

Capability Area	Specific Gap/Challenge	Detailed Skills & Requirements	Impact on Value Chain Development
Managerial, Entrepreneurial & Business Development	Ambiguous regulatory environment for bush-feed	- Bush-based animal feed is not yet treated as a standard commodity product. - Requires licenses from MAFWLR for production and sale, governed by the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act No 36 of 1947.	- Creates uncertainty for producers and investors. - Potential administrative barriers to entry or scaling up operations.
	Need for improved biomass utilization framework	A recognized need for an improved and more supportive legal and regulatory framework for large-scale bush control and biomass utilization in general, which would benefit the animal feed sub-sector.	Broader policy and regulatory gaps hinder the optimal development of the entire biomass sector, including feed production.
	Lack of specific national standards for bush-based feed	Critical gap: no specific national standards for bush-based animal feed quality and safety.	- Hinders quality assurance efforts. - No clear benchmark for producers. - Reduces buyer confidence, especially in commercial and export markets.
	Need for effective policy alignment and coordination	Lack of alignment and coordination in policies supporting the entire value chain – from sustainable harvesting practices and resource access, through to processing, quality assurance, and market access.	- Fragmented support for the sector. - Potential for policy conflicts or gaps. - Inefficiencies in overall value chain development and support.

The business capability gaps identified above directly translate into a spectrum of skills requirements that are currently underdeveloped or lacking within the Namibian context for the animal feed from the bush value chain.

Table 15: Skills implications- Bush to Feed value chain

Skills implications - Bush to Feed value chain

Capability Area ¹⁶³	Specific Business Capability Gap/Challenge	Skill(s) Needed
Technological & Infrastructural Deficiencies	Lack of appropriate, affordable, locally adapted machinery	- Machine Operation (Specialized Biomass Equipment) - Technology Adaptation and Troubleshooting - Selection of Appropriate Technology
	Insufficient local equipment maintenance capacity	Equipment Maintenance and Repair
	Limited access to efficient equipment	- Financial Management & Investment Appraisal (linked to selecting affordable tech) - Knowledge of different equipment options
	Inadequate storage and logistical infrastructure	- Drying, Storage, and Preservation Techniques - Logistics and Supply Chain Management
Operational Inefficiencies & Quality Management	Lack of standardized production protocols	- Understanding of Standard Operating Procedures - Feed Formulation, Mixing, and Supplement Knowledge - Operations Management and Efficiency Improvement
	Suboptimal feed formulation and supplement use	- Feed Formulation, Mixing, and Supplement Knowledge - Safe Handling of Materials - Feed Science and Animal Nutrition Expertise (for higher level/advisory)
	Inadequate quality control and testing mechanisms	- Quality Control Procedures and Laboratory Techniques - Safe Handling of materials
	No specific national standards for bush-based feed	- Understanding of Regulatory Compliance (Feed Safety) - Advocacy skills (for industry bodies to help develop standards)
	Poor post-harvest handling and storage practices	Drying, Storage, and Preservation Techniques

Footnotes

¹⁶³ https://researchrepository.ilo.org/view/pdfCoverPage?instCode=41ILO_INST&filePid=13100915560002676&download=true
https://erc.undp.org/api/download?filePath=/documents/9046/mgmtresponse/keyaction/doc_15062173642745933692016_03_23_Pilot_AnimalFeedcopy.pdf
<http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>
<https://allafrica.com/stories/202110250631.html>
<https://panorama.solutions/en/solution/namibian-bush-biomass-ecosystem-restoration-solution>
https://issuu.com/foodworldmedia/docs/feed_aqua_middle_east_africa_magazine_issue_
https://eia.meft.gov.na/screening/4864_20241025_eia_ki_gunzel.pdf
https://www.resakss.org/sites/default/files/2024_ator_individual_chapters/Chapter%2012_ReSAKSS_AW_ATOM_2024.pdf
<https://thoughtforfood.org/content-hub/whats-the-future-of-animal-feed-in-africa/>
<https://documents1.worldbank.org/curated/en/09985031112236455/pdf/IDU0ff2db1400403c046b2099a300571336f9a6d.pdf>

Skills implications - Bush to Feed value chain

Capability Area ¹⁶³	Specific Business Capability Gap/Challenge	Skill(s) Needed
Financial Access & Investment Barriers	Limited access to affordable finance	- Financial Literacy - Business Planning and Proposal Writing for Finance - Understanding of Financial Products and Loan Management
	Mismatch between financial products and industry needs	- Financial Literacy & Management (as above) - Advocacy skills (for industry bodies)
	High initial investment costs	- Investment Appraisal - Business Planning - Knowledge of Phased Investment/ Alternative Technologies
	Lack of specific incentive schemes	Understanding of Policy Environment & Advocacy
	Overall Financial Gap Impact	Financial Literacy, Business Planning, Financial Management, Investment Appraisal, Understanding Financial Products, Entrepreneurship
Managerial, Entrepreneurial & Business Development	Limited business management and financial literacy	- Financial Management - Business Planning and Development - Operations Management & Efficiency Improvement - Basic ICT Literacy - Data Collection and Analysis
	Weak entrepreneurial skills	- Entrepreneurship and Innovation - Business Planning and Development - Soft skills such as Problem-solving, critical thinking, communication, teamwork
	Insufficient business development, marketing & sales capacity	- Marketing, Sales, and Customer Relationship Management - Market Research and Intelligence - Product Branding and Promotion - Basic ICT Literacy
	Challenges in community-based enterprise management	- Cooperative/Community Enterprise Management - Community Consultation, Participation, and Conflict Resolution skills
Market Development & Access Limitations	Fragmented and underdeveloped market	- Market Research and Intelligence - Marketing, Sales, and Customer Relationship Management - Supply Chain Coordination - Networking and Business Development skills.
	Limited market information	- Market Research and Intelligence - Basic ICT Literacy - Data Collection and Analysis
	Challenges in meeting consistent quality/ volume standards	- Quality Control Procedures and Laboratory Techniques - Understanding of Commercial Standards - Operations Management.
	Lack of branding and marketing strategies	- Product Branding and Promotion - Marketing, Sales, and Customer Relationship Management

Skills implications - Bush to Feed value chain

Capability Area ¹⁶³	Specific Business Capability Gap/Challenge	Skill(s) Needed
Regulatory & Policy Considerations	Ambiguous regulatory environment for bush-feed	Understanding of Regulatory Compliance (Environmental, Feed Safety)
	Need for improved biomass utilization framework	- Advocacy and Policy Engagement Skills (for industry bodies) - Understanding of Environmental Regulations
	Lack of specific national standards for bush-based feed	- Understanding of Feed Safety Standards - Advocacy and Policy Engagement Skills (for industry bodies)
	Need for effective policy alignment and coordination	- Understanding of Policy Landscape - Advocacy and Inter-stakeholder Communication skills
Cross-Cutting Area	Need for sustainable harvesting and rangeland aftercare	- Sustainable Bush Harvesting and Resource Assessment - Aftercare and Rangeland Restoration Techniques - Understanding and Implementing Sustainable Harvesting Practices - Knowledge of Environmental Regulations and Compliance
	Need for Digital and Green Economy Skills	- Basic ICT Literacy - Skills related to Green Technologies and Circular Economy - Data Collection and Analysis

5.2.7 Biochar Value Chain

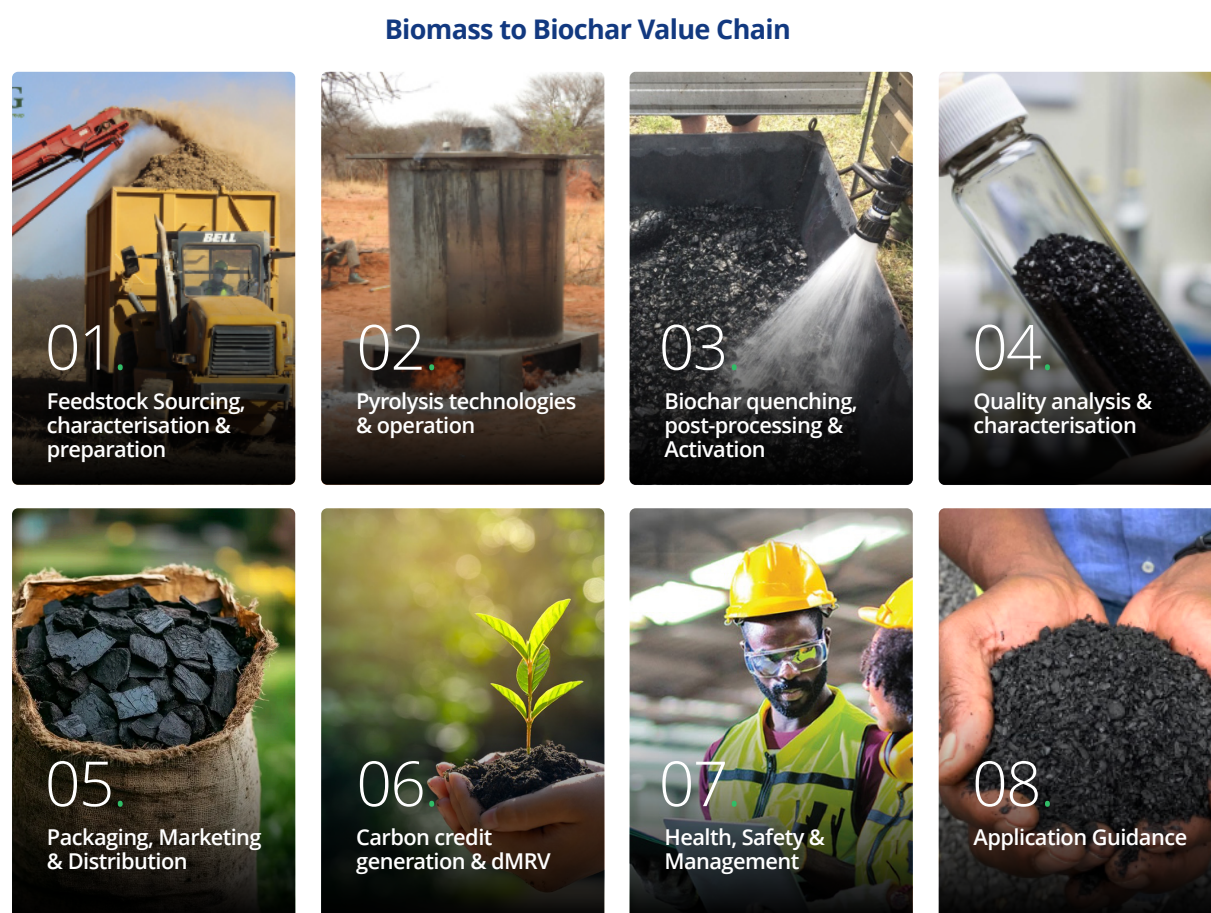


Figure 5: Biomass to Biochar Value Chain

The Namibian biochar value chain, primarily focused on utilising invader bush, can be delineated into several interconnected stages, each involving specific activities and opportunities for value addition. The integration of agricultural residues into this value chain is less developed but represents a significant area for future expansion.

5.2.7.1 Feedstock Collection, Pre-processing, and Logistics

This initial stage involves the sourcing and preparation of biomass. For invader bush, this includes sustainable harvesting practices such as selective thinning and adherence to FSC standards, where implemented, followed by chipping or shredding to reduce volume and facilitate handling. For agricultural residues, activities would encompass post-harvest gathering from fields, potential baling for easier transport, and similar pre-processing steps like chopping or shredding. Drying of the biomass to an appropriate moisture content is often a critical pre-processing step. Finally, the prepared feedstock is transported to pyrolysis processing sites.¹⁶⁴

Footnotes

¹⁶⁴ <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://carbonherald.com/how-carbon-removal-is-helping-solve-bush-encroachment-in-africa/>
<https://planboo.eco/designing-a-successful-biochar-project-first-steps/>
<https://www.researchgate.net/post/How-Biochar-is-produced>

5.2.7.2 Biochar Production and Primary Processing

This initial stage involves core stage involves the thermochemical conversion of biomass into biochar through pyrolysis. A range of technologies is employed in Namibia, from relatively simple, manually operated Kon-Tiki kilns, often used for artisanal or small-scale community projects, to more sophisticated, industrial-scale pyrolysis plants that offer greater control over the process and higher throughput. Following pyrolysis, the biochar is typically quenched to halt combustion and then undergoes initial grading or sieving to remove oversized particles or contaminants¹⁶⁵.

Achieving consistent biochar quality is paramount for its effective use and market value. This involves careful control of pyrolysis conditions (temperature, heating rate, residence time), appropriate feedstock selection and preparation, and adherence to recognised quality standards, such as those developed by the European Biochar Certificate (EBC) or the International Biochar Initiative (IBI), or forthcoming Namibian national standards. Key quality parameters include carbon content, hydrogen-to-carbon molar ratio (an indicator of stability), levels of polycyclic aromatic hydrocarbons (PAHs), porosity, pH, and ash content¹⁶⁶.

5.2.7.3 Product Diversification, Value Addition, and Secondary Processing

Raw biochar can undergo further processing to enhance its properties or be tailored for specific applications. This may include milling to achieve specific particle sizes, sieving for uniformity, and inoculation or "charging" with nutrients (e.g., by mixing with compost, manure, or beneficial microbes) to create enriched soil amendments. Packaging for retail or specialised markets is also a key value-adding activity. There is also potential for developing a wider range of biochar-based products, such as supplements for animal feed, media for water filtration systems, or components in sustainable building materials¹⁶⁷.

This stage holds significant potential for increasing the economic value derived from biochar beyond its basic form. While current applications in Namibia are predominantly focused on soil improvement and carbon sequestration, the National Strategy on Sustainable Management of Bush Resources, for example, identifies advanced value chains from bush biomass generally, such as wood-cement composites, wood-plastic composites (WPCs), and medium-density fibreboards (MDFs), some of which could potentially incorporate biochar¹⁶⁸.

Footnotes

¹⁶⁵ <https://omitibiochar.com/who-we-are>
<https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://carbonherald.com/how-carbon-removal-is-helping-solve-bush-encroachment-in-africa/>
<https://www.nampa.org/text/22481438>

¹⁶⁶ <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://voconsulting.net/wp-content/uploads/2024/04/Mobilising-climate-finance-through-carbon-removal-Namibian-bush-biomass-iochar.pdf>
<https://planboo.eco/designing-a-successful-biochar-project-first-steps/>

¹⁶⁷ <https://africa.cgtn.com/namibian-farmers-turn-to-locally-produced-biochar-as-fertilizer/>
<https://africalive.net/article/namibian-desert-blooms-as-farmers-turn-bush-into-black-gold/>
https://edgecollective.io/projects/water_biochar/
<https://planboo.eco/designing-a-successful-biochar-project-first-steps/>

¹⁶⁸ <https://voconsulting.net/wp-content/uploads/2024/04/Mobilising-climate-finance-through-carbon-removal-Namibian-bush-biomass-iochar.pdf>

5.2.7.4 Market Channels and Distribution

Local/Domestic Market:	Current local demand is primarily from farmers seeking soil amendments, livestock producers exploring feed supplements, and horticultural projects. There are emerging opportunities in land restoration projects and potentially in decentralised water treatment systems. However, the overall domestic market remains nascent and relatively small ¹⁶⁹ .
International Market:	The primary driver for international market engagement is currently the voluntary carbon market, where biochar projects can generate Carbon Dioxide Removal Certificates (CRCs). There is also potential for exporting bulk biochar or specialised, value-added biochar products to niche international markets, although this is less developed ¹⁷⁰ .
Logistics:	Effective market access requires robust logistics, including appropriate storage facilities for biochar (which can be dusty and require protection from moisture), efficient transportation networks to reach end-users or export hubs (ports), and compliance with any applicable export regulations ¹⁷¹ .

The current Namibian biochar value chain exhibits a strong orientation towards the "production-for-carbon-credits" model, particularly leveraging invader bush as the primary feedstock. Many prominent projects and enterprises, such as PyroNam and Omiti Biochar, heavily emphasise carbon credit generation as a principal revenue stream. This is understandable given the growing international demand for carbon removals. However, this focus means that the diversification into other potentially high-value applications and the development of robust local markets for biochar products remain comparatively underdeveloped. This situation presents both an opportunity and a vulnerability; while carbon markets provide an initial impetus, an over-reliance on them makes the sector susceptible to price volatility and changes in international carbon accounting methodologies. Developing stable local markets for applications in agriculture, animal husbandry, or even industrial uses would create more resilient demand and enhance domestic value creation¹⁷².

5.2.8 Business Capability Gaps and Skills Implications

A detailed examination of the Namibian biochar sector reveals several critical business capability gaps that currently constrain its growth, diversification, and overall impact. Addressing these gaps is essential for the sector to mature and contribute meaningfully to the national economy.

Footnotes

¹⁶⁹ <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://africalive.net/article/namibian-desert-blooms-as-farmers-turn-bush-into-black-gold/>
<https://omitibiochar.com/who-we-are>

¹⁷⁰ <https://bluskycarbon.com/blusky-carbon-aims-to-increase-footprint-in-africa/>
<https://voconsulting.net/wp-content/uploads/2024/04/Mobilising-climate-finance-through-carbon-removal-Namibian-bush-biomass-iochar.pdf>

¹⁷¹ <https://bluskycarbon.com/blusky-carbon-aims-to-increase-footprint-in-africa/>
<https://sdgs.un.org/partnerships/omiti-community-based-biochar-project-namibia>
<https://thebrief.com.na/2024/08/namibias-carbon-and-biodiversity-credit-market-remains-untapped/>

¹⁷² <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://biochar-international.org/news/empowering-the-global-south-with-biochar-carbon-removal/>
<https://bluskycarbon.com/blusky-carbon-aims-to-increase-footprint-in-africa/>
<https://sdgs.un.org/partnerships/omiti-community-based-biochar-project-namibia>
<https://analabnam.com/about-us/>

Table 16: Business Capability Gap and Skills Implications- Biochar Value Chain

Business Capability Gap and Skills Implications- Biochar Value Chain			
Core Business Capability ¹⁷³	Description of Gap	Implications of the Gap	Key Sector Insights
Sustainable Feedstock Mobilization & Management	- Scalable & Diversified Feedstock Mobilization - Critically, viable supply chains for agricultural residues are lacking	Limits overall growth potential and diversification. Creates over-reliance on invader bush, restricting geographical spread of benefits (excluding regions with mainly agricultural residues). Sub-optimal logistics lead to higher costs.	Directly impacts Supply Chain & Logistics). Over-reliance on one feedstock hinders resilience and achieving broader economic diversification goals.
Efficient Production & Technological Proficiency	Consistent High-Quality Biochar Production & Technological Adaptability	Inconsistent quality hinders development of specialized biochar markets, reduces product value, complicates certification for premium markets (beyond basic carbon sequestration), and can damage consumer confidence. Higher production costs may result.	- Directly impacts Quality Assurance as inconsistent production makes QA harder. - Also affects Market Development and R&D Commercialization, as reliable quality is crucial for both.
Quality Assurance & Standardization	Robust Quality Assurance and National Standards Implementation	Limits credibility and market access for Namibian biochar, especially in discerning export markets. Increases operational costs. Makes systematic quality control difficult, particularly for SMEs, and can be a barrier to entry. Inconsistent product for end-users.	Crucially interconnected with Production, Market Development, and R&D. Without QA, market development for specialized products and commercialization of R&D is severely hampered. Lack of local testing facilities places a disproportionate burden on SMEs.
Product Development & Innovation (Advanced R&D and Commercialization)	Advanced Product R&D and Commercialization	Misses significant opportunities for higher value addition, economic diversification, and innovative solutions to local challenges (e.g., sustainable building, water quality). Restricts the sector's ability to move up the value chain. The sector remains commodity-focused.	- Dependent on Quality Assurance for new products to meet standards. - Stronger Stakeholder Engagement, especially public-private R&D links, is needed. Weakness here contributes to the "soft" capability deficit and the tension between bulk commodity vs. value-added products. This is vital for long-term sustainability.
Market Development & Access (Local & Niche Export, Beyond Carbon Credits)	Market Development Beyond Carbon Credits	Economic viability highly sensitive to carbon price fluctuations. Under-realized potential for local economic benefits, circular economy models in agriculture, and addressing local environmental challenges. Limited market diversification.	- Affected by Production Quality and Quality Assurance, as consistent, quality-assured products are needed for market trust. Highlights the "tension" between focusing on bulk carbon credits versus higher-value diversified products. - Weak "soft" capabilities like marketing are a major constraint, especially for SMEs. This is key for achieving broader economic diversification goals.

Footnotes

¹⁶⁵ <https://www.atmosfair.de/en/climate-protection-projects/negative-emissions/namibia-industrial-biochar-en/>
<https://biochar-international.org/news/empowering-the-global-south-with-biochar-carbon-removal/>
<https://bluskycarbon.com/blusky-carbon-aims-to-increase-footprint-in-africa/>
<https://sdgs.un.org/partnerships/omiti-community-based-biochar-project-namibia>
<https://analabnam.com/about-us/>
<https://www.n-big.org/bush-value-chains-projects/>
<https://ikigai biodiversity.com/why-namibia%3F>
https://dbn.naftal.dev-imcon.com/wp-content/uploads/2025/02/presentation-2022-08-omusati_compressed.pdf
https://www.afdb.org/sites/default/files/esms_ar-p-na-haa-006_development_bank_of_namibia_dbn_esms_assessment_report_07_10_2024_2_1.pdf

Skills implications - Bush to Feed value chain

Core Business Capability ¹⁷³	Description of Gap	Implications of the Gap	Key Sector Insights
Carbon Project Development & Management (Carbon Market Navigation & Monitoring, Reporting and Verification Expertise)	Carbon Market Navigation and MRV Expertise	Benefits of carbon finance risk being unevenly distributed, potentially excluding smaller players. Limits inclusivity of sector growth and poverty reduction impact. Higher transaction costs for smaller players.	While a current revenue driver, over-reliance is risky. This highlights a disparity in "soft" capabilities, with smaller players struggling to access this potentially lucrative market.
Efficient and Cost-Effective Supply Chain & Logistics Management	Efficient and Cost-Effective Supply Chain and Logistics	Increased operational costs reduce Namibian biochar competitiveness. Difficulties reaching dispersed markets or remote feedstock sources can limit economies of scale and hinder participation from less accessible regions.	Closely linked to Feedstock Mobilization. Efficient logistics are fundamental for scaling up production and accessing diverse markets. This is crucial if the sector aims for bulk commodity supply and diversified products.
Access to Appropriate Finance & Investment Readiness	Access to Appropriate Finance and Investment	Slows overall sector growth and innovation. Hinders adoption of better, more efficient technologies, particularly among local entrepreneurs and community-based initiatives. Stifles SME development.	Affects the ability to address nearly all other gaps, as investment is often needed for new technologies, R&D, scaling logistics, and meeting Quality Assurance standards. It underpins the need for enhanced business development services including financial literacy.
Regulatory Compliance & Advocacy	- Need for greater clarity on some regulations (e.g., concerning communal land use for carbon projects). - Challenges in consistent enforcement of existing regulations.	Uncertainty for investors and producers. Potential for unsustainable practices if monitoring and enforcement are weak.	Effective advocacy can help address issues like the need for national standards and streamline processes that might affect carbon projects or feedstock access.
Stakeholder Engagement & Partnership Building	- Need for more systematic and broader engagement, particularly with farming communities for agricultural residue utilization. - Strengthening public-private R&D linkages for better technology transfer and commercialization.	Slower adoption of innovations and best practices. Missed opportunities for inclusive development that benefits a wider range of stakeholders, including local communities.	- Crucial for improving Feedstock from agricultural residues, R&D commercialization via public-private links, and ensuring benefits from Carbon Markets are more widely distributed. - Further supports the development of "soft" capabilities across the sector.

● Skills Implications

Skill Category	Specific Skill	Description & Link to Business Capability Gaps
Technical Skills	Sustainable Biomass Management	Expertise in agronomy for agricultural residues and sustainable forestry practices (e.g., FSC principles) for invader bush. Includes biomass resource assessment, quantification, and safe operation of harvesting and pre-processing machinery.
	Pyrolysis Plant Operation & Maintenance	Ability to manage various pyrolysis units, control processes to optimize biochar quality and yield, perform routine troubleshooting, and conduct preventative maintenance. Requires a strong understanding of thermochemical conversion.

Skills implications - Bush to Feed value chain

Skill Category	Specific Skill	Description & Link to Business Capability Gaps
Technical Skills	Quality Control & Laboratory Analysis	Skills in proper sampling, sample preparation, and performing analytical tests (e.g., pH, carbon content, PAH levels). Crucially, it requires the ability to interpret results against standards like EBC or IBI.
	Product Formulation & Application	Involves enhancing biochar properties (e.g., activation, inoculation) and blending it with other materials like compost or fertilizers. For agricultural use, knowledge of soil science and application techniques is necessary.
Business & Management Skills	Supply Chain & Logistics Management	Competencies in planning biomass collection routes, managing feedstock and biochar inventory, developing storage solutions, overseeing transportation logistics, and minimizing losses.
	Financial Management & Accounting	Skills in developing business plans, cost accounting for production, financial modeling, preparing grant/loan applications, and managing daily finances, especially for SMEs.)
	Marketing & Sales (Domestic & International)	Expertise in market research, developing branding and strategies for diverse customer segments, using digital marketing, understanding export requirements, and building customer relationships.
	Carbon Project Development & Management	Specialized skills in applying carbon accounting methodologies (e.g., Verra, Puro.earth), developing Project Design Documents (PDDs), implementing Monitoring, Reporting, and Verification (MRV) systems, and navigating carbon credit trading.
	Entrepreneurship & Business Development	Ability to identify business opportunities, develop innovative business models, manage innovation, conduct risk assessments, and provide effective leadership, particularly for SME growth.
	Regulatory Compliance & Standards Adherence	Thorough understanding of and ability to comply with relevant environmental, forestry, and business regulations. Knowledge of quality standards and certification processes is key.
Research & Development Skills	Applied Research & Experimentation	Capacity to design and conduct scientific trials to develop new biochar applications (e.g., construction, water filtration), test local feedstocks, and optimize pyrolysis conditions.
	Data Analysis & Scientific Reporting	Skills in statistical analysis of research data, clear scientific writing for reports and publications, and presenting findings effectively to various audiences.
Soft Skills (Cross-cutting)	General Competencies	Includes problem-solving, critical thinking, effective written and verbal communication, teamwork, collaboration, adaptability to new technologies and market changes, and digital literacy. These are important across all roles.

5.3 Skills in Demand in the Biomass Sub-Sector

5.3.1 Charcoal



While offering low entry barriers for some, the Namibian charcoal industry exhibits a notable dichotomy in its workforce. A significant portion of primary production, particularly harvesting and traditional kiln operations, relies on an estimated 6,000 low-skilled labourers who receive informal training. Conversely, the increasing demand for sustainably produced and certified charcoal, especially for export markets, is driving a need for more formalised roles and higher skill levels. This trend towards professionalisation necessitates upskilling in sustainable harvesting practices, efficient and cleaner carbonisation technologies, and stringent quality control¹⁷⁴.

The push for certifications like FSC acts as a direct catalyst for skill enhancement. The role of a certification manager, as exemplified by Frank Detering of CARBO Namibia, involves training staff in species identification, adherence to harvesting norms (e.g., diameter limits, exclusion of protected species), quality assessment of charcoal, and meticulous record-keeping. This demonstrates how certification schemes elevate the skill requirements from basic manual labour to more knowledge-intensive and responsible practices, fostering a more professional workforce. Consequently, supporting and expanding certification can be a strategic lever for overall workforce development and improving the sustainability and market competitiveness of the Namibian charcoal sector¹⁷⁵.

Because of challenges in obtaining reliable data on demand in the sector, this report will not provide any insights into specific demand numbers in the biomass sub-sector. Further recommendations are made for an in-depth sectoral review of specific demand numbers.

Table 17: Occupations and Skills in the Biomass to Charcoal Value Chain

Occupations and Skills in the Biomass to Charcoal Value Chain				
Value Chain Stage ¹⁷⁶	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Sustainable Bush Harvesting & Collection	Selective harvesting of encroacher bush, species identification, adherence to size/species regulations (e.g., FSC), felling/cutting, on-site preparation, rangeland restoration principles.	Bush Harvester / Cutter	- Species identification - Safe operation of manual tools (axes, pangas) and semi-mechanized tools (chainsaws) - Basic equipment maintenance, - Understanding of environmental regulations - Basic fire prevention and management.	Physical stamina and fitness, attention to detail, adherence to safety and environmental guidelines, teamwork, reliability, ability to work outdoors.
		Harvesting Supervisor / Team Leader	- Planning and organizing harvesting operations - Ensuring compliance with harvesting plans and FSC standards - Worker supervision and training - Basic first aid - Record-keeping	Leadership, communication, problem-solving, decision-making, organizational skills.
Carbonization: Kiln Technologies & Operation	Transporting wood to kilns, stacking wood in various kiln types (earth, brick, metal, clay), kiln ignition, airflow and temperature control for pyrolysis, managing burn cycle, ensuring efficient carbonization.	Kiln Operator / Charcoal Burner	- Kiln construction (traditional types) - Wood stacking techniques for optimal carbonization, - Fire management and draught control - Understanding of pyrolysis principles - Temperature monitoring - Operation of different kiln types - Identifying burn completion - Basic kiln maintenance	Patience, vigilance (long monitoring periods), problem-solving (adjusting burn conditions), physical endurance, attention to detail.
Post-Carbonization Processing	Cooling and extracting charcoal, sorting and grading by size/quality, sieving to remove fines/ash, (optional) crushing charcoal fines, mixing with binders, briquette production using presses/extruders.	Charcoal Sorter / Grader / Siever	- Manual sorting and grading skills - Operation of sieving equipment - Identification of charcoal quality defects	Attention to detail, manual dexterity, diligence, ability to perform repetitive tasks.
		Briquette Machine Operator (where applicable)	- Operation of crushing, mixing, and briquetting machinery - Knowledge of binder properties and mixing ratios - Basic machine maintenance and troubleshooting	Mechanical aptitude, attention to detail, adherence to process parameters.

Footnotes

- ¹⁶⁵ https://unu.edu/sites/default/files/2025-02/Case%20Study%20Green%20Minimalist%20Company%20Case%20Study_UNU-FLORES.pdf
https://mit.gov.na/documents/41692/64347/Wood+Charcoal_Strategies_Web.pdf/d6be8fcd-7b70-d576-9cf2-502f5d15e2ca?t=1600687400508&download=true
<https://fsc.org/en/newscentre/stories/from-bush-to-charcoal-the-greenest-charcoal-comes-from-namibia>
http://the-eis.com/elibrary/sites/default/files/downloads/literature/N-BiG_Harvesting-and-Processing-Encroacher-Bush-Booklet_2023.pdf

Skills implications - Bush to Feed value chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Quality Assessment & Control	Inspecting charcoal (chunk size, color, impurities), laboratory testing (moisture, ash, volatile matter, fixed carbon), adherence to FSC and international standards), record-keeping.	Quality Control Technician / Inspector	- Knowledge of charcoal quality parameters and testing methods - Sample collection techniques - Operation of basic lab equipment - Understanding of FSC standards - Data recording and analysis, - Visual inspection skills	Meticulousness, analytical skills, integrity, objectivity, good observational skills.
		FSC Auditor / Certification Manager	- In-depth knowledge of FSC standards and auditing procedures - Environmental science/ forestry background - Report writing, training skills, stakeholder communication.	Analytical skills, strong ethics, communication, attention to detail, impartiality.
Packaging, Marketing & Distribution	Bagging charcoal (various sizes), labeling, warehousing, marketing strategies (pricing, branding), sales, managing distribution channels (local, export), transport logistics.	Packaging Operator	- Operation of bagging and sealing equipment, weighing, labeling, stacking - Inventory management basics.	Efficiency, attention to detail, physical fitness, adherence to packaging standards.
		Marketing & Sales Personnel / Exporter	- Market research skills - Developing marketing and pricing strategies - Sales and negotiation techniques - Knowledge of export documentation and procedures - Understanding of international buyer requirements and standards - Logistics coordination.	Communication, negotiation, networking, business acumen, cultural sensitivity (for export), customer service.
		Transport / Logistics Coordinator	- Route planning - Vehicle fleet management (if applicable) - Managing shipping documents, ensuring timely delivery, - Understanding transport regulations for flammable goods.	Organizational skills, problem-solving, communication, time management.
Overall Management	Business planning, financial management, labor management, regulatory compliance, supply chain coordination, strategic decision-making.	Charcoal Producer / Farm Owner / Business Manager	- Comprehensive understanding of the entire charcoal value chain, - Business administration and financial management skills, human resource management - Knowledge of relevant laws and permits (production, transport, export) - Quality management systems - Market analysis.	Leadership, entrepreneurial skills, decision-making, strategic thinking, problem-solving, communication, risk management, adaptability.

5.3.2 Power Generation



The operational phase of a biomass power plant, particularly larger facilities, marks a significant shift from the often manual or semi-mechanised labour seen in initial bush harvesting. While harvesting for power generation shares some similarities with charcoal production in terms of basic labour, the power plant itself demands a higher echelon of technical proficiency. This includes a deep understanding of complex industrial machinery (boilers, turbines, gasifiers), sophisticated control systems like SCADA, and stringent safety and environmental protocols. Training initiatives, such as those planned by NamPower for the Otjikoto plant and those implemented in smaller projects like the "Bush to Electricity" gasification initiative, are essential to build this skilled workforce.

For smaller, potentially decentralised biomass power or gasification units, as suggested by projects focusing on local energy solutions, the workforce requirements may differ. Operators and technicians in these settings might necessitate a broader, more versatile range of skills. Instead of highly specialised roles typical of large industrial plants, individuals may need to cover aspects of operation, routine maintenance, and even some basic feedstock handling and quality assessment. This multi-skilling approach is crucial for the economic viability and operational sustainability of smaller-scale rural energy initiatives.

Table 18: Occupations and Skills in the Biomass to Power Generation Value Chain

Occupations and Skills in the Biomass to Power Generation Value Chain				
Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Bush Harvesting & Feedstock Supply Logistics	Sustainable harvesting of encroacher bush, species identification, operation of harvesting machinery (manual, semi-mechanized, mechanized), collection, on-site handling, transportation to plant/depot, fuel supply contract management.	Bush Harvester / Forestry Worker	- Species identification, selective & sustainable harvesting techniques, - Operation of manual tools (axes, pangas) and machinery (chainsaws, chippers, tractors, forwarders) - Basic equipment maintenance - Adherence to environmental guidelines (FSC if applicable) - GPS operation	Physical fitness, safety consciousness, environmental awareness, teamwork, reliability.

Occupations and Skills in the Biomass to Power Generation Value Chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Bush Harvesting & Feedstock Supply Logistics	Sustainable harvesting of encroacher bush, species identification, operation of harvesting machinery (manual, semi-mechanized, mechanized), collection, on-site handling, transportation to plant/depot, fuel supply contract management.	Fuel Supply Logistics Coordinator / Manager	- Biomass resource assessment - Supply chain planning & optimization - Inventory management - Supplier negotiation & contract management - Quality control of incoming biomass - Understanding of transport logistics - Knowledge of sustainability certifications	Planning & organizational skills, negotiation, communication, problem-solving, analytical skills.
		Wood Chipper / Grinder Operator	- Operation of industrial chippers, grinders, hammer mills - Understanding of material properties - Blade/screen maintenance - Quality checks (chip size, moisture)	Mechanical aptitude, attention to detail, safety consciousness, operational discipline.
		Pellet Mill Operator (if applicable)	- Operation of pelletizing line (grinders, dryers, conditioners, pellet mills, coolers, sifters) - Understanding of pellet quality parameters (density, durability, moisture) - Process control - Routine maintenance	Process understanding, mechanical skills, attention to detail, quality focus.
Feedstock Pre-processing	Size reduction (chipping, grinding), drying, pelletizing (if applicable), quality control of processed feedstock.	Dryer Operator (if applicable)	- Operation of industrial biomass dryers - Moisture content monitoring and control - Understanding of drying principles and energy efficiency	Process control, attention to detail, understanding of thermodynamics.
		Boiler Operator (Biomass)	- Understanding of combustion principles - Operation of biomass boilers (stoker, fluidized bed) - Steam system management - Water chemistry monitoring - Safety procedures for high-pressure systems, emissions control	Vigilance, problem-solving, understanding of thermodynamics, safety focus, adherence to procedures.
Energy Conversion	Feeding biomass to boilers/gasifiers, operating combustion/gasification systems, managing syngas/steam.	Gasifier Operator	- Understanding of gasification principles (chemistry, thermodynamics), operation of gasification reactors and syngas cleaning systems - Monitoring gas quality - Safety protocols for handling flammable gases.	Process understanding, analytical skills (gas quality), troubleshooting, safety consciousness.

Occupations and Skills in the Biomass to Power Generation Value Chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Power Plant Operations & Control	Operating turbines, generators, auxiliary systems, SCADA monitoring, process optimization, emergency response.	Control Room Operator / Plant Operator	• SCADA system operation and interpretation • Monitoring and control of turbines • Generators, and plant processes • Understanding of plant interlocks and safety systems • Alarm management, data logging • Communication with field staff • Emergency procedures.	Operations monitoring, critical thinking, decision-making under pressure, strong attention to detail, communication, ability to interpret complex data.
		Auxiliary Plant Operator / Field Operator	• Local operation of plant equipment (pumps, fans, conveyors) • Routine inspections, minor adjustments • Assisting control room	Mechanical aptitude, observational skills, adherence to safety protocols, communication.
Maintenance & Repair	Routine, preventive, and corrective maintenance of mechanical, electrical, and I&C equipment, troubleshooting, spare parts management.	Mechanical Maintenance Technician	• Repair of rotating equipment (pumps, fans, turbines), static equipment (boilers, heat exchangers), conveyors and hydraulic/pneumatic systems • Welding • Machining • Reading mechanical drawings	Diagnostic skills, problem-solving, manual dexterity, knowledge of materials.
		Electrical Maintenance Technician	• Troubleshooting and repair of motors, generators, transformers, switchgear • Plant wiring • Reading electrical schematics • High-voltage safety	Electrical theory, troubleshooting skills, knowledge of electrical codes, safety focus.
		Instrumentation & Control (I&C) Technician	• Calibration, troubleshooting, and repair of sensors, transmitters, control valves, PLCs, and DCS/SCADA components, • Loop checking, reading P&IDs and control logic diagrams.	Understanding of control systems, electronics, analytical instrumentation, problem-solving.
Electricity Transmission & Grid Integration	Generator synchronization, switchyard operation, ensuring stable export to grid, compliance with grid codes.	Electrical Engineer (Grid/Substation)	• High-voltage equipment operation & maintenance • Protection relay testing & configuration • Grid synchronization procedures • Understanding of grid stability • Power flow analysis, SCADA for substations.	Analytical skills, problem-solving, knowledge of power systems, attention to detail.

Occupations and Skills in the Biomass to Power Generation Value Chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Environmental Compliance & Ash Management	Emissions monitoring, ash handling & disposal, adherence to environmental permits.	Environmental Compliance Officer	• Knowledge of environmental regulations (air, water, waste) • Emissions monitoring techniques • Waste management practices • Ash characterization and disposal options • Permit compliance and reporting.	Regulatory interpretation, analytical skills, record-keeping, communication with authorities.
		Ash Handler / Material Handler	• Operation of ash conveying and storage systems • Dust control measures • Safe handling of potentially hazardous materials • Basic equipment maintenance.	Safety consciousness, operational discipline, physical capability.
Overall Management	Plant operations management, budget control, personnel supervision, safety program management, strategic planning, regulatory liaison.	Plant Manager / Operations Manager	• Comprehensive knowledge of biomass power plant operations • Engineering principles • Financial management & budgeting • Human resource management • Safety & environmental regulations • Project management • Strategic planning.	Leadership, decision-making, critical thinking, problem-solving, communication, coordination, risk management.
		Project Manager (Construction Phase)	• Overseeing plant design • Procurement • Construction • Commissioning • Budget and schedule management • Contractor management	Project management methodologies, contract management, engineering design review, construction supervision, risk management, stakeholder communication.

5.3.3 Animal Feed from Bush



The effective utilisation of encroacher bush for animal feed hinges on a symbiotic relationship between indigenous knowledge and scientific expertise. Local farmers often possess generations of experience regarding local plant species, their palatability, and traditional uses. However, this traditional knowledge may not always align with optimal nutritional outcomes or address issues like anti-nutritional factors (e.g., tannins) effectively. Scientific research, on the other hand, provides detailed analysis of nutrient profiles, digestibility, the impact of processing techniques, and strategies for mitigating anti-nutritional factors. Successful workforce development in this subsector, therefore, must focus on bridging this gap. This can be achieved by training extension officers and advisors who are skilled in communicating scientific findings in a practical, accessible manner and who can work collaboratively with communities to integrate this knowledge with local practices. Furthermore, involving communities directly in research and pilot projects, as seen in the CARP+ initiative, can foster co-learning and ensure that innovations are contextually relevant and readily adopted¹⁷⁷.

Farmers engaging in on-farm or small to medium-scale bush-based feed production require a remarkably diverse and integrated skill set. Unlike specialised roles in larger industrial settings, these farmers often manage multiple stages of the value chain themselves. This includes sustainable harvesting of appropriate bush species, the operation and basic maintenance of various processing machinery (such as chippers, hammer mills, pelletisers, or silage-making equipment), understanding fundamental principles of animal nutrition for basic feed formulation and mixing with locally available supplements, and conducting rudimentary quality assessments of their products. For instance, a farmer might need to identify the right bush, harvest it, mill it, mix it with molasses and a protein source, and then feed it to their animals, all while managing costs and observing animal response. This necessitates holistic training programs that cover the entire on-farm production cycle, from rangeland to ration. The "train the trainers" model, emphasised in projects like CARP+, is particularly vital for achieving the necessary scale and reach to empower a large number of farmers with these multifaceted skills, thereby enhancing both their livelihoods and the resilience of the agricultural sector¹⁷⁸.

Footnotes

¹⁷⁷ https://www.researchgate.net/publication/384140245_Indigenous_knowledge_of_browse_species_and_nutritional_quality_of_dominant_Indigenous_browses_species_in_the_Kavango_West_Region_of_Namibia

<https://www.farm4tradesuite.com/blog/encroacher-bush-as-animal-feed-resources>

https://www.researchgate.net/publication/384140245_Indigenous_knowledge_of_browse_species_and_nutritional_quality_of_dominant_Indigenous_browses_species_in_the_Kavango_West_Region_of_Namibia

https://noa.org.na/images/Afrikaans_factsheets/Factsheet_new/Alternative_Feed_Supplements_for_Organic_Livestock.pdf

<https://repository.unam.edu.na/server/api/core/bitstreams/e7610b7d-5e89-4128-a83c-d9597b0b9a7c/content>

¹⁷⁸ http://the-eis.com/elibrary/sites/default/files/downloads/literature/Factsheet_Bush-to-Feed%202016.pdf

<https://akzente.giz.de/en/prickly-solution>

Table 19: Occupations and Skills in the Biomass to Animal Feed Value Chain

Occupations and Skills in the Biomass to Animal Feed Value Chain				
Value Chain Stage ¹⁷⁹	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Selective Harvesting of Nutritious Bush Species & Rangeland Management	Identifying nutritious/suitable bush species, selective & sustainable harvesting, operating harvesting tools/machinery, understanding rangeland health principles.	Forage Harvester / Bush Collector / Rangeland Worker	- Species identification (local flora, nutritional indicators, tannin presence) - Selective harvesting techniques (preserving biodiversity, promoting grass recovery) - Operation of manual tools (pangas, axes) and mechanized equipment (chainsaws, "Bosvreter", forage harvesters) - Basic equipment maintenance - Understanding of sustainable rangeland management practices (grazing patterns, bush density control)	Physical fitness, strong observational skills (plant health, animal preferences), environmental awareness, adherence to safety, patience, teamwork.
		Rangeland Management Advisor / Extension Officer	- Rangeland ecology - Plant identification - Sustainable harvesting planning - Knowledge of bush control methods and aftercare - Training and facilitation skills - Community mobilization.	
Feedstock Processing (Milling, Chipping, Pelletizing, Ensiling)	Reducing particle size (milling/chipping), pelletizing (mixing, conditioning, pressing, cooling), ensiling (chopping, adding inoculants/substrate, compacting, sealing).	Feed Mill Operator / Processing Technician	- Operation of hammer mills, chippers, pellet mills (including conditioners, coolers), silage making equipment (choppers, baggers, bunkers) - Understanding of process parameters (moisture, particle size, temperature, compaction) - Routine equipment maintenance and troubleshooting.	Mechanical aptitude, attention to detail, operational discipline, problem-solving, adherence to safety and hygiene protocols.
Feed Formulation & Supplementation	Analyzing bush nutritional content, identifying deficiencies and anti-nutritional factors (tannins), selecting and mixing appropriate supplements (energy, protein, minerals, tannin-binders like PEG).	Animal Nutritionist / Feed Formulator	- Deep knowledge of livestock (ruminant) nutrition, digestive physiology, interpretation of feed analysis reports (for bush and supplements) - Ration formulation techniques (manual or using software) - Understanding of nutrient requirements for different animal classes - Knowledge of anti-nutritional factors and mitigation (e.g., use of PEG, biochar) - Familiarity with feed additives and local supplement availability	Analytical skills, critical thinking, problem-solving, mathematical proficiency, communication skills (to explain formulations), research skills (staying updated).

Footnotes

- ¹⁷⁹ http://the-eis.com/elibrary/sites/default/files/downloads/literature/Factsheet_Bush-to-Feed%202016.pdf
https://panorama.solutions/sites/default/files/n-big_harvesting_and_processing_encroacher_bush_booklet_2023_0.pdf
<https://akzente.giz.de/en/prickly-solution>
<https://dialnet.unirioja.es/descarga/articulo/277661.pdf>

Occupations and Skills in the Biomass to Animal Feed Value Chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Quality Control & Laboratory Testing	Sampling ingredients and finished feed, conducting visual inspections, performing lab analyses (moisture, protein, fiber, ash, toxins), ensuring consistency and safety.	Quality Control / Laboratory Technician (Feed)	- Proficiency in feed sampling techniques, operation of laboratory equipment for proximate analysis (Kjeldahl for protein, Soxhlet for fat, muffle furnace for ash, fiber analysis apparatus) - Understanding of wet chemistry and potentially NIRS methods, mycotoxin testing - Record-keeping - Knowledge of feed safety standards and regulatory compliance	Meticulousness, accuracy, analytical skills, attention to detail, adherence to laboratory protocols, integrity.
Packaging, Storage, Marketing & Distribution	Bagging/bulk handling of feed, labeling, proper storage to maintain quality, developing marketing materials, sales, transport logistics.	Packaging & Warehouse Operator	- Operation of bagging, weighing, and sealing equipment - Forklift operation (if applicable) - Inventory management - Understanding of feed storage conditions (preventing mold, pests)	Organizational skills, attention to detail, physical stamina, reliability.
		Marketing & Sales Representative (Animal Feed)	- Knowledge of animal nutrition basics and product benefits - Understanding of local farming systems and livestock markets, sales and negotiation skills - Customer relationship management - Developing promotional materials, understanding of pricing and distribution channels.	Strong communication and interpersonal skills, persuasion, customer service orientation, business acumen.
Farmer Advisory & Extension Services	Training farmers on bush-feed production, sustainable harvesting, ration balancing, feeding trials, disseminating best practices.	Agricultural Extension Officer / Farmer Advisor	- Strong knowledge of local agricultural systems, animal husbandry, forage production (including bush-based) - Feed formulation principles - Sustainable land management - Adult education and training methodologies - Facilitation skills - Ability to conduct demonstrations and interpret trial results	Excellent communication and presentation skills, empathy, problem-solving, patience, ability to build trust with farmers, cultural sensitivity.
Overall Management (Small-scale producer/ Cooperative Manager)	Overseeing entire on-farm/cooperative operation: harvesting, processing, formulation, feeding/sales, record-keeping, basic financial management.	Farmer / Small-Scale Feed Producer / Cooperative Manager	- Broad understanding of the entire bush-to-feed process - Basic bookkeeping and business management - Equipment operation and maintenance - Animal observation skills (response to feed) - Knowledge of local regulations	Entrepreneurial spirit, adaptability, problem-solving, decision-making, resourcefulness, leadership (for cooperatives).

5.3.4 Biochar



Biochar production from encroacher bush is an emerging and promising subsector in Namibia, offering multifaceted benefits including sustainable soil amendment, effective carbon sequestration, and the potential for new revenue streams through carbon credit markets. Namibian initiatives, such as those by Omiti Biochar and projects supported by entities like N-BiG and the CARP+ project, are actively exploring and developing this value chain. The process transforms woody biomass into a stable, carbon-rich material with diverse applications¹⁸⁰.

The biochar sector, particularly with its strong linkages to carbon markets and soil science, is fostering the emergence of specialised "green-collar" jobs. Roles such as Digital Monitoring, Reporting, and Verification System Operators and Carbon Project Managers are becoming increasingly critical. These positions demand a unique blend of technical understanding of biochar production and stability, sophisticated data management capabilities, and in-depth knowledge of carbon accounting methodologies and evolving market standards. This signifies a shift towards a more data-driven and scientifically grounded approach within the biomass industry. Consequently, training programs must adapt to cultivate these new competencies, integrating elements of environmental science, data analytics, climate finance, and regulatory compliance to meet the demands of this innovative and growing field¹⁸¹.

Furthermore, the inherent characteristics of biochar production and handling—involving high temperatures, potential feedstock contaminants, and the generation of dust, volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs)—underscore the critical importance of specialised health and safety expertise. This goes beyond general industrial safety, requiring a nuanced understanding of the specific hazards associated with biochar. Workers at all levels, from feedstock preparation to final application, must be thoroughly trained in identifying these risks, correctly using PPE, understanding contaminant pathways, and adhering to specific emergency procedures.

Footnotes

- ¹⁸⁰ <https://carbonherald.com/how-carbon-removal-is-helping-solve-bush-encroachment-in-africa/>
<https://climateactionreserve.org/wp-content/uploads/2022/10/Biochar-Carbon-Credit-Analysis-BF-Reports-2022-compressed.pdf>
https://www.researchgate.net/publication/386148640_Role_of_biochar_made_from_low-value_woody_forest_residues_in_ecological_sustainability_and_carbon_neutrality
<https://www.rit.edu/sustainabilityinstitute/blog/what-biochar-and-how-it-made>
- ¹⁸¹ <https://www.sylvera.com/blog/sylveras-new-biochar-framework-ensuring-quality-and-trust-in-carbon-projects>
<https://www.bestongroup.com/industry-news/how-to-get-carbon-credit-from-biochar/>
<https://www.carbonfuture.earth/magazine/robust-data-management-for-carbon-removal-projects-5-things-cdr-suppliers-need-to-know>
<https://climateactionreserve.org/wp-content/uploads/2022/10/Biochar-Carbon-Credit-Analysis-BF-Reports-2022-compressed.pdf>

This specialised health and safety knowledge must be an integral and non-negotiable component of all vocational training and operational protocols within the biochar value chain to protect both worker well-being and environmental integrity¹⁸².

Table 20: Occupations and Skills in the Biomass to Biochar Value Chain

Occupations and Skills in the Biomass to Biochar Value Chain				
Value Chain Stage ¹⁸³	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Feedstock Sourcing, Characterization & Preparation	Harvesting bush, feedstock analysis (density, moisture, composition), drying, size reduction (chipping, grinding, sieving), decontamination (if needed), storage.	Feedstock Manager / Technician	- Sustainable harvesting practices, biomass sourcing & logistics - Operation of drying, chipping, grinding equipment - Basic feedstock characterization & quality control - Inventory management	Organizational skills, attention to detail, problem-solving, supplier communication
Pyrolysis Technologies & Operation	Operating pyrolysis reactors (fixed bed, kiln, retort etc., controlling temperature, heating rate, residence time, managing syngas/ bio-oil by-products.	Pyrolysis Plant Operator / Technician	- Operation of specific pyrolysis units - Understanding of thermochemical conversion principles - Process control & monitoring - Basic equipment maintenance & troubleshooting - Adherence to safety protocols for high-temperature operations	Mechanical aptitude, vigilance, problem-solving, attention to detail, adherence to operational procedures, safety consciousness
Biochar Quenching, Post-Processing & Activation	Cooling/quenching biochar, grinding/ sieving for particle size, pelletizing, activation (steam, chemical) to enhance properties	Biochar Processing Technician	- Operation of quenching, grinding, sieving, pelletizing, and activation equipment - Understanding of how post-processing affects biochar properties - Quality control of processed biochar	Attention to detail, mechanical skills, process understanding, adherence to safety
Quality Analysis & Characterization	Sampling biochar, lab testing (pH, C content, ash, moisture, porosity, contaminants like PAHs, heavy metals), adherence to IBI/EBC standards.	Biochar Quality Analyst / Lab Technician	- Proficiency in laboratory testing procedures for biochar characterization (e.g., elemental analysis, BET surface area, pH, proximate analysis) - Operation of analytical instruments (GC-MS, ICP-MS for contaminants) - Understanding of IBI/EBC standards & testing protocols - Data analysis & interpretation - Meticulous record-keeping.	Analytical skills, precision, attention to detail, ethical conduct, problem-solving in analytical methods

Footnotes

¹⁸² https://www.researchgate.net/publication/385158226_Potential_Health_Risks_Associated_with_Biochar-From_Production_to_Field_Application
<https://biochar-international.org/wp-content/uploads/2024/01/Biochar-Sustainability-Protocols-Mar-2011-Draft-1-1.pdf>

¹⁸³ <https://shapiroe.com/blog/biochar-production-feedstock/>
<https://en.wikipedia.org/wiki/Biochar>
<https://wpcdn.web.wsu.edu/cahnrs/uploads/sites/44/Biomass2Biochar-Chapter11.pdf>
<https://www.terra.do/climate-jobs/job-board/facility-director---biochar-farm-manager-SA-8330245/>

Occupations and Skills in the Biomass to Biochar Value Chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Packaging, Marketing & Distribution	Packaging biochar (various sizes/types), marketing to agriculture, construction, filtration sectors, B2B/B2C sales, logistics.	Packaging Operator	- Operation of bagging/packaging machinery, labelling, quality checks on packaging - Basic inventory.	Efficiency, attention to detail, manual dexterity
		Marketing & Sales Specialist (Biochar)	- Knowledge of biochar applications & benefits in various sectors (agriculture, industry) - Market research & analysis - Developing marketing materials, B2B/B2C sales strategies - Customer relationship management - Understanding of product value proposition (soil health, carbon sequestration)	Communication, persuasion, negotiation, presentation skills, market awareness, customer service
Carbon Credit Generation & dMRV	Using Digital Monitoring, Reporting, and Verification (dMRV) systems, tracking biomass flow, pyrolysis data, sequestration, preparing for audits, Life Cycle Assessment (LCA).	dMRV System Operator / Carbon Project Data Analyst	- Data management & analysis skills - Proficiency with dMRV software/platforms - Understanding of carbon accounting methodologies (e.g., Puro.earth, Isometric) - LCA principles, audit preparation - Meticulous record-keeping.	Analytical thinking, high attention to detail, data integrity focus, process-oriented, communication with auditors
		Carbon Project Manager	- Overseeing carbon credit project development & certification - Ensuring compliance with chosen standards - Stakeholder liaison (producers, verifiers, buyers) - Understanding of carbon market dynamics	Project management, knowledge of carbon markets & standards, regulatory understanding, communication, negotiation
Health & Safety Management	Implementing safety protocols, risk assessment for contaminants (PAHs, VOCs, dust, heavy metals), worker training on PPE and safe handling.	Health & Safety Officer / Coordinator	- In-depth knowledge of occupational health & safety regulations - Specific hazards related to biochar production & handling (dust, chemical exposure, heat stress) - Risk assessment, development & implementation of safety procedures - PPE management - Emergency response planning - Worker training	Strong safety ethos, attention to detail, communication, training skills, leadership in safety culture
Application Guidance (e.g., Agriculture)	Advising on biochar application rates, methods, soil testing, integration with farming practices.	Agronomist / Soil Scientist / Agricultural Advisor	- Soil science expertise - Understanding of biochar's effects on soil properties & plant growth - Ability to interpret soil & biochar analyses - Knowledge of appropriate application techniques & rates (the "4Rs") - Experience with field trials - Nutrient management	Advisory & communication skills, problem-solving, analytical skills, ability to translate research into practical advice for farmers

Occupations and Skills in the Biomass to Biochar Value Chain

Value Chain Stage	Key Processes	Key Occupations	Required Technical Skills	Required Soft Skills
Overall Management	Overseeing the entire facility/project, supply chain, production, quality, compliance, finance, team leadership.	Biochar Plant / Facility Manager / Director	• Comprehensive understanding of biochar production processes & technologies • Operational management • Supply chain management • Quality control systems • Environmental & safety compliance • Financial management & budgeting • Team leadership & development • Stakeholder management • Business development	Leadership, strategic thinking, problem-solving, decision-making, technical aptitude, communication, business acumen

5.3.5 Common Technical Skills Across Bush Biomass Subsectors



While each of the four bush biomass subsectors—charcoal, power generation, biochar, and animal feed—possesses unique value chains and specialised occupational roles, a careful analysis reveals a significant overlap in certain foundational and transferable skills. Identifying these commonalities is strategically important for Namibia. It allows for the development of synergistic training programs, fosters a more versatile and adaptable workforce, and can enhance overall efficiency in the burgeoning bioeconomy. A worker with core competencies in biomass handling, for example, might more easily transition or contribute to different subsectors as market demands and opportunities evolve.

Table 21: Cross-Cutting Skills areas in Bush Biomass Sub-sectors

Cross-Cutting Skills areas in Bush Biomass Sub-sectors		
Common Technical Skills ¹⁸⁴	Description	Key Occupations
Sustainable Bush Harvesting	Selective cutting of appropriate bush species, adherence to environmental guidelines, basic tool/equipment use for felling and collection.	All subsectors: Initial Feedstock Sourcing & Collection.
Basic Biomass Size Reduction (Chipping/Grinding)	Operation of chippers or grinders/hammer mills to reduce biomass particle size for further processing.	Power Generation (Feedstock Pre-processing), Biochar (Feedstock Preparation), Animal Feed (Feedstock Processing).
Operation of Basic Conveying Equipment	Managing conveyors for material transport within a processing facility.	Charcoal (Post-Carbonization), Power Generation (Feedstock Handling & Pre-processing), Biochar (Feedstock Prep & Post-Processing), Animal Feed (Processing).
Routine Equipment Monitoring & Minor Maintenance	Performing daily checks on machinery, lubrication, cleaning, identifying and reporting minor faults.	All subsectors: Harvesting, Processing, and Conversion stages involving machinery.
Fundamental Quality Assessment	Basic visual inspection of feedstock and products for obvious defects, contamination, or inconsistencies; basic moisture assessment.	All subsectors: Feedstock Reception, In-process Checks, Final Product Inspection.
Adherence to Health & Safety Protocols	Understanding and applying general workplace safety, use of PPE, fire prevention, safe handling of materials.	All subsectors: All operational stages.
Basic Record-Keeping & Data Logging	Documenting quantities harvested/processed, operational parameters, quality checks, inventory levels.	All subsectors: Increasingly important for traceability, compliance, and management.

Footnotes

¹⁸⁴ <https://fsc.org/en/newscentre/stories/from-bush-to-charcoal-the-greenest-charcoal-comes-from-namibia>
https://www.nampower.com.na/public/docs/biomass/BIO_Fuel%20Supply%20Fact%20Sheet_25Oct23_v1.0.pdf
http://the-eis.com/elibrary/sites/default/files/downloads/literature/N-BiG_Harvesting-and-Processing-Encroacher-Bush-Booklet_2023.pdf
https://neufin.co/capital/projects/Biochar-project-in-Namibia_a911e678-104e-46db-bd54-f795cdaa535f

5.4 Skills supply in Biomass



The existing educational and training landscape in Namibia provides a range of foundational and, in some areas, emerging specialised skills relevant to the biomass sector. This supply emanates from both the TVET sector, regulated by the Namibia Training Authority (NTA), and higher education institutions, primarily NUST and UNAM.

Key findings indicate that while foundational vocational and higher education programs exist, providing a base level of relevant skills, significant gaps persist when aligning these with the specific needs of the biomass value chains. The charcoal industry, largely informal at the primary production level, requires formalised training in sustainable harvesting and efficient kiln operation, alongside expertise in quality assurance and FSC certification, which are not explicitly covered in current mainstream TVET offerings. The animal feed sector, driven by farmer innovation, needs enhanced skills in bush-based feed formulation, specialised processing of woody biomass (ensiling, pelletising), on-farm quality control, and the integration of scientific research into practical application; existing agricultural qualifications offer foundational knowledge but lack this specific focus. The nascent biochar industry demands specialised knowledge in pyrolysis technologies, biochar characterisation, soil science applications, and the complex domain of carbon credit markets and dMRV systems – areas largely outside current standard engineering or agricultural curricula. Similarly, power generation from bush biomass necessitates advanced skills in operating and maintaining specialised plant technologies (e.g., gasifiers, biomass boilers), grid integration, and sustainable feedstock supply chain management, which require more than generic mechanical or electrical engineering qualifications.

Cross-cutting skills shortages are evident in sustainable harvesting practices tailored to Namibian encroacher bush conditions, operation and maintenance of specialised biomass processing equipment, robust quality control mechanisms across all value chains, and business management and entrepreneurship, particularly for SMEs. Furthermore, a critical need exists for integrating health, safety, and environmental compliance specific to biomass operations into all training programs.

5.4.1 TVET Sector Provision

The NTA plays a crucial role in developing and reviewing national Vocational Education and Training (VET) qualifications for registration on the National Qualifications Framework (NQF). This process involves industry stakeholders to ensure the relevance of training programs, and the NTA also produces associated training manuals and curricula. Vocational certificates typically fall within NQF Levels 1-4¹⁸⁵.

Several Vocational Training Centres (VTCs) across Namibia offer trades that provide foundational skills applicable to the biomass industry:

Agriculture-related Qualifications ¹⁸⁶	- National Vocational Certificates in Agriculture, focusing on Farm Machinery & Infrastructure (Levels 2-3), are available at institutions like Rundu VTC and Zambezi VTC. - Qualifications in Horticulture & Crop Husbandry (Levels 2-4) are offered by Rundu VTC, Zambezi VTC, Homestead Skills and Technical Education Academy, Ongcha VTC, RIK Technical College, National Youth Service (NYS), Welwitschia University (Mururani site), and Wolwedans Foundation Trust. - The NTA has a broader National Vocational Certificate in Agriculture (Level 4). Its unit standards include competencies such as managing farm infrastructure through maintenance and improvements, applying knowledge of value addition of farm produce, managing the sustainable utilisation of water in agriculture, managing wildlife on a farm, and procuring agricultural inputs.
Mechanical Trades ¹⁸⁷	- Welding and Metal Fabrication: National Vocational Certificates (Levels 2-4) are widely available at VTCs, including Eenhana, Rundu, Valombola, Zambezi, Gobabis, Namibian Institute of Mining and Technology (NIMT), NYS, Namibian College of Open Learning (NAMCOL), Niche Training Academy, and RIK Technical College. NTA unit standards for Metal Fabrication (e.g., Q0036 V2.0) cover applying safety rules, planning work, using hand and power tools, interpreting welding signs, assembling and testing oxy-acetylene equipment, and performing basic welding and cutting operations. - Boilermaking: Qualifications (Levels 2-4) are offered at Eenhana, Rundu, Valombola, Zambezi, Gobabis, and NIMT. NIMT, for example, provides training equipping artisans for mining, engineering, and construction, covering tasks like cutting plates, shaping material, and assembling parts by bolting, riveting, or welding. - Fitting and Machining/Turning: NIMT offers this at Level 3, and Windhoek VTC (WVTC) has non-NQF modular qualifications at Levels 1-3. NTA unit standards for a National Vocational Certificate in Mechanical Engineering (Fitting and Machining) (Level 2) include demonstrating understanding of engineering materials, installing and maintaining belts, pulleys, chain drives, sprockets, lifting loads, and maintaining valves and couplings. - Automotive Mechanics/Mechatronics: Various VTCs offer qualifications (Levels 1-4) in this area, which is relevant for the maintenance of agricultural machinery and transport vehicles used in biomass logistics.

Footnotes

¹⁸⁵ <https://www.nta.com.na/qualifications/>
<https://transcriptresearch.com/blogs/news/namibian-national-qualifications-framework>

¹⁸⁶ <https://www.nta.com.na/training-services/>
<https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>

¹⁸⁷ <https://www.nta.com.na/training-services/>
<https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>
<http://www.wvtc.edu.na/wp-content/uploads/2022/11/WF-combined.pdf>
<https://www.nimtnam.com/trades/boilermaking-and-welding>

Electrical Trades ¹⁸⁸	National Vocational Certificates in Electrical General (typically Levels 2-4, up to Level 5 at Rundu VTC) are provided by Nakayale VTC, Rundu VTC, Valombola VTC, Gobabis VTC, NIMT, NYS, Okakarara VTC, Ongha VTC, and WVTC (non-NQF modular). NTA unit standards for a National Vocational Certificate in Electrical Engineering (Electronics) (Level 2) encompass applying health and safety rules, planning work, using tools and instruments, understanding circuit concepts and measurements, analogue and digital electronics, and soldering/de-soldering tasks. Ondangwa Commercial College also offers Electrical General training (Levels 1-3) covering installation, repair, and maintenance of electrical systems.
Forestry/Bush Control ¹⁸⁹	- Direct "Forestry Operations" or "Bush Control" certificates are not listed as widely available from the VTCs. However, the NTA has developed unit standard ID 13971: "Coordinate tasks to manage undesirable plant encroachment in rangeland." This standard, intended for those in agriculture and natural resource management, specifies competencies to prepare for and implement plant encroachment management methods, including identifying beneficial and undesirable species, assessing encroachment magnitude, describing and implementing control methods (chemical, mechanical, biological, fire), preparing and using control tools (including chainsaws), and disposing of or utilising removed plants (including for energy harvesting). - Furthermore, organisations like the Cheetah Conservation Fund (CCF) Bush Pty Ltd have established internal standards and provide informal training for their bush harvesting operations, emphasising sustainable thinning regimes, species identification, adherence to permit requirements, safety (PPE usage), and minimal environmental impact.
Renewable Energy (Solar Focus) ¹⁹⁰	- Eenhana VTC offers a National Vocational Certificate in Solar Equipment Installation and Maintenance (Levels 1-5). Gobabis VTC provides training in Solar Maintenance (Levels 2-3). - A GIZ and NTA collaborative project has developed and implemented hands-on solar PV system training, including Training of Trainers (ToT) for VTC staff and courses for SMEs, hosted at Eenhana VTC. These courses cover energy systems, solar resources, off-grid PV systems, PV pumping, and solar water heaters.

A significant development is N-BiG's creation of three industry-specific qualification modules, which are currently in the process of registration with the NTA¹⁹¹:

- **Module 1:** National Vocational Certificate: Bush Control (BC)
- **Module 2:** National Vocational Certificate: Biomass Utilisation (BU)
- **Module 3:** National Vocational Certificates: BCBU SME Management (SME) While detailed curricula for these N-BiG certificates were not available in the provided materials, their titles clearly indicate direct relevance to the biomass sector's specific needs.

Footnotes

¹⁸⁸ <https://www.nta.com.na/training-services/>
<https://unitstandards.nta.com.na/wp-content/uploads/2020/08/Q1115-National-Vocational-Certificate-in-Electrical-Engineering-Electronics-Level-2.pdf>
<https://commercial-college.com/electrical-general-nta-level-123/>

¹⁸⁹ <https://www.nta.com.na/training-services/>
<https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>
<https://unitstandards.nta.com.na/wp-content/uploads/2020/08/ID13971.pdf>
<https://cheetah.org/bushblok/management/>

¹⁹⁰ https://energypedia.info/images/1/1a/Skills_Development_in_the_Field_of_Renewable_Energy_in_Namibia_GBE_Case_Study_GIZ_2023.pdf
<https://www.nta.com.na/training-services/>

¹⁹¹ <https://www.n-big.org/capacity-development-projects/>

5.4.2 Higher Education Sector Provision (NUST and UNAM)

Higher education institutions are crucial for supplying advanced technical, scientific, and managerial skills.

Namibia University of Science and Technology (NUST)¹⁹²

NUST hosts several faculties and institutes pertinent to biomass.

The Faculty of Engineering and the Built Environment (FEBE) offers programs such as:

- Bachelor of Engineering in Chemical Engineering: Graduates are equipped with chemical engineering principles for industries that process raw materials into higher-value goods.
- Bachelor of Engineering in Mechanical Engineering: Provides general mechanical engineering skills.
- Bachelor of Engineering in Electrical Power Engineering: Focuses on planning, designing, modelling, and solving electrical power systems problems.
- Master of Sustainable Energy Systems: A key program covering renewable energy technologies (explicitly including bioenergy), energy efficiency, energy management, environmental sustainability, project design, implementation, operation, maintenance, and policy generation. Admission is open to graduates from various engineering fields and even experienced professionals with degrees in economics, social sciences, or environmental studies.
- Master of Environmental Engineering: Relevant for sustainable resource management and waste-to-energy concepts.
- Programs in Industrial Engineering are also offered, focusing on process optimisation.

The Faculty of Health, Natural Resources and Applied Sciences (FHNRAS) provides:

- Bachelor of Science in Agriculture: Aims to impart knowledge of agricultural principles and problem-solving techniques relevant to Namibian farming sectors.
- Bachelor of Natural Resource Management: Offers a broad introduction to NRM principles, concepts, and problem-solving techniques.
- Postgraduate programs include a Doctor of Philosophy in Natural Resources Sciences and a Master of Natural Resources Management.

NUST also houses relevant institutes such as the Namibia Energy Institute (NEI), which engages in research and policy work related to energy, including renewables. The Biomass Utilisation by Sustainable Harvest (BUSH) initiative and the associated ButoVal Research Project are significant. ButoVal focuses on sustainable biomass utilisation from encroacher bush, developing processes like compaction into "bush cigars," cutting, rotary debarking, screening, milling, and de-sanding to produce wood and feed pellets, and raw materials for charcoal and fuel, all within a circular economy framework.

Footnotes

¹⁹² <https://www.nust.na/programmes>
<https://febe.nust.na/>
<https://solarenergymasters.net/master-of-sustainable-energy-systems-namibia-university-of-science-and-technology-nust/>
<https://fhnras.nust.na/>
<https://nei.nust.na/home>

University of Namibia (UNAM)¹⁹³

UNAM's Faculty of Agriculture, Engineering & Natural Sciences is central to skills supply for the biomass sector.

The School of Agriculture & Fisheries Sciences offers:

- Bachelor of Science in Agriculture (Honours) with specialisations in Crop Science (modules include Soil Science, Plant Physiology, Crop Production Systems, Pasture Science), Animal Science (modules include Animal Nutrition, Rangeland Management), Agricultural Economics, and Food Science and Technology.
- Bachelor of Science in Natural Resources (Honours) with specialisations in Fisheries and Aquaculture Science, Forestry and Rangeland Management (modules include Forest Ecology, Rangeland Ecology, Silviculture, Forest Mensuration, Natural Resource Management and Policy, Soil Science), Wildlife Management and Ecotourism, and Integrated Environmental Science.
- Master of Science programs are available in areas like Rangeland Resources and Management, Crop Science, Animal Science, and Food Science and Technology.

The School of Engineering & the Built Environment offers:

- Bachelor of Science in Mechanical Engineering (Honours), which includes modules like Fluid Mechanics and Energy Sources and Technologies (this module explicitly covers bioenergy principles, conversion, efficiency, and techno-economic analysis).
- Bachelor of Science in Electrical Engineering (Honours), which includes a module on Renewable Energy Technologies (this module details solar, wind, and explicitly bio-energy systems, their components, design, sizing, and grid integration).
- Master of Science programs in relevant engineering disciplines.

The School of Science offers:

- Bachelor of Science in Environmental and Geographical Sciences (modules include Environmental Impact Assessment, Natural Resource Governance, Sustainable Management of Forest and Rangelands, Ecosystems & Climate Change).
- Master of Science programs in Biodiversity Management (modules include Integrated Natural Resources Management, Biodiversity and Climate Change), Industrial Biochemistry (modules cover fermentation technology, biomass & production of single-cell protein), Microbiology (modules on wastewater microbiology, role of microorganisms in climate change adaptation including biofuel production), Renewable Energy Materials Science, Renewable Energy Photovoltaics (modules on Advanced Theory of Solar Cells, Renewable Energy), and Applied Geology (including EIA).

UNAM is also active in research and outreach, such as the Agri-PV Outreach Programme, which explores the synergy between agriculture and solar energy, and it has broader research programs in renewable energy. The National Laboratory of Sustainability Science (LANCIS) at UNAM addresses energy systems and environmental restoration among its research themes¹⁹⁴.

Footnotes

¹⁹³ <https://www.unam.edu.na/faculty-of-agriculture-natural-resources>
<https://nagoya.repo.nii.ac.jp/record/7183/files/15-27.pdf>
<https://www.unam.edu.na/wp-content/uploads/2024/12/2025-Prospectus-School-of-Agriculture-Fisheries-Sciences.pdf>
<https://forumonline.unam.edu.na/agri-pv-outreach-programme-inspires-young-minds-in-renewable-energy/>
<https://www.eurekalert.org/news-releases/1084954>
<https://www.ecologia.unam.mx/web2/index.php/en/research/lanca-lab>

¹⁹⁴ <https://forumonline.unam.edu.na/agri-pv-outreach-programme-inspires-young-minds-in-renewable-energy/>
<https://www.ecologia.unam.mx/web2/index.php/en/research/lanca-lab>

The current skills supply landscape suggests that while foundational trade skills and general academic qualifications in engineering, agriculture, and natural sciences are available, highly specialised, dedicated programs for the diverse biomass subsectors are less common. Many existing programs can be applied to biomass, but they may not offer the depth of specific expertise required for advanced or niche applications within the sector.

This observation points towards an emerging phase of specialisation. Initiatives like N-BiG's vocational certificates, NUST's BUSH/ButoVal project focusing on applied research and processing technologies, UNAM's inclusion of bioenergy in specific engineering modules, and Perivoli Rangeland Institute (PRI's) practical biochar training are indicative of a growing recognition of the need for more tailored skills. These efforts, however, are not yet system-wide and represent early steps towards a more specialised skills ecosystem¹⁹⁵.

Industry bodies such as N-BiG and research-focused institutions like PRI and NUST's institutes are taking a proactive stance in defining and sometimes delivering specialised training. This is a common characteristic of developing sectors where formal education systems may adapt more slowly to rapidly evolving industry needs. The success of these initiatives and their formal integration into the national qualifications framework will be crucial for ensuring standardised and recognised skills development.

Even within relevant university programs in agriculture or engineering, there may be curricular gaps concerning advanced topics critical for maximising biomass value addition. For example, detailed instructions on biorefinery processes, advanced thermochemical conversion technologies like gasification or pyrolysis for specific products beyond basic principles, or the engineering of specialised biochar production units might be limited. Available information indicates some relevant modules, but often these appear to be at an introductory or survey level for biomass-specific aspects, rather than deep dives into complex biomass engineering.

Finally, while VTCs provide a solid base of foundational trade skills in areas like welding, electrical work, and mechanics, the direct application of these skills to the specific equipment, processes, and safety standards of the biomass industry (e.g., maintenance of pelletisers, gasifiers, specialised harvesters, or biomass boilers) may require additional, targeted post-qualification training or an updating of existing VTC curricula to include biomass-specific contexts.

The following tables provide an overview of the relevant qualifications identified:

Table 22: Bush Biomass- Relevant TVET Qualifications and Specialisations

Bush Biomass- Relevant TVET Qualifications and Specialisations			
VTC Name / Provider ¹⁹⁶	Relevant Trade/Qualification	NQF Level(s)	Specific Biomass Relevance
Eenhana VTC	Metal Fabrication (Boiler Making)	2-4	Construction/maintenance of biomass boilers
Eenhana VTC	Solar Equipment Installation & Maintenance	1-5	General renewable energy, some transferable skills
Rundu VTC	Agriculture: Farm Machinery & Infrastructure	2-3	Operation/maintenance of harvesting/transport equipment
Rundu VTC	Agriculture: Horticulture & Crop Husbandry	2-4	Biomass feedstock production basics

Footnotes

¹⁹⁶ <https://www.nta.com.na/training-services/>
<https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>
<https://unitstandards.nta.com.na/wp-content/uploads/2020/08/ID13971.pdf>
<https://www.nimtnam.com/trades/boilermaking-and-welding>
<https://www.n-big.org/capacity-development-projects/>
<http://www.wvtc.edu.na/wp-content/uploads/2022/11/WF-combined.pdf>

Bush Biomass- Relevant TVET Qualifications and Specialisations

VTC Name / Provider	Relevant Trade/Qualification	NQF Level(s)	Specific Biomass Relevance
Rundu VTC	Boiler Making	2-4	Construction/maintenance of biomass boilers
Rundu VTC	Electrical General	2-5	Electrical systems in biomass plants
Valombola VTC	Metal Fabrication (Boiler Making / Welding)	2-4	Equipment fabrication/repair, boiler work
Valombola VTC	Electrical Engineering (General / Electronics)	2-4	Electrical systems, controls in biomass plants
Zambezi VTC	Agriculture: Farm Machinery & Infrastructure	2-3	Operation/maintenance of harvesting/transport equipment
Zambezi VTC	Metal Fabrication (Boiler Making / Welding)	2-4	Equipment fabrication/repair, boiler work
Gobabis VTC	Welding & Metal Fabrication / Boilermaking	2-3	Equipment fabrication/repair, boiler work
NIMT	Electrical General, Diesel Mechanics, Boilermaking, Fitting & Turning, Instrumentation	3	Core engineering trades for plant O&M
NYS	Farm Machinery & Infrastructure, Agriculture, Various Trades (Welding, Electrical etc.)	2-5	Feedstock production, general trades
NAMCOL	Metal Fabrication (Welding), Automotive Mechanics	1-4	General fabrication, machinery maintenance
NTA (Unit Standards)	Coordinate tasks to manage undesirable plant encroachment in rangeland	(Level not specified)	Direct bush control skills
NTA (Qualifications)	National Vocational Certificate in Agriculture	4	Farm management, sustainable water use, value addition
N-BiG (in development)	National Vocational Certificate: Bush Control (BC)	(Pending NTA Reg.)	Specialised bush control
N-BiG (in development)	National Vocational Certificate: Biomass Utilisation (BU)	(Pending NTA Reg.)	Specialised biomass processing
N-BiG (in development)	National Vocational Certificate: BCBU SME Management (SME)	(Pending NTA Reg.)	Business skills for biomass enterprises

Table 23: Bush Biomass- Relevant Higher Education Degrees and Specialisations at NUST & UNAM

Bush Biomass- Relevant Higher Education Degrees and Specialisations at NUST and UNAM

Institution ¹⁹⁷	Faculty/School	Degree Program	Specialisation/Relevant Modules for Biomass
NUST	Engineering & Built Environment	BSc Eng. Chemical Engineering	Chemical processing, value addition
NUST	Engineering & Built Environment	BSc Eng. Mechanical Engineering	Machinery design, O&M, thermal processes
NUST	Engineering & Built Environment	BSc Eng. Electrical Power Engineering	Power generation, grid integration, plant electrics
NUST	Engineering & Built Environment	MSc Sustainable Energy Systems	Renewable energy tech (incl. bioenergy), policy, management.
NUST	Engineering & Built Environment	MSc Environmental Engineering	Sustainable resource management, waste-to-energy

Bush Biomass- Relevant Higher Education Degrees and Specialisations at NUST and UNAM

Institution	Faculty/School	Degree Program	Specialisation/Relevant Modules for Biomass
NUST	Health, Natural Resources & Applied Sciences	BSc Agriculture	Feedstock production, agricultural practices
NUST	Health, Natural Resources & Applied Sciences	BSc Natural Resource Management	Sustainable harvesting, ecosystem management.
NUST	(Institutes)	BUSH/ButoVal Research Project	Applied research in biomass processing, pellets, fuel
UNAM	Agriculture, Engineering & Natural Sciences	BSc Agriculture (Hons)	Crop science, animal science (nutrition, rangeland management.), soil science
UNAM	Agriculture, Engineering & Natural Sciences	BSc Natural Resources (Hons)	Forestry & Rangeland Management. (ecology, silviculture, NRM policy), integrated environmental science
UNAM	Agriculture, Engineering & Natural Sciences	BSc Mechanical Engineering (Hons)	Energy sources & technologies (incl. bioenergy)
UNAM	Agriculture, Engineering & Natural Sciences	BSc Electrical Engineering (Hons)	Renewable energy technologies (incl. bioenergy)
UNAM	Agriculture, Engineering & Natural Sciences (School of Science)	MSc Biodiversity Management	Integrated NRM, climate change impacts
UNAM	Agriculture, Engineering & Natural Sciences (School of Science)	MSc Industrial Biochemistry	Fermentation, biomass for SCP
UNAM	Agriculture, Engineering & Natural Sciences (School of Science)	MSc Microbiology	Wastewater management., biofuel production (microbial)
UNAM	Agriculture, Engineering & Natural Sciences (School of Science)	MSc Renewable Energy (Materials/PV)	Broader renewable energy context

5.4.3 Analysis of Skills Gaps in the Namibian Biomass Sector

A direct comparison of the occupational and skills requirements outlined in Section 3.3 with the current skills supply detailed in Section 3.4 reveals several gaps across Namibia's biomass subsectors. These gaps span vocational, technical, managerial, and research competencies and are evident at both TVET and higher education levels.

Charcoal Subsector Gaps¹⁹⁸

The charcoal sector requires skills in sustainable harvesting, modern and efficient kiln technology, consistent quality control, adherence to standards like FSC, and effective business management for its numerous small-scale producers.

- **Current Supply:** While UNAM offers general forestry principles within its Natural Resources programs, and the NYS has provided some training in charcoal production, dedicated, widespread formal training in modern, efficient, and sustainable charcoal production techniques is limited. The N-BiG certificates for Bush Control, Biomass Utilisation, and SME Management are still in development and not yet widely implemented. Much of the existing skill base relies on traditional, on-the-job learning.
- **Identified Gap:** There is a significant lack of accessible, formal training programs specifically addressing efficient carbonisation technologies (e.g., retort kilns to improve yield and reduce emissions beyond traditional methods), comprehensive quality assurance protocols for export markets, and business management skills tailored to the unique operational context of small-scale charcoal entrepreneurs. The scale of NYS training relative to the over 1,300 producers is also a point of consideration.

Footnotes

¹⁹⁸ <https://www.unam.edu.na/wp-content/uploads/2024/12/2025-Prospectus-School-of-Agriculture-Fisheries-Sciences.pdf>
<https://thebrief.com.na/2025/04/namibia-to-create-3600-jobs-through-global-accelerator-project/>
<https://www.n-big.org/capacity-development-projects/>

Biomass Power Generation Subsector Gaps¹⁹⁹	This emerging subsector, exemplified by the Otjikoto Power Plant, demands specialised skills in biomass power plant operation, targeted operation and maintenance (O&M) for systems fuelled by wood chips, biofuels engineering, and advanced electrical and mechanical engineering specific to biomass energy conversion, including process control and instrumentation. • Current Supply: NUST and UNAM provide general Mechanical and Electrical Engineering degrees. NUST's Master in Sustainable Energy Systems is highly relevant but is a postgraduate qualification. VTCs offer foundational electrical and mechanical trades. • Identified Gap: A clear shortage exists of specialized technicians and engineers with practical, hands-on experience in biomass-specific power plant technologies, such as the combustion of wood chips from encroacher bush. Generic engineering degrees may lack dedicated modules on the thermodynamics of biomass conversion, design and operation of biomass-fired boilers, flue gas treatment specific to biomass combustion, or advanced control systems for such plants. VTC qualifications, while providing a base, would require substantial upskilling and specialisation for personnel to be effective in a biomass power plant environment.
Biochar Sub-sector Gaps²⁰⁰	The biochar sector needs skills in pyrolysis technology operation, kiln management, quality control of biochar, knowledge of its application for soil improvement, and project management for production initiatives. • Current Supply: Training initiatives like those by PRI are valuable but currently niche and project-based. UNAM's MSc in Industrial Biochemistry touches upon biomass for single-cell protein, which involves related biotechnological principles, and NUST's Chemical Engineering degree provides a foundation. However, specific TVET or widespread university programs dedicated to biochar production and technology are largely absent. • Identified Gap: There is a substantial gap in formal, accredited training programs for biochar production specialists and technicians. Current expertise appears concentrated within research institutions and pilot projects. The lack of VTC-level qualifications, such as a "Biochar Production Technician" certificate, hinders the development of a skilled workforce for scaling up this subsector.
Animal Feed from Bush Subsector Gaps²⁰¹	This subsector requires specialised knowledge in identifying local encroacher bush species suitable for feed, sustainable harvesting methods tailored for animal feed production, specific processing techniques (milling, mixing, pelletising of tough, woody biomass), formulation of balanced feeds using these unconventional ingredients, and nutritional analysis of bush-based feeds. • Current Supply: A body of experiential knowledge exists among farmers. UNAM's BSc Agriculture (with options in Animal Science and Rangeland Management) and NUST's BSc Agriculture provide general agricultural principles. VTC agriculture programs cover general farm machinery operation and crop/animal husbandry. • Identified Gap: There is a deficiency in specialised training focused on the unique aspects of utilising Namibian encroacher bush for animal feed. This includes in-depth knowledge of the nutritional profiles of diverse local encroacher species (which can vary significantly), appropriate processing technologies to enhance digestibility and safety (e.g., managing high lignin content or anti-nutritional factors like tannins), and practical feed formulation based on these variable and often low-protein raw materials. General agriculture courses may not adequately cover these specific challenges and opportunities.

Footnotes

¹⁹⁹ <https://allafrica.com/stories/202505050623.html>

<https://www.nust.na/programmes>

<https://www.unam.edu.na/wp-content/uploads/2024/12/2025-Prospectus-School-of-Engineering-the-Built-Environment.pdf>

<https://www.nta.com.na/training-services/>

²⁰⁰ <https://perivolirangeland.com/projects/large-farms/>

<https://www.ugandajob.com/job-vacancies-uganda/biochar-operations-specialist-mechanical-masindi-kiryandongo-102176>

<https://www.unam.edu.na/wp-content/uploads/2023/12/2024-Prospectus-School-of-Science.pdf>

<https://www.nust.na/programmes>

²⁰¹ <http://the-eis.com/elibrary/sites/default/files/downloads/literature/Animal%20Feed%20from%20Namibian%20encroacher%20bush.pdf>

<https://www.ankawini.com/about-boskos.html>

<https://www.unam.edu.na/wp-content/uploads/2024/12/2025-Prospectus-School-of-Agriculture-Fisheries-Sciences.pdf>

<https://www.nta.com.na/training-services/>

<https://www.nust.na/programmes>

Cross-Cutting Skills Gaps²⁰²

Beyond subsector-specific needs, several overarching skills gaps affect the entire biomass industry:

- **Advanced Technical Skills for Value Addition:** While basic processing is addressed, skills for developing and operating more complex biomass conversion technologies (e.g., gasification for syngas production, pyrolysis for bio-oils, biorefineries for extracting chemicals and producing advanced biofuels) appear largely absent from current mainstream curricula. The ButoVal project's aim to produce pellets and raw materials for fuel suggests an emerging need for such advanced processing skills.
- **Entrepreneurship and Business Management for Biomass SMEs:** Although N-BiG is developing an SME management certificate, there is likely a broader gap in widespread, accessible training that integrates core business skills (finance, marketing, operations, HR) with the specific nuances of biomass enterprises. This includes understanding biomass value chains, accessing markets for biomass products, financing biomass technologies, and navigating relevant regulations.
- **Research and Development (R&D) Capacity:** The National Human Resources Plan (NHRP 2010-2025) previously highlighted a systemic lack of qualified graduates in engineering, biology, and chemistry, which constrains national capacity for applied research in critical sectors like agriculture and manufacturing. While NUST and UNAM have commendable research initiatives (e.g., NUST's ButoVal project, UNAM's LANCIS and renewable energy research), dedicated and well-resourced R&D capacity focused on Namibian biomass challenges—such as developing locally adapted conversion technologies, optimising feedstock processing, and creating new value-added products—requires significant strengthening.
- **Sustainability and Comprehensive Environmental Management:** While some university programs include modules on Environmental Impact Assessment (EIA) and sustainable natural resource management, the integration of comprehensive sustainability practices—such as life cycle assessment (LCA) of biomass products, implementation of circular economy principles, and ensuring robust social safeguards in biomass project development—across all levels of biomass-related training is crucial and potentially underdeveloped. The skills needed for FSC certification auditing or navigating the socio-economic aspects of a "just transition" require more than general environmental awareness.
- **Data Management and Digital Skills:** As noted previously, the increasing adoption of technology for biomass resource assessment and for monitoring and evaluation in projects like biochar production points to an emerging gap in digital literacy and data handling skills specifically tailored for the biomass sector.

Footnotes

- ²⁰² <https://www.bioenergy-news.com/news/innovative-biomass-initiative-launched-in-namibia/>
<https://bioenergytimes.com/namibia-launches-butoval-project-to-combat-bush-encroachment-and-boost-biomass-utilisation/>
<https://www.n-big.org/capacity-development-projects/>
<https://www.ecologia.unam.mx/web2/index.php/en/research/lanca-lab>
<https://forumonline.unam.edu.na/agri-pv-outreach-programme-inspires-young-minds-in-renewable-energy/>
<https://www.marketwatch.com.na/business/biomass-industry-going-from-strength-to-strength2025-04-16154170>
<https://www.unam.edu.na/wp-content/uploads/2024/12/2025-Prospectus-School-of-Agriculture-Fisheries-Sciences.pdf>
<https://www.nta.com.na/training-services/>
<https://www.nust.na/programmes>

The systemic issues identified in past national plans, such as the NHRP (2010-2025), regarding the VET system's limited access, traditional trade focus, and shortages of experienced instructors, likely continue to affect the biomass sector's ability to source appropriately skilled vocational personnel. The current TVET Skills Development Plan (SDP2 2022-2026) does prioritise "Bush Control" with a target of 550 trainees and "Solar Equipment Maintenance Installer" with 200 trainees. This is a positive development. However, "Biomass Utilisation" in its broader sense, particularly for power generation technicians or specialised biochar operators, is not explicitly prioritised with trainee targets in the same plan, suggesting a potential oversight in addressing the full spectrum of the biomass industry's needs²⁰³.

A significant area of concern across multiple subsectors is the "missing middle" – the cohort of skilled technicians and supervisors who operate at a level above basic VTC certificate holders but do not necessarily require full engineering degrees. These roles are vital for operating and maintaining increasingly sophisticated biomass processing equipment, overseeing production lines, ensuring quality control, and bridging the gap between engineers and on-the-ground operators. The current NQF structure includes Diplomas at Levels 5 and 6, but the availability of programs at these levels specifically tailored to biomass technologies (e.g., a Diploma in Bioenergy Plant Operations, or Advanced Charcoal Production Technology) is not clearly evident from the available data²⁰⁴.

The development of specialised curricula, such as the N-BiG certificates and the research-driven training in projects like ButoVal, indicates that curriculum development is often reactive to immediate industry needs or specific project outcomes. This suggests a potential lag in the formal education system's capacity to anticipate and systematically address the specialised skill requirements of an emerging and rapidly evolving sector like biomass. A more proactive and nationally coordinated strategy for biomass skills development is needed²⁰⁵.

Furthermore, while technical skills are paramount, a general deficit in soft skills (such as problem-solving, critical thinking, communication, teamwork, and adaptability) may also impact the biomass workforce's overall effectiveness. The NHRP's earlier concerns about the VET system and the SDP2's current emphasis on integrating employability skills into training programs suggest this is a broader challenge that extends to the biomass sector.

Table 24: Matrix Summarising the Identified Skills Gaps per Sub-sector, Differentiating between TVET and Higher Education

Matrix Summarising the Identified Skills Gaps per Sub-sector, Differentiating between TVET and Higher Education			
Biomass Subsector	Specific Skill/Competency Required	Current TVET Supply (Relevant Qualifications/Modules & Identified Gap)	Current Higher Education Supply (Relevant Degrees/Modules & Identified Gap)
Charcoal	Sustainable harvesting practices (FSC compliant)	NTA Bush Control Unit Standards (limited uptake); N-BiG BC Cert (dev). Gap: Widespread, accredited training.	UNAM Forestry/NRM (general principles). Gap: Specific FSC auditing/operational skills.
	Modern/efficient Kiln Operation & maintenance	Informal on-the-job. Gap: Formal training in retort/advanced kilns.	Eng. degrees (general mech./chem. principles). Gap: Specific kiln design/optimisation.
	Charcoal quality control & grading	Minimal formal. Gap: Standardised QC training.	Science degrees (general lab skills). Gap: Applied charcoal analysis.
	Small Business management. for charcoal producers	N-BiG SME Cert (dev). Gap: Accessible, tailored business training.	General business degrees. Gap: Biomass SME specifics.

Footnotes

²⁰³ <https://ean.org.na/download/republic-of-namibia-national-human-resources-plan-2010-2025/>

²⁰⁴ <https://transcriptresearch.com/blogs/news/namibian-national-qualifications-framework>

²⁰⁵ <https://www.n-big.org/capacity-development-projects/>
<https://www.bioenergy-news.com/news/innovative-biomass-initiative-launched-in-namibia/>

Matrix Summarising the Identified Skills Gaps per Sub-sector, Differentiating between TVET and Higher Education

Biomass Subsector	Specific Skill/Competency Required	Current TVET Supply (Relevant Qualifications/Modules & Identified Gap)	Current Higher Education Supply (Relevant Degrees/Modules & Identified Gap)
Biomass Power Generation	Biomass power plant operation	VTC Electrical/mechanical (foundational). Gap: Specialised biomass plant operator training.	NUST MSc Sust. Energy (PG); UNAM Eng. (bioenergy modules). Gap: Undergrad specialisation; hands-on plant O&M.
	Maintenance of biomass boilers, turbines, feedstock systems	VTC Trades (general). Gap: Specifics of biomass equipment.	Mech./Elect. Eng. (general). Gap: Design/maintenance of specialised biomass power components.
	Process control & instrumentation for biomass plants	VTC Electronics (basic). Gap: Advanced process control for biomass systems.	Eng. degrees (general control theory). Gap: Applied instrumentation for biomass plants.
Biochar	Pyrolysis technology & kiln operation	PRI training (niche). Gap: Formal VTC "biochar technician" qualification.	NUST Chem Eng (foundational); UNAM Ind. Biochem (related). Gap: Dedicated biochar engineering/tech programs.
	Biochar quality control & analysis	Minimal formal. Gap: Standardised QC for biochar.	Science degrees (general lab). Gap: Specialised biochar characterisation.
	Biochar application & soil science	PRI training (niche). Gap: Agronomic training on biochar use.	UNAM Agri./soil science (general). Gap: Specifics of biochar-soil interactions, application protocols.
Animal feed from bush	Bush species ID & nutritional profiling (Namibian context)	Farmer knowledge. Gap: Formal training on local species.	UNAM Agri./rangeland (general). Gap: In-depth local bush nutrition.
	Sustainable harvesting for feed quality	Farmer knowledge; NTA Bush Control (general). Gap: Harvesting for optimal feed value.	UNAM NRM/Forestry (general). Gap: As above.
	Bush processing (milling, treatment, pelletising)	Farmer knowledge. Gap: VTC training on bush-specific processing equipment.	Agri. Eng. (general machinery). Gap: Design/optimisation of bush processing tech.
	Bush-based feed formulation & safety	Farmer knowledge. Gap: Formal training on formulating with bush.	UNAM Animal Science (general nutrition). Gap: Specifics of bush feed formulation, anti-nutritional factors.

5.4.3 Strategic recommendations for bridging the gaps in the Biomass Sector

Addressing the identified skills gaps requires a concerted and strategic effort involving educational institutions, industry stakeholders, and government bodies. The following recommendations are proposed to build a robust human capital base for Namibia's biomass sector:

Enhancing TVET Curricula and Delivery:

Formalise and Scale N-BiG Certificates:

Prioritise the full registration of the National Vocational Certificates in Bush Control (BC), Biomass Utilisation (BU), and BCBU SME Management (SME) through the Namibia Training Authority (NTA). Subsequently, these curricula should be rolled out through capable VTCs, ensuring they are industry-validated, adequately resourced with appropriate training equipment and materials, and delivered by qualified instructors²⁰⁶.

Footnotes

²⁰⁶ <https://www.n-big.org/capacity-development-projects/>

Enhancing TVET Curricula and Delivery:

Develop New Specialised Biomass Unit Standards, Certifications and Qualifications:

Based on the detailed gap analysis, collaborate with the NTA and industry experts (including N-BiG, CAoN, and companies in power generation and biochar) to develop new national unit standards and qualifications. These should target roles such as "Biomass Power Plant Technician," "Biochar Production and Application Technician," and "Bush-to-Feed Processing Operator." These qualifications should ideally align with NQF Levels 3-5 to address the "missing middle" technical skills.

Integrate Biomass Modules into Existing Trades:

Revise and update the curricula for existing VTC trades like Mechanical Fitting, Welding, Electrical General, and Agriculture. This revision should incorporate specific modules addressing the application of these trades to biomass equipment (e.g., maintenance of pelletisers, chippers, biomass boilers, kilns), unique materials used, relevant safety standards, and basic principles of biomass conversion processes. This would enhance the direct applicability of foundational trade skills.

Strengthen VTC Capacity and Resources:

Address the systemic issues previously noted in the VET system by investing in the upgrading of VTC workshops and equipment to include modern biomass processing tools suitable for training (e.g., small-scale gasifiers, pellet mills, various types of biochar kilns). Equally important is the enhancement of instructor training and continuous professional development, potentially through specialised Training of Trainers (ToT) programs, adapting successful models like the GIZ/NTA solar training initiative for biomass technologies²⁰⁷.

Promote and Expand Work-Integrated Learning (WIL) and National Internship Programme & Youth Tax Allowance:

Actively expand apprenticeship and internship opportunities for TVET learners within biomass companies. This practical, on-the-job experience is invaluable and aligns with NTA's National Policy on Work-Integrated Learning for Technical and Vocational Education²⁰⁸. A recent government-backed incentive, the National Internship Programme and Youth Tax Allowance, encourages employers to employ interns in lieu of paying lower corporate taxes.

Strengthening Higher Education Programs (NUST & UNAM):

a. Introduce Specialised Biomass Programs or Streams:

NUST and UNAM should explore the development of dedicated Bachelor's or Master's degree programs, or at least clearly defined specialisations/streams within existing programs, focusing on areas like Bioenergy Engineering, Biomass Science and Technology, or Sustainable Biomass Management. This would cultivate a cadre of highly skilled professionals with deep expertise.

b. Develop and Integrate Advanced Biomass Modules:

Existing Engineering (Chemical, Mechanical, Electrical, Environmental, Industrial), Agriculture, and Natural Resource Management degree programs should be reviewed and enhanced. This involves incorporating more in-depth modules on specific biomass conversion pathways (e.g., detailed thermodynamics and kinetics of pyrolysis and gasification, anaerobic digestion system design, biorefining concepts), bioenergy systems engineering, advanced combustion technologies for biomass, comprehensive biochar properties and engineering applications, and sustainable feedstock logistics and characterisation. This would address the current situation where biomass-specific content is often at an introductory level within broader modules.

c. Foster Industry-Academia Research & Innovation:

Actively strengthen and formalise applied research collaborations between NUST, UNAM, and the biomass industry (including N-BiG, individual companies, and international partners). Support joint R&D projects, similar to NUST's ButoVal initiative, that focus on addressing local Namibian biomass challenges, developing innovative and locally adapted technologies, and creating new value-added products. Findings from such research should feed back into curriculum development²⁰⁹.

Footnotes

²⁰⁷ <https://ean.org.na/download/republic-of-namibia-national-human-resources-plan-2010-2025/>

²⁰⁸ <https://unitstandards.nta.com.na/wp-content/uploads/2020/07/Q1101-National-Vocational-Certificate-in-Agriculture-Level-4.pdf>
<http://www.wvtc.edu.na/wp-content/uploads/2022/11/FT-combined.pdf>

²⁰⁹ <https://www.bioenergy-news.com/news/innovative-biomass-initiative-launched-in-namibia/>

Strengthening Higher Education Programs (NUST & UNAM):	d. Support Postgraduate Research in Biomass: Establish dedicated scholarships, research grants, and post-doctoral fellowship opportunities for Master's and PhD students whose research focuses on critical aspects of Namibia's biomass sector. This will build local expert knowledge, drive innovation, and provide future academics and industry leaders.
Cross-Sectoral Collaboration and Policy Alignment	a. Establish a National Biomass Skills Development Task Force: Create a formal, multi-stakeholder platform comprising representatives from N-BiG, CAoN, other key industry players, NTA, NQA, NUST, UNAM, and relevant Government Ministries (e.g., Labour, Higher Education, Energy, Forestry, Agriculture). This task force should be mandated to provide ongoing guidance on biomass skills forecasting, curriculum development and review, quality assurance mechanisms, and the alignment of training efforts with industry needs. b. Align Biomass Skills with National Development Strategies: Ensure that the skills requirements for the biomass sector are explicitly integrated into future revisions of the National Human Resources Plan, National Development Plans (NDPs), and sector-specific strategies for energy, agriculture, industrialisation, and environmental management. The current TVET SDP2 requires a more explicit and comprehensive focus on the diverse skills needed for biomass utilisation beyond basic bush control²¹⁰. c. Standardise and Accredite Industry-Led and Project-Based Training: Facilitate the process for NQA accreditation of training programs and qualifications developed by industry bodies (like N-BiG's certificates) or research institutes (like PRI's biochar training). This will ensure quality, national recognition, and transferability of these specialised skills, addressing the current reactive nature of some curriculum development²¹¹.
Short-Term Interventions and Upskilling Initiatives	a. Develop and Deliver Targeted Short Courses and Micro-Credentials: Offer accessible, specialised short courses, workshops, and potentially micro-credentials for upskilling the existing workforce and providing focused training for new entrants. These should cover specific, in-demand skills such as sustainable bush harvesting techniques, operation of specific kilns (charcoal, biochar), basic biochar production and application, bush-to-feed formulation principles, and critical safety standards for biomass operations. These can be delivered flexibly by VTCs, university extension services, or qualified industry experts. b. Support Biomass SME Development: Actively promote and support the rollout of the N-BiG BCBU SME Management certificate once registered. Crucially, this training should be linked to access to finance, business mentorship, and market linkage support services to foster the growth and sustainability of small and medium enterprises across the biomass value chains²¹². c. Integrate Sustainability and Essential Soft Skills: Ensure that all biomass-related training programs, from vocational certificates to university degrees, comprehensively incorporate modules on environmental sustainability (going beyond basic EIA to include concepts like LCAs, circular economy principles), climate change adaptation and mitigation, occupational health and safety specific to biomass, and essential soft skills (e.g., critical thinking, problem-solving, communication, teamwork, digital literacy). This address identified gaps in the "sustainability skill set" and general employability²¹³.

Footnotes

²¹⁰ https://www.nta.com.na/wp-content/uploads/2022/07/Skills-Development-Plan-VET_2022-2026_1.pdf

²¹¹ <https://www.n-big.org/capacity-development-projects/>
<https://perivolirangeland.com/projects/large-farms/>

²¹² <https://www.n-big.org/capacity-development-projects/>

²¹³ <https://www.bioenergy-news.com/news/innovative-biomass-initiative-launched-in-namibia/>

Implementing these recommendations should ideally follow a phased approach, acknowledging the different maturity levels of the subsectors. For instance, immediate efforts could focus on upskilling and improving practices in the established charcoal sector and providing foundational trades relevant to the imminent needs of the Otjikoto power plant. Medium-term actions could concentrate on developing specialised technician-level training for biochar and power generation, while long-term strategies would build advanced engineering and R&D capacity.

This strategy should also leverage existing strengths within the Namibian education and industry landscape. This means enhancing and specialising current programs at NUST and UNAM, providing capacity to the VTC network to deliver biomass-relevant modules, and building upon the initiatives already started by industry groups like N-BiG and research entities like PRI²¹⁴.

Finally, a robust Monitoring and Evaluation (M&E) framework must be established for all biomass skills development interventions. This framework should track key performance indicators such as trainee enrolment and completion rates, graduate employment in the biomass sector, employer satisfaction with skills, and the overall impact of training programs on industry productivity and sustainability. This data-driven feedback loop, as implicitly supported by the NHRP's call for better data management, is essential for the adaptive management and continuous improvement of Namibia's biomass skills development strategy²¹⁵.

Footnotes

²¹⁴ <https://solarenergymasters.net/master-of-sustainable-energy-systems-namibia-university-of-science-and-technology-nust/>
<https://www.nust.na/programmes/master-sustainable-energy-systems>
<https://www.unam.edu.na/wp-content/uploads/2024/12/2025-Prospectus-School-of-Agriculture-Fisheries-Sciences.pdf>
<https://www.nta.com.na/training-services/>

²¹⁵ <https://ean.org.na/download/republic-of-namibia-national-human-resources-plan-2010-2025/>

06

Energy Sector Skills Strategy - Namibia

GREEN HYDROGEN & RENEWABLES SUB-SECTOR

6. GREEN HYDROGEN AND RENEWABLES

SUB-SECTOR

Namibia is strategically positioning itself as a global frontrunner in the burgeoning green hydrogen (GH2) economy. This ambition is underpinned by a confluence of world-class renewable energy resources, strong political will, and a clear vision for leveraging GH2 for national development and economic diversification.

Namibia's commitment to developing a GH2 economy is deeply embedded within its highest-level national development frameworks. The Harambee Prosperity Plan II (HPPII), launched in 2021, was the first policy document to explicitly identify GH2 production for export and local industrialisation as a complementary engine for growth. This initiative aligns with the country's long-term objectives outlined in Vision 2030, which aims to transform Namibia into an industrialised nation. Further reinforcing this strategic direction is Namibia's Long-Term Low-Emission Development Strategy (LT-LEDS), which sets a course for a net-zero and climate-resilient economy by 2050. Within these frameworks, GH2 is not merely an energy commodity but is envisioned as a cornerstone for sustainable economic growth and a significant contribution to global decarbonisation efforts²¹⁶.

The strategic impetus behind Namibia's GH2 ambitions extends beyond environmental considerations and energy transition. The Namibian economy has experienced a period of relative stagnation since 2016, grappling with high unemployment rates—exceeding 30% overall and 40% for the youth—and the persistent challenge of the "middle-income trap". In this context, the GH2 initiative is explicitly framed as a "new growth opportunity" and a "once in a generation opportunity to jump start Namibia's industrialisation". This perspective elevates the GH2 agenda from a purely sectoral project to a national economic revitalisation strategy, aimed at diversifying the economy, creating mass employment, and propelling the nation towards a higher income status and greater prosperity for its citizens²¹⁷.

6.1 Dominant and Emerging Green Hydrogen and Renewables Value Chains

The development of Namibia's GH2 economy involves the establishment of several interconnected value chains, starting from the harnessing of renewable energy to the production of hydrogen and its conversion into various end-user products for domestic use and export.

Footnotes

²¹⁶ <https://gh2namibia.com/>

https://newclimate.org/sites/default/files/2023-11/The%20landscape%20of%20green%20hydrogen%20in%20Namibia_nov2023.pdf

<https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development#>

²¹⁷ <https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>

²¹⁸ https://dechema.de/green_hydrogen_namibia_report/_/H2-Report_Green-H2_digital.pdf

<https://isa-ghic.org/countries/namibia-2>

<https://gh2namibia.com/>

<https://enertrag.com/projects-show-cases/hydrogen-projects/hyphen-project-for-green-hydrogen-in-namibia#>

6.1.1 Renewable Energy Generation (Solar, Wind)



The foundation of Namibia's GH2 ambition lies in its exceptional renewable energy resources. The country is endowed with world-class solar irradiation, receiving over 3,000 hours of sunlight annually, with many regions boasting an annual solar irradiation of 2,200 to 2,400 kilowatt-hours per square meter (kWh/m²). This positions Namibia among the top global locations for solar energy potential. Similarly, its coastal regions, particularly near Lüderitz and along the northern coast, experience high and consistent wind speeds, making them ideal for large-scale wind farm development²¹⁸.

Recognising this potential, Namibia's Long-Term Low-Emission Development Strategy (LT-LEDS) targets a significant scaling up of solar and wind capacity to over 3,200 megawatts (MW) by 2050. The GH2 projects themselves will drive an unprecedented expansion of this capacity. For instance, the Hyphen Hydrogen Energy project alone is projected to require approximately 7 gigawatts (GW) of renewable generation capacity. To meet the national GH2 equivalent production target of 10-15 million tonnes per annum (Mtpa) by 2050, an estimated 750 terawatt-hours per year (TWh/year) of renewable electricity will be needed. This scale of renewable energy deployment will involve extensive land use planning, major infrastructure development for generation and transmission, and a substantial workforce for construction, operations, and maintenance²¹⁹.

While a significant portion of this new renewable energy capacity will be dedicated to export-oriented GH2 production, its development is also intrinsically linked to Namibia's broader national energy and development goals. The country currently imports a considerable share of its electricity, often from neighbouring countries reliant on coal-fired power plants. The National Energy Policy aims to increase domestic generation, achieve 70% renewable electricity by 2030, and attain full energy independence by 2040. The massive build-out of renewable energy for GH2 production can, therefore, offer a dual benefit: generating export revenues while simultaneously enhancing national energy security and accelerating the decarbonisation of the domestic electricity supply. However, to fully realise this synergy, clear regulatory frameworks governing grid integration, electricity wheeling, and prioritisation of supply during periods of constraint will be essential to ensure that GH2 production does not compromise domestic energy access or decarbonisation efforts. This also implies a growing need for advanced skills in smart grid management and the integration of large-scale, variable renewable energy sources²²⁰.

For the purpose of this report, solar and wind production technologies will be combined under GH2 and not treated as separate energy generation pillars.

Footnotes

²¹⁸ https://dechema.de/green_hydrogen_namibia_report/_/H2-Report_GreenH2_digital.pdf

<https://isa-ghic.org/countries/namibia-2>

<https://gh2namibia.com/>

<https://enertrag.com/projects-show-cases/hydrogen-projects/hyphen-project-for-green-hydrogen-in-namibia#>

²¹⁹ <https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development#>

<https://hyphenafrika.com/hyphen-launches-skills-census-map-for-employment-skills/>

https://dechema.de/green_hydrogen_namibia_report/_/H2-Report_GreenH2_digital.pdf

<https://isa-ghic.org/countries/namibia-2>

²²⁰ https://newclimate.org/sites/default/files/2023-11/The%20landscape%20of%20green%20hydrogen%20in%20Namibia_nov2023.pdf

https://issuu.com/travelnewsnamibia/docs/namibia_trade_network_2025

<https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development#>

6.1.2 Green Hydrogen Production (Electrolysis Technologies)

The core process for producing green hydrogen is electrolysis, where electricity generated from renewable sources is used to split water (H₂O) into hydrogen (H₂) and oxygen (O₂). The efficiency, cost, and scalability of electrolyser technologies are critical determinants of the final cost of GH₂²²¹.

Several projects in Namibia are already implementing or planning significant electrolyser capacities. The Hylron Oshivela plant is utilising a 12MW electrolyser, reportedly the largest currently operational in Southern Africa. The Hyphen project envisages a massive 3 GW of electrolyser capacity at full scale. The Cleanergy Solutions Namibia pilot project also incorporates an electrolyser system, with installation expected to commence by May 2025²²².

Regarding technology choices, there appears to be flexibility. For instance, SMA Altenso, a technology provider for the Cleanergy project, supplies rectifier solutions that are compatible with various leading electrolyser types, including Proton Exchange Membrane (PEM), Solid Oxide Electrolyser Cell (SOEC), and alkaline electrolysers. This adaptability allows projects to select technologies best suited to their specific operational requirements and evolving market availability²²³.

A key strategic consideration for Namibia is the current reliance on imported electrolyser technology. The electrolyser for the Hylron plant, for example, was sourced from China's Peric Hydrogen Systems, while SMA Altenso represents German technology. However, Namibia's national strategy includes ambitions to foster local manufacturing capabilities. Pilot projects are intended, in part, to build "local component manufacturing" capacity. Furthermore, the Green Industrialisation Blueprint explicitly identifies renewable energy hardware, including electrolysers, as a potential supporting industry for local development. This points to a long-term vision of reducing import dependency and capturing more value domestically. This dynamic suggests a phased approach may be optimal: initially relying on proven imported technologies for rapid project deployment, while concurrently fostering local capabilities, perhaps starting with assembly and maintenance services, and progressively moving towards the manufacturing of certain components. Such a strategy would require a carefully planned development of highly specialised engineering, manufacturing, and quality control skills within the Namibian workforce²²⁴.

Footnotes

²²¹ <https://www.eurekalert.org/news-releases/1085939>

²²² <https://isa-ghic.org/countries/namibia-2>
<https://africasustainabilitymatters.com/namibia-achieves-historic-first-in-green-hydrogen-production/#:->
<https://hyphenafrika.com/hyphen-launches-skills-census-map-for-employment-skills/>
<https://sasscal.org/driving-namibias-green-hydrogen-future-sasscals-site-visits-to-daures-and-cleanergy/>

²²³ <https://www.sma.de/en/newsroom/news-details/namibia-gigawatt-milestone-hydrogen-technology-altenso>

²²⁴ <https://isa-ghic.org/countries/namibia-2>
<https://www.sma.de/en/newsroom/news-details/namibia-gigawatt-milestone-hydrogen-technology-altenso>
<https://gh2.org/countries/namibia>
<https://ammoniaenergy.org/articles/namibia-green-industrialisation-blueprint/>

6.1.3 Conversion and End-user Products

GH2 End-User Products

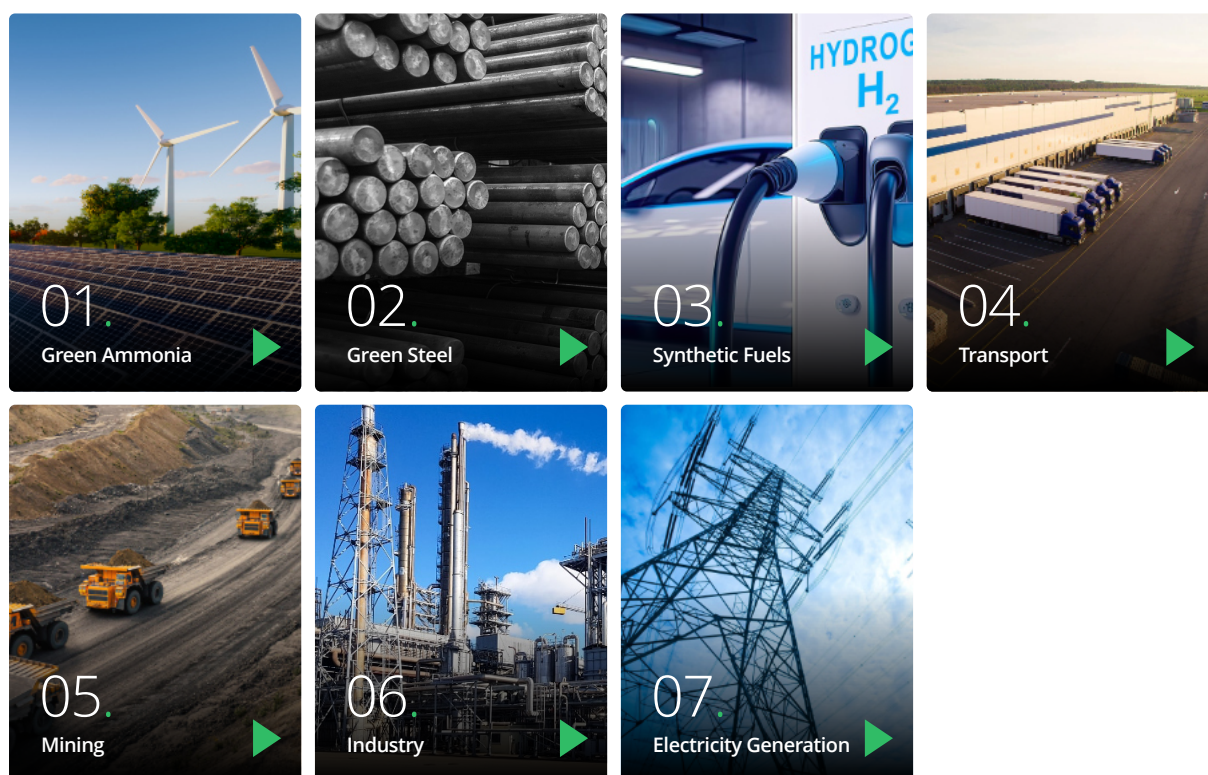


Figure 6: Examples of GH2 End-User Products

Green hydrogen can be used directly or converted into a variety of end-user products, opening multiple value chains for domestic use and export.

Green Ammonia (for export, fertilisers):

Green ammonia (NH₃), produced by combining green hydrogen with nitrogen from the air, is a primary focus for Namibia's export strategy. Ammonia is significantly easier and more cost-effective to transport over long distances by ship compared to pure hydrogen. The Hyphen project plans to produce 2 million tonnes of green ammonia per year. An MoU with RWE for a potential offtake of 300,000 tonnes per year underscores the interest in the export market. Other significant ammonia projects include the planned Etof Hansson plant (430,000 tonnes/year) and Zhero's project near Walvis Bay (500,000 tonnes/year). Domestically, green ammonia has vital applications in agriculture. The Daures Green Hydrogen Village is conducting fertiliser trials using its green ammonia, and the Environmental Investment Fund has developed a concept for the Neckartal Green Scheme Fertiliser Plant, which aims to produce fertiliser from green hydrogen, potentially boosting local food security and creating export opportunities to neighbouring countries²²⁵.

Footnotes

²²⁵ <https://www.rwe.com/en/press/rwe-supply-and-trading/2022-12-02-rwe-and-hyphen-explore-offtake-of-green-ammonia-from-namibia/>
<https://www.aventure.org/technology/namibia-green-hydrogen-ammonia-steel-task/>
<https://hyphenafrika.com/hyphen-launches-skills-census-map-for-employment-skills/>
<https://www.rwe.com/en/press/rwe-supply-and-trading/2022-12-02-rwe-and-hyphen-explore-offtake-of-green-ammonia-from-namibia/>
<https://gh2.org/countries/namibia>

Green Steel (Direct Reduced Iron - DRI):	Namibia is pioneering the use of green hydrogen for green steel production in Africa. The Hylron Oshivela plant is already producing DRI by using green hydrogen as a reducing agent instead of coal or natural gas, significantly lowering the carbon footprint of iron production. This aligns with the LT-LEDS, which proposes the use of GH2 in steel manufacturing. An offtake agreement for Hylron's DRI with a German steel manufacturer is already in place, demonstrating market demand for this green industrial product. This represents significant in-country value addition ²²⁶ .
Synthetic Fuels:	The production of synthetic fuels (e-fuels) using green hydrogen is another promising avenue. The forthcoming Synthetic Fuels Act is intended to provide the regulatory framework for this sub-sector. Namibia's Green Hydrogen and Derivatives Strategy involves the production of e-methanol and synthetic kerosene (e-kerosene). The Namibia Green Hydrogen Programme (NGH2P) is actively conducting pre-feasibility studies for synthetic fuels production. These fuels have the potential to decarbonise hard-to-abate sectors like aviation and shipping, creating high-value export products ²²⁷ .
Electricity Generation and Grid Integration:	GH2 can be used to generate electricity, offering a way to store renewable energy and provide power during periods of low solar or wind output, thus contributing to grid stability. The LT-LEDS aims for 70% renewable electricity by 2030, and Namibia's hydrogen strategy notes the potential for GH2 to contribute to a decarbonized grid. HDF Energy's Renewstable Swakopmund project is an example of a utility-scale power plant incorporating green hydrogen for a stable power supply. However, as previously noted, clear regulations on grid access, feed-in tariffs for hydrogen-to-power projects, and prioritisation are needed to fully leverage this potential ²²⁸ .
Other Industrial and Transport Applications:	Transport: The LT-LEDS calls for the electrification of transport and the development of hydrogen-based transport alternatives. Several pilot initiatives are underway: Cleanergy Solutions Namibia is converting diesel trucks to dual-fuel (diesel-hydrogen) operation and has established a hydrogen refuelling station. Hylron is also exploring opportunities to use green hydrogen or its derivatives to decarbonise shipping, long-haul trucking, and rail transport. A notable project is the green hydrogen locomotive pilot for TransNamib, the national rail operator, which aims to convert the first hydrogen-powered train in Africa²²⁹. Mining: The mining sector, a significant part of Namibia's economy, offers potential for decarbonisation through the use of green hydrogen, for example, in heavy-duty mining trucks and equipment²³⁰. Industry: Beyond steel and ammonia, green hydrogen can be used as a clean feedstock or energy source in other manufacturing processes²³¹.

Footnotes

- ²²⁶ <https://isa-ghic.org/countries/namibia-2> https://international-partnerships.ec.europa.eu/news-and-events/news/global-gateway-namibia-becomes-pioneer-africas-green-transition-2025-04-11_en
<https://africasustainabilitymatters.com/namibia-achieves-historic-first-in-green-hydrogen-production/> <https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development> https://international-partnerships.ec.europa.eu/news-and-events/news/global-gateway-namibia-becomes-pioneer-africas-green-transition-2025-04-11_en
- ²²⁷ <https://gh2.org/countries/namibia>
https://dechema.de/green_hydrogen_namibia_report/_/H2-Report_GreenH2_digital.pdf
<https://research.csiro.au/hyresource/policy/international/namibia/>
<https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
- ²²⁸ [https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development#:~:text=Energy%20Sector%20Decarbonisation%20and%20Green,battery%20energy%20storage%20systems%20\(BESS\)](https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development#:~:text=Energy%20Sector%20Decarbonisation%20and%20Green,battery%20energy%20storage%20systems%20(BESS))
https://newclimate.org/sites/default/files/2023-11/The%20landscape%20of%20green%20hydrogen%20in%20Namibia_nov2023.pdf
<https://gh2.org/countries/namibia>
- ²²⁹ <https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development>
<https://gh2.org/countries/namibia>
<https://sassoc.org/driving-namibias-green-hydrogen-future-sassoc-site-visits-to-daures-and-cleanergy/>
<https://cmb.tech/h2-infra/cleanergy-solutions-namibia>
<https://bioenergytimes.com/hylron-begins-green-hydrogen-production-in-namibia/>
- ²³⁰ https://newclimate.org/sites/default/files/2023-11/The%20landscape%20of%20green%20hydrogen%20in%20Namibia_nov2023.pdf
<https://cmb.tech/h2-infra/cleanergy-solutions-namibia>
- ²³¹ <https://www.undp.org/namibia/blog/namibias-long-term-low-emission-development-strategy-strategic-policy-shift-climate-resilient-economic-development>

While large-scale export, particularly of green ammonia, is a primary economic driver for Namibia's GH2 sector, there is a clear and concurrent strategic emphasis on domestic value addition and utilisation. The Green Industrialisation Blueprint strongly advocates for this, aiming to use green hydrogen to power new local industries and decarbonise existing ones. Projects like Hylron (green steel), Daures (green fertiliser), the Neckartal fertiliser concept, and the various transport initiatives (Cleanergy, TransNamib locomotive) are tangible manifestations of this commitment to in-country industrial development. This dual-track approach—developing large-scale export capabilities while simultaneously fostering domestic industries that can utilise GH2—creates a more resilient and diversified economic impact. It mitigates the risks associated with over-reliance on volatile global export markets and ensures that the benefits of the GH2 revolution, such as job creation and technological advancement, are more broadly distributed within Namibia. This balanced strategy, however, necessitates a diversified approach to infrastructure investment, policy development, and, critically, skills development to cater to a wider array of industrial applications²³².

6.1.4 Storage and Transportation

The effective movement of green hydrogen and its derivatives from production sites to domestic end-users or international markets requires substantial and specialised infrastructure for storage, handling, and transportation. The Namibian government recognises this and plans the development of a shared Common User Infrastructure (CUI) to lower overall development costs and risks for individual projects²³³.

Significant investment is earmarked for storage and transportation infrastructure, including ports, specialised trucks, and derivative conversion plants, with an estimated USD 30 billion needed by 2040. Key existing ports like Lüderitz and Walvis Bay are central to these plans and are slated for upgrades to handle GH2 products. The Green Industrialisation Blueprint specifically includes plans for developing new deepwater ports equipped with ammonia handling and bulk cargo export capabilities. To facilitate this, NamPort has formed a strategic partnership with the Port of Rotterdam, one of the world's leading ports for energy products and a future hydrogen hub in Europe²³⁴.

Pipelines are also being considered for efficient overland transport. A feasibility study for a potential Namibia-South Africa cross-border hydrogen pipeline is currently underway, which could open up regional markets and create synergies with South Africa's own hydrogen ambitions²³⁵.

Footnotes

- ²³² <https://gh2.org/countries/namibia>
<https://www.rwe.com/en/press/rwe-supply-and-trading/2022-12-02-rwe-and-hyphen-explore-offtake-of-green-ammonia-from-namibia/>
<https://www.aventine.org/technology/namibia-green-hydrogen-ammonia-steel-task/>
<https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>
<https://ammoniaenergy.org/articles/namibia-green-industrialisation-blueprint/>
- ²³³ <https://gh2.org/countries/namibia>
- ²³⁴ https://newclimate.org/sites/default/files/2023-11/The%20landscape%20of%20green%20hydrogen%20in%20Namibia_nov2023.pdf
<https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>
<https://ammoniaenergy.org/articles/namibia-green-industrialisation-blueprint/>
<https://gh2.org/countries/namibia>
- ²³⁵ <https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>

Pipelines are also being considered for efficient overland transport. A feasibility study for a potential Namibia-South Africa cross-border hydrogen pipeline is currently underway, which could open up regional markets and create synergies with South Africa's own hydrogen ambitions²³⁵.

The development of this extensive infrastructure network is a major engineering, logistical, and financial undertaking. The Green Industrialisation Blueprint acknowledges that the development of common user infrastructure, such as transmission upgrades and port development, will be partly funded through public funds. This reliance on public financing, however, carries the risk that constraints on the public purse could potentially slow down the progress of these critical infrastructure projects. This highlights a potential "chicken and egg" scenario: large-scale GH2 production requires the prior existence of enabling infrastructure, but substantial investment in such infrastructure might be contingent on confirmed production volumes and secured offtake agreements. The phasing, financing mechanisms, and timely delivery of this common user infrastructure are therefore of paramount importance to unlock the entire GH2 value chain. Any significant delays in infrastructure development could have cascading negative impacts on achieving national production targets and investor confidence. This critical path also implies a substantial demand for skilled professionals in civil engineering, large-scale construction project management, logistics, and specialised port and pipeline operations²³⁶.

Footnotes

²³⁵ <https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>

²³⁶ <https://ammoniaenergy.org/articles/namibia-green-industrialisation-blueprint/>

6.2 Analysing Business Capability Implications for the Green Hydrogen Industry

6.2.1 Solar and Wind Energy for Green Hydrogen Production Value Chain



Figure 7: Solar Energy Production Value Chain

A comprehensive understanding of the value chains for solar photovoltaic (PV) and wind energy generation is essential for identifying Namibia's potential roles and capability gaps and ensuring skills requirements in supporting its green hydrogen ambitions. These RE technologies are the primary energy source for the electrolysis process that produces green hydrogen. Since these renewables (solar and wind) are intrinsically linked with GH2, they will be covered under this sub-sector and not as a standalone sub-sector in this report.

6.2.1.1 The Solar PV Value Chain for (Green Hydrogen)

The solar PV value chain encompasses a sequence of activities from raw material extraction and processing to the manufacturing of components, project development, installation, operation, and eventual decommissioning and recycling of solar plants.

The Solar PV Value Chain for (Green Hydrogen)	A. Raw Materials and Component Manufacturing This segment involves the production of the core elements of solar panels and associated systems: Polysilicon Production: Polysilicon is the ultra-pure silicon material that forms the primary input for the vast majority of solar PV cells (crystalline silicon technology). Its production is a highly energy-intensive and capital-intensive process, typically involving the conversion of metallurgical-grade silicon into trichlorosilane, followed by distillation and decomposition to yield high-purity polysilicon. The global market for polysilicon is characterised by significant concentration, with China dominating production, accounting for over 80% of the global share, a figure projected to approach 95% in the near future
--	---

Footnotes

²³⁷ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>
[https://one.oecd.org/document/TAD/TC\(2024\)12/FINAL/en/pdf](https://one.oecd.org/document/TAD/TC(2024)12/FINAL/en/pdf)

The Solar PV Value Chain for (Green Hydrogen)

- **Ingot and Wafer Manufacturing:** The purified polysilicon is melted and cast or drawn to form large crystalline structures known as ingots (either monocrystalline or multicrystalline). These ingots are then precisely sliced into very thin discs or squares called wafers, which serve as the substrate for solar cells. This manufacturing stage is also geographically concentrated, with China holding a dominant market share²³⁸.
- **Solar Cell Production:** Wafers undergo a series of sophisticated chemical and physical processing steps. These include texturing to reduce reflectivity, diffusion to create the p-n junction (the heart of the solar cell where the photovoltaic effect occurs), passivation to reduce electron-hole recombination, deposition of anti-reflective coatings, and screen-printing of metallic contacts to collect the generated electrical current. These processes transform the wafer into a functional solar cell capable of converting sunlight directly into DC electricity.
- **Solar Module (Panel) Assembly:** Individual solar cells are electrically interconnected in series and parallel configurations to achieve desired voltage and current characteristics. These interconnected cells are then encapsulated between layers of protective materials (typically glass on the front and a polymer back sheet, or dual glass) and laminated under heat and pressure. The laminate is then framed (usually with aluminium) and fitted with a junction box containing bypass diodes and output cables, resulting in a complete, durable solar module or panel. Along with cell production, module assembly is one of the most labour-intensive segments within the PV manufacturing chain²³⁹.
- **Balance of System (BoS) Components:** This broad category encompasses all other essential components required for a functioning solar PV system, beyond the modules themselves. Key BoS components include:
 - **Inverters:** Devices that convert the DC electricity generated by the solar panels into AC electricity suitable for use by electrical grids or appliances.
 - **Mounting Structures:** Racking systems (fixed-tilt or tracking) that support and orient the solar panels.
 - **Cabling and Wiring:** Electrical cables to connect panels, inverters, and other system components.
 - **Combiner Boxes, Switchgear, and Transformers:** Equipment for aggregating power, providing circuit protection, and stepping up voltage for grid connection.

The extreme global concentration of solar PV manufacturing – particularly for polysilicon, ingots, and wafers – predominantly within China, presents a dual challenge for countries aiming to enter this market. Firstly, it creates a significant supply chain vulnerability for the global solar industry, as disruptions in one region can have worldwide repercussions on price and availability. Secondly, for new entrants like Namibia, it represents a formidable barrier to entry. Establishing competitive manufacturing in these segments would require immense capital investment, access to advanced proprietary technology, highly skilled labour, and the ability to overcome the deeply entrenched economies of scale and technological leadership already established by dominant players. This reality suggests that Namibia's strategic approach to local content and industrial development within the solar value chain might be more pragmatically focused on production activities, such as module assembly or the manufacturing of certain BoS components, or on specialised niche markets, rather than attempting to compete in primary material processing or cell manufacturing in the short to medium term²⁴⁰.

Footnotes

²³⁸ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>
[https://one.oecd.org/document/TAD/TC\(2024\)12/FINAL/en/pdf](https://one.oecd.org/document/TAD/TC(2024)12/FINAL/en/pdf)

²³⁹ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>

²⁴⁰ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>
[https://one.oecd.org/document/TAD/TC\(2024\)12/FINAL/en/pdf](https://one.oecd.org/document/TAD/TC(2024)12/FINAL/en/pdf)

The Solar PV Value Chain for (Green Hydrogen)

B. Project Development, EPC (Engineering, Procurement, Construction), and Installation

This phase covers the entire lifecycle of bringing a solar PV power plant from concept to operational reality:

- **Project Development:** This initial stage involves a wide array of activities, including comprehensive site identification and assessment. This includes detailed solar irradiation studies (often using satellite data and ground measurements), geotechnical surveys to determine soil suitability for foundations, securing land rights through purchase or long-term lease agreements, conducting thorough Environmental and Social Impact Assessments (ESIAs) to identify and mitigate potential adverse effects, obtaining all necessary permits and licenses from relevant authorities, arranging project financing (which can be complex for large-scale projects), and negotiating Power Purchase Agreements (PPAs) with off-takers or establishing internal energy transfer pricing mechanisms if the plant is dedicated to supplying a specific facility like a green hydrogen plant²⁴¹.
- **Engineering:** Once a project is deemed feasible, detailed engineering and design work commences. This includes optimising the plant layout to maximise energy yield and minimise land use, selecting the most appropriate solar module and inverter technologies based on site conditions and project economics, designing the electrical system (including cabling schemes, protection systems, and substation design), and performing structural engineering for the mounting systems to withstand local wind and seismic loads. Grid integration studies are also crucial to ensure the plant can be safely and reliably connected to the existing electrical network²⁴².
- **Procurement:** This involves the strategic sourcing and purchasing of all necessary components and equipment for the solar plant. This includes solar modules, inverters, mounting structures, cables, transformers, switchgear, monitoring systems, and other BoS equipment. For large-scale projects, procurement often involves managing complex international supply chains and logistics.
- **Construction & Installation:** This is the physical realisation of the solar plant. It typically begins with site preparation, such as clearing and grading the land. This is followed by civil works, including the construction of foundations for mounting structures and other equipment. Mechanical installation involves erecting the mounting structures and affixing the solar panels to them. Electrical installation encompasses the laying of cables, connection of panels to combiner boxes and inverters, installation of transformers and switchgear, and the establishment of the plant's internal electrical network and control systems. The final steps include commissioning the plant to ensure all components are functioning correctly and connecting it to the electrical grid²⁴³.

While the manufacturing stages of the solar PV value chain are characterised by high capital intensity and technological barriers, the project development, EPC, and installation segments offer more immediate and accessible avenues for local business participation and job creation in Namibia. These activities are, by their nature, more localised. Namibia has an established construction sector and has already accumulated some experience in the development and construction of solar power plants, albeit on a smaller scale than what is envisaged for the green hydrogen projects.

Footnotes

²⁴¹ <https://www.seai.ie/sites/default/files/publications/Solar-Chain-Opportunity-report.pdf>

²⁴² <https://www.seai.ie/sites/default/files/publications/Solar-Chain-Opportunity-report.pdf>

²⁴³ <https://www.seai.ie/sites/default/files/publications/Solar-Chain-Opportunity-report.pdf>

The primary challenge, as highlighted by Hyphen's own assessments, will be the significant scaling up of these local capabilities—in terms of technical expertise, project management capacity, access to specialised equipment, and the availability of a sufficiently large and skilled labour force (including electricians, civil engineers, and construction workers)—to meet the unprecedented size, complexity, and rapid timelines associated with developing multi-gigawatt solar farms required to power the nation's green hydrogen ambitions²⁴⁴.

The Solar PV Value Chain for (Green Hydrogen)	C. Operations and Maintenance (O&M) Once a solar PV plant is commissioned, it enters a long-term operational phase, typically lasting 25-30 years or more. Effective O&M is critical to ensure the plant performs optimally, maximises energy generation, and achieves its expected financial returns. Key O&M activities include: • Performance Monitoring: Continuous tracking of the plant's energy output and key performance indicators (KPIs) using sophisticated monitoring systems (e.g., SCADA). • Preventative Maintenance: Regularly scheduled inspections and servicing of components such as modules (e.g., cleaning to remove dust and soiling that reduces efficiency), inverters (e.g., filter replacement, software updates), mounting structures (e.g., checking for corrosion or loose fittings), and electrical connections. Vegetation control around the plant is also a common preventative measure. • Corrective Maintenance: Addressing unforeseen issues and component failures, which may involve troubleshooting, repairing, or replacing faulty modules, inverters, cables, or other equipment. • Plant Security: Implementing measures to protect the plant from theft, vandalism, or other unauthorised access²⁴⁵.
--	--

Solar PV O&M activities provide a consistent stream of long-term employment opportunities that are inherently local. The development of strong, indigenous O&M capabilities is therefore of paramount importance for Namibia. This will not only ensure the sustained productivity and economic viability of the massive solar assets required for green hydrogen production but also represents a significant area for local skills development, the growth of specialised local enterprises, and the retention of economic value within the country. Local O&M capacity reduces dependence on potentially more costly international contractors, allows for quicker response times to operational issues, and contributes to the overall efficiency and cost-effectiveness of the renewable electricity that will feed Namibia's green hydrogen plants

Footnotes

²⁴⁴ <https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>
<https://newerlive.na/housing-backlog-headache/>
<https://isa-ghic.org/countries/namibia-2>
<https://enertrag.com/projects-show-cases/hydrogen-projects/hyphen-project-for-green-hydrogen-in-namibia>
<https://www.esi-africa.com/industry-sectors/smart-technologies/first-green-hydrogen-produced-in-namibia/>
²⁴⁵ <https://www.seai.ie/sites/default/files/publications/Solar-Chain-Opportunity-report.pdf>

The Solar PV Value Chain for (Green Hydrogen)

D. Decommissioning and Recycling:

At the end of their operational lifespan (typically 25-30 years), solar PV plants must be decommissioned. This final stage of the value chain involves the safe dismantling of the plant, removal of components, site remediation if necessary, and the management of all resulting materials. A critical aspect of end-of-life management is the recycling of solar panels and other BoS components²⁴⁶.

- Key activities in this stage include the safe disconnection and removal of panels, inverters, and structures; transportation of these materials to specialised facilities; and the processing of used panels to recover valuable constituent materials. These materials can include aluminium from frames, copper from wiring, glass, silicon from the cells, and even precious metals like silver used in the cell contacts²⁴⁷.
- The International Energy Agency (IEA) has highlighted the growing importance of solar PV recycling, not only for environmental waste management but also as a strategic approach to enhance the security of supply for critical raw materials and to promote a circular economy within the solar industry²⁴⁸.

Considering the enormous scale of solar PV deployment anticipated to support Namibia's green hydrogen ambitions (e.g., Hyphen's project alone includes 3.5 GW of solar capacity), the volume of panels reaching their end-of-life in the coming decades will be substantial. Therefore, it is imperative for Namibia to proactively develop comprehensive national strategies and establish the necessary infrastructure for solar panel decommissioning and recycling at an early stage. While private initiatives like NamiGreen are emerging to offer solar panel recycling services, a broader, nationally coordinated approach will be essential. This proactive stance will not only mitigate potential environmental liabilities associated with large quantities of PV waste but also present a significant opportunity for resource recovery, the creation of new "green-collar" jobs in the circular economy, and the further strengthening of Namibia's credentials as a leader in sustainable green industrialisation. Research from neighbouring regions, such as Lusaka, indicates that a lack of dedicated infrastructure and clear regulatory frameworks for PV waste management are common challenges, underscoring the need for Namibia to address this proactively²⁴⁹.

Footnotes

²⁴⁶ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>

<https://www.namigreen.com/recycle/solarpanels>

²⁴⁷ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>

²⁴⁸ <https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>

²⁴⁹ <https://ammoniaenergy.org/articles/first-step-in-establishing-namibias-renewable-hydrogen-and-ammonia-industry/>

<https://enertrag.com/projects-show-cases/hydrogen-projects/hyphen-project-for-green-hydrogen-in-namibia>

<https://www.namigreen.com/recycle/solarpanels>

https://www.researchgate.net/publication/385377731_An_Assessment_of_the_Potential_Impending_Negative_Implications_of_Transitioning_to_Solar_PV_Energy_on_Waste_Management_in_Lusaka

6.2.1.2 The Wind Energy Value Chain for Green Hydrogen

Wind Energy Production Value Chain

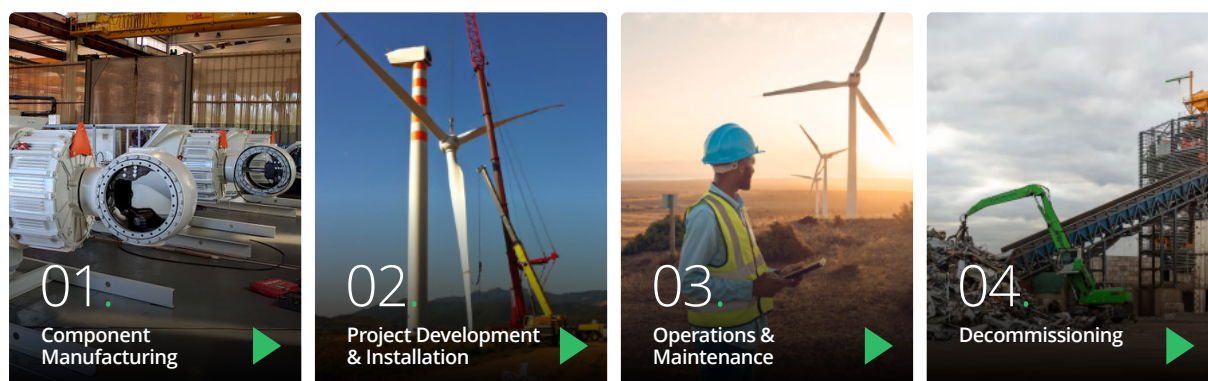


Figure 8: Wind Energy Production Value Chain

The wind energy value chain, similar to solar PV, spans from raw material sourcing and component manufacturing to project deployment, long-term operation, and eventual end-of-life management. It presents distinct technological and logistical characteristics.

Wind Energy Production Value Chain

A. Raw Materials and Component Manufacturing

The manufacturing of wind turbines involves several key, technologically complex components.

- **Blades:** Modern wind turbine blades are large, aerodynamically optimised structures, typically manufactured from composite materials such as fiberglass, carbon fibre, and specialised resins, often reinforced with balsa wood or PET foam cores. The manufacturing process involves precision moulding, curing, and finishing, requiring significant investment in specialised facilities and a highly skilled workforce.
- **Nacelles:** The nacelle is the housing situated at the top of the tower that encloses the turbine's critical power generation and control components. These include the gearbox (in geared turbines), generator, main shaft and bearings, brake system, yaw drive (to orient the nacelle into the wind), pitch system (to adjust blade angle), and sophisticated electronic control systems. Nacelle production is primarily an assembly operation, integrating numerous complex sub-components sourced from various suppliers.
- **Towers:** Wind turbine towers support the nacelle and rotor at optimal heights to capture stronger winds. They are commonly fabricated from rolled steel plates welded into cylindrical or conical sections. Increasingly, especially for taller onshore towers, pre-cast concrete segments or hybrid steel-concrete designs are being used. Concrete towers, in particular, offer a greater potential for local manufacturing using locally sourced materials like cement and aggregates²⁵⁰.

Footnotes

²⁴⁴ <https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>
<https://miningandenergy.com.na/namibia-could-generate-n13-9bn-from-local-wind-turbine-production/>
<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>

Wind Energy Production Value Chain

- **Foundations:** Foundations provide the structural base for the wind turbine and must withstand significant loads. Designs vary based on soil conditions and turbine size for onshore applications (e.g., spread footings, rock anchors). Offshore foundations are considerably more complex and can include monopiles, jacket structures, or floating platforms, each requiring specialised design, manufacturing, and installation capabilities.
- **Other Key Components:** This category includes technologically advanced items such as gearboxes (for geared turbines, which multiply the slow rotation of the rotor to a speed suitable for the generator), generators (various types exist, including doubly-fed induction generators and permanent magnet synchronous generators, the latter often utilising rare earth elements, which can pose supply chain risks), power converters (to condition the electricity to grid standards), bearings, and sophisticated electronic control and monitoring systems. Global manufacturing capacity for the main wind turbine components (nacelles, towers, and blades) was estimated to be between 170 and 180 GW in 2023. China has emerged as a major manufacturing hub, alongside established European and American Original Equipment Manufacturers (OEMs)²⁵¹.

Similar to the solar PV sector, the manufacturing of core, high-technology wind turbine components like gearboxes, generators, and advanced control systems is globally concentrated and presents high barriers to entry for new players. However, specific components offer more feasible opportunities for localisation in Namibia. Notably, the local manufacturing of wind turbine towers, especially those made from concrete, is identified as a "practical immediate step". A McKinsey & Company study specifically highlighted that Namibia could generate substantial economic benefits (N\$13.9 billion or US\$700 million in GDP by 2050) and create around 27,000 jobs through the local production of towers and potentially blades, driven by the significant domestic demand from the green hydrogen sector (estimated at 20 GW of wind capacity).

The report suggests Namibia could achieve competitive production costs for concrete towers and blades. Furthermore, the development of Namibia's Hylron green steel project could provide a local source of key raw material for steel tower manufacturing. While Hyphen's value chain mapping includes "Wind" as a critical component with a 30% local procurement target, it also acknowledges the likely need to import most of the advanced technology and equipment. This points towards a strategic opportunity for Namibia to focus on developing local manufacturing capabilities for specific components like towers and possibly blade assembly, rather than attempting to compete across the entire spectrum of highly complex wind turbine technologies²⁵².

Footnotes

²⁵¹ <https://www.energy.gov/sites/default/files/2022-02/Wind%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf>

<https://www.iea.org/energy-system/renewables/wind>

<https://miningandenergy.com.na/namibia-could-generate-n13-9bn-from-local-wind-turbine-production/>

https://www.duh.de/fileadmin/user_upload/download/Projektinformation/Energiewende/240617_DUH_Wind_Joint_Recommendations_for_Action-1.pdf

²⁵² <https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>

<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>

<https://miningandenergy.com.na/namibia-could-generate-n13-9bn-from-local-wind-turbine-production/>

<https://ammoniaenergy.org/articles/first-step-in-establishing-namibias-renewable-hydrogen-and-ammonia-industry/>

<https://etangonam.com/?p=561>

Wind Energy Production Value Chain	B. Project Development, EPC, and Installation (Onshore and Offshore considerations): This phase involves bringing a wind farm from concept to operation: • Project Development: This encompasses detailed wind resource assessment (often involving meteorological mast installations for year-long wind measurement campaigns, as planned by NamPower), site selection (considering wind resource, land availability, grid access, and environmental sensitivities), comprehensive Environmental Impact Assessments (EIAs), securing necessary permits and licenses, arranging project financing, and negotiating PPAs or other off-take agreements²⁵³. • Engineering: This includes selecting appropriate wind turbine generator (WTG) models, optimising the wind farm layout to maximise energy capture while minimising wake losses and environmental impact, designing foundations suitable for local soil conditions, and conducting grid connection studies to ensure stable integration with the power system. • Procurement: Sourcing wind turbines (which typically include blades, nacelles, and tower sections) and all Balance of Plant (BoP) components, such as transformers, switchgear, and cabling. • Construction & Installation: This involves significant civil works, including the construction of access roads capable of handling heavy and oversized components, and the pouring of massive concrete foundations. Turbine erection is a specialised operation requiring heavy-lift cranes and meticulous logistical planning, particularly given the increasing size of modern wind turbine components. Electrical infrastructure, including internal farm cabling, a collection substation, and high-voltage lines for grid connection, must also be constructed. Offshore wind installation is considerably more complex, involving specialised marine vessels for foundation installation and turbine erection, as well as subsea cabling and potentially offshore substations²⁵⁴.
---	---

The logistics associated with transporting and installing increasingly large wind turbine components present a substantial challenge, particularly for projects located in remote areas or for the development of offshore wind farms. This necessitates specialised infrastructure, including robust road networks capable of bearing heavy loads, suitably equipped ports for handling oversized components, and specialised transport and erection vessels (especially for offshore). The skills required for these logistical and installation operations are also highly specialised. Namibia's vast geographical expanse and the location of some of its designated Hydrogen Valleys in areas with potentially limited existing infrastructure mean that transport and logistics will be critical success factors. While upgrades to ports like Lüderitz and Walvis Bay are underway, they will need to be specifically tailored to accommodate the unique requirements of the wind energy sector²⁵⁵.

Furthermore, while offshore wind energy offers the potential for very high-capacity factors due to stronger and more consistent winds, it presents a significantly higher level of technical complexity, capital cost, and operational challenge compared to onshore wind. The development, installation, and O&M of offshore wind farms require highly specialised maritime skills, advanced port infrastructure, and dedicated supply chains, all of which Namibia is only beginning to explore, as indicated by ongoing pre-feasibility studies. Global experience shows that offshore wind, while growing rapidly, faces distinct hurdles, and Namibia's current maritime and port infrastructure, despite ongoing upgrades, would require substantial further development to support large-scale offshore wind deployment²⁵⁶.

Footnotes

²⁵³ <https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
²⁵⁴ <https://www.energy.gov/sites/default/files/2022-02/Wind%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf>
²⁵⁵ <https://www.energy.gov/sites/default/files/2022-02/Wind%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf>
²⁵⁶ <https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>

**Wind Energy
Production Value
Chain**
C. Operations and Maintenance (O&M):

Long-term O&M is crucial for ensuring the reliability, availability, and optimal performance of wind farms throughout their operational life (typically 20-25 years or more). Key O&M activities include:

- **Scheduled Maintenance:** Regular inspections, lubrication of moving parts (e.g., gearbox, bearings), and servicing of various turbine systems according to manufacturer recommendations.
 - **Unscheduled Repairs:** Addressing unexpected component failures or malfunctions, which can range from minor sensor issues to major component replacements (e.g., gearbox, generator, blades).
 - **Remote Monitoring and Diagnostics:** Continuous monitoring of turbine performance and health parameters via SCADA (Supervisory Control and Data Acquisition) systems to detect anomalies and enable predictive maintenance.
 - **Blade Inspection and Repair:** Blades are susceptible to damage from erosion, lightning strikes, and fatigue. Regular inspections (often using drones or rope access technicians) and specialised repairs are necessary to maintain aerodynamic efficiency and structural integrity.
-

Wind turbine O&M demands a workforce of specialised technicians who are comfortable working at significant heights and possess expertise in complex mechanical, electrical, and hydraulic systems. This segment of the value chain offers significant potential for long-term, skilled local job creation and is a critical area for targeted skills development programs in Namibia. Localising these O&M skills is key not only for retaining economic benefits within the country but also for ensuring the operational efficiency, rapid response to issues, and overall cost-effectiveness of the wind energy assets that will power the GH2 facilities.

**Wind Energy
Production Value
Chain**
D. Decommissioning and Recycling:

At the end of a wind farm's operational life, turbines must be decommissioned. This involves dismantling the turbines, managing the resulting waste materials, and potentially rehabilitating the site.

- A particular challenge in wind turbine decommissioning is the disposal or recycling of composite blades, which are made from materials that are difficult to separate and reprocess²⁵⁷.
 - Other components, such as steel towers, copper in cabling and generators, and concrete from foundations, have more established recycling pathways.
 - Innovative approaches, such as repurposing blade materials for other applications (e.g., construction materials, street furniture) or developing advanced chemical recycling processes, are being explored globally.
-

Footnotes

²⁵⁷ <https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>
<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>

The challenge of sustainably managing and recycling composite wind turbine blades is a global concern. As Namibia plans for significant wind energy deployment to support its GH2 ambitions, it has an opportunity to proactively adopt or even contribute to the development of innovative solutions for end-of-life blade management. This aligns with the country's broader green industrialisation strategy and could potentially create niche expertise and new green job opportunities in the circular economy. The Environmental and Social Impact Assessment (ESIA) for projects like the Diaz Wind Farm already includes provisions for waste management plans covering sorting, recycling, and safe disposal, indicating an awareness of these end-of-life considerations²⁵⁸.

6.2.2 Cross-Cutting Business capability gaps and skills implications

Several systemic capability gaps affect both the solar and wind value chains in Namibia, posing challenges to the successful realisation of its green hydrogen ambitions.

Cross-Cutting Business capability gaps & skills implications:	A. Technological and manufacturing limitations: A significant overarching challenge is Namibia's relatively small and underdeveloped existing manufacturing base. As a consequence, the country currently imports the vast majority of renewable energy components, with China being a primary source. There is a recognised limited local technical capacity for engaging in advanced manufacturing processes and for the widespread adoption and adaptation of new technologies. This is further compounded by a general "dependence on foreign expertise for most large-scale technology projects". This fundamental gap in high-tech manufacturing capabilities and technological absorptive capacity means that any significant move towards local production of RE components will require a concerted national effort. This effort must include targeted industrial policies, strategic attraction of Foreign Direct Investment (FDI) aimed at technology transfer and know-how, and substantial, long-term investment in developing a skilled technical and engineering workforce. Without addressing this foundational weakness, opportunities for local value addition in the more technologically sophisticated segments of the RE value chains will remain limited²⁵⁹. B. Infrastructure constraints: The development of a large-scale green hydrogen economy, powered by gigawatts of solar and wind energy, is critically dependent on robust and adequate supporting infrastructure. Several key infrastructure areas present challenges: • Electricity Grid: While NamPower is undertaking initiatives for transmission expansion, Namibia's current national grid is relatively small. Integrating the massive, and often intermittent, renewable energy capacities required for GH2 production will be a major technical and financial undertaking. This will likely necessitate significant upgrades, the incorporation of smart grid technologies, and the deployment of large-scale energy storage solutions to ensure grid stability and reliability²⁶⁰.
--	---

Footnotes

²⁵⁸ <https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>
<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>
<https://innovent.fr/en/2025/04/24/diaz-wind-farm-namibia/>

²⁵⁹ <https://etangonam.com/?p=561>
<https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>
<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>

²⁶⁰ <https://www.worldbank.org/en/country/namibia/overview>
<https://researchleap.com/policy-framework-for-enhancing-energy-access-and-shift-toward-renewable-energy-sources-in-namibia/>
<https://www.iea.org/reports/renewables-2024/electricity>

**Cross-Cutting
Business capability
gaps & skills
implications:**

- **Transport Infrastructure:** The sheer size and weight of many renewable energy components, particularly wind turbine blades, nacelles, and tower sections, place considerable strain on existing logistics networks. Upgrades to roads and potentially rail infrastructure will be necessary to facilitate the efficient and safe movement of these components from ports to often remote project sites²⁶¹.
- **Port Facilities:** The ports of Walvis Bay and Lüderitz are undergoing upgrades and are being positioned to handle the import of large RE components and the eventual export of green hydrogen and its derivatives. Partnerships with international ports like Rotterdam and Antwerp are aimed at enhancing these capabilities. However, the scale of operations anticipated will require continued and substantial investment in specialised handling equipment, storage facilities, and deep-water berths²⁶².
- **Water Supply:** The production of green hydrogen through electrolysis requires significant quantities of purified water. Given Namibia's arid climate, this water will primarily be sourced from seawater desalination plants. The construction and operation of these large-scale desalination facilities add another layer of complexity to the infrastructure requirements and will also have their own energy demands. The holistic and coordinated development of this "Common User Infrastructure" (CUI) encompassing energy, transport, port, and water systems is a critical enabler for the entire GH2 value chain, including its solar and wind energy inputs. Any delays, inadequacies, or lack of coordination in developing these foundational infrastructure elements will create significant bottlenecks, potentially jeopardising project timelines, increasing costs, and hindering the overall competitiveness of Namibia's GH2 industry. The NGH2P's consideration of CUI ownership and governance models reflects an understanding of the strategic importance of this integrated approach²⁶³.

C. Access to Finance for Local Enterprises, Particularly SMEs

While large-scale green hydrogen projects, such as Hyphen, are attracting significant Foreign Direct Investment (FDI) and benefit from dedicated international financing mechanisms, a distinct challenge lies in mobilising adequate and appropriate finance for local enterprises, especially Small and Medium-sized Enterprises (SMEs), to enable their meaningful participation in the associated solar and wind value chains. General financial constraints have been identified as hindering renewable energy adoption and project investment in Namibia. Specifically, a lack of access to credit often prevents smaller firms and lower-income households from investing in RE technologies. Furthermore, local financiers and developers frequently struggle to design or implement financing packages that are well-suited to the specific risk profiles and cash flow characteristics of RE projects. Although national initiatives like the SDG Namibia One Fund and international funds like Climate Investor Three (CI3) are being established to support GH2 development, dedicated financial instruments and targeted support programs are needed to ensure that Namibian SMEs can effectively participate as suppliers, service providers, and sub-contractors in the rapidly expanding solar and wind sectors. Without such support, there is a risk that local content aspirations may not be fully realised, and the economic benefits of the GH2 boom may not be broadly distributed. Ensuring financial inclusion for SMEs is therefore key to achieving genuine local content development and fostering a more equitable distribution of the economic benefits arising from the GH2 initiative²⁶⁴.

Footnotes

²⁶¹ <https://www.energy.gov/sites/default/files/2022-02/Wind%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf>

²⁶² <https://economy.com.na/green-hydrogen>

<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>

<https://sponsored.foreignpolicy.com/country-reports/the-new-hub-for-green-hydrogen-and-logistics/>

https://issuu.com/travelnewsnamibia/docs/namibia_trade_network_2025

²⁶³ <https://ammoniaenergy.org/articles/first-step-in-establishing-namibias-renewable-hydrogen-and-ammonia-industry/>

<https://economy.com.na/green-hydrogen>

<https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>

<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>

<https://gh2.org/countries/namibia>

²⁶⁴ <https://www.energymonitor.ai/tech/hydrogen/namibia-stakes-its-future-on-the-green-hydrogen-market/>

<https://www.cleanenergywire.org/news/namibia-launches-10-billion-dollar-hydrogen-project-german-participation>

<https://energy-news-network.com/industry-news/green-hydrogen-at-heart-of-namibias-vision-2030/>

<https://researchleap.com/policy-framework-for-enhancing-energy-access-and-shift-toward-renewable-energy-sources-in-namibia/>

https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_RAGAs/Namibia_RAGA_EN_Released.pdf

Cross-Cutting Business capability gaps & skills implications:	D. Policy, Regulatory, and Local Content Framework Effectiveness: Namibia has made commendable progress in establishing a policy and regulatory framework to support its green hydrogen ambitions. This includes the overarching Green Hydrogen and Derivatives Strategy and the ongoing development of crucial legislation such as the Synthetic Fuels Act, which will govern standards for production, environmental safeguards, and land use. The Namibia Green Hydrogen Programme (NGH2P) is actively working to promote local participation in the value chain. Furthermore, specific local content targets have been set for major projects, such as Hyphen's commitment to 30% local procurement and 90% Namibian employment during various project phases. The National Trade Policy also emphasises policy coherence and focuses on promoting value-added exports²⁶⁵.
--	---

Despite all this progress, a general challenge identified within Namibia's broader energy sector has been the "poor implementation of policy and regulatory framework". Inconsistencies, administrative gaps, and delays in execution can create an uncertain investment climate and hinder the effective translation of policy intent into tangible outcomes. Critiques of industrial policy effectiveness in similar developmental contexts often point to the risks of political capture and underscore the need for strong governance, transparency, and robust institutional capacity for effective implementation. Therefore, while supportive policies and ambitious local content targets are being put in place for the GH2 sector, their ultimate success will hinge on effective implementation, diligent monitoring, and consistent enforcement. These mechanisms must ensure that local content provisions are not merely aspirational but lead to genuine value creation and capability development for Namibian businesses and workers. The historical challenges in energy policy implementation serve as a pertinent reminder of the complexities involved and the need for sustained focus on execution. Effective local content policies require more than just targets; they necessitate a supportive ecosystem that includes access to finance, skills development, technology transfer, and clear, consistently applied standards²⁶⁶.

Cross-Cutting Business capability gaps & skills implications:	E. Barriers to Economic Diversification and Industrial Upgrading Namibia's economy has historically been export-driven, with a heavy reliance on a few key sectors, primarily mining, tourism, fishing, and agriculture. There is a long-standing and widely recognised national imperative to diversify the economic base and move towards higher value-added activities. However, efforts towards diversification have faced persistent challenges. These include the constraints of a small domestic market, continued dependence on volatile global commodity prices, and various structural impediments that limit productivity gains and broad-based job creation. National strategies like the "Growth at Home" initiative and the National Industrial Policy have explicitly focused on promoting value addition and industrial development. General barriers to export diversification in the African context, which are also relevant to Namibia, include inadequate infrastructure, limited access to finance (especially for SMEs), and inconsistencies in policy implementation²⁶⁷.
--	---

Footnotes

²⁶⁵ <https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
<https://isa-ghic.org/countries/namibia-2>
<https://gh2.org/countries/namibia>
<https://www.namibian.com.na/beyond-the-rush-namibias-green-hydrogen-strategy/>

²⁶⁶ <https://researchleap.com/policy-framework-for-enhancing-energy-access-and-shift-toward-renewable-energy-sources-in-namibia/>
<https://www.wider.unu.edu/sites/default/files/wp2011-041.pdf>
https://unctad.org/system/files/official-document/alddcin2020d1_en.pdf
<https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
<https://www.giz.de/expertise/downloads/giz2024-en-energy-news-89.pdf>

²⁶⁷ https://issuu.com/travelnewsnamibia/docs/namibia_trade_network_2025
<https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
<https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>
https://epaper.thebrief24.com/2025/February+/The+Brief_20+February+2025.pdf
<https://ean.org.na/download/republic-of-namibia-national-human-resources-plan-2010-2025/>

The green hydrogen initiative, with its associated large-scale development of solar and wind energy infrastructure and the potential for end-user industries (such as green steel, synthetic fuels, and renewable energy component manufacturing), represents arguably Namibia's most significant opportunity in decades for achieving meaningful economic diversification and industrial upgrading. However, the success of this endeavour in transforming the broader economy will depend crucially on the country's ability to overcome these longstanding structural barriers. It will require a concerted effort to actively foster strong linkages between the new GH2 sector and the existing domestic economy, ensuring that benefits and opportunities are widely disseminated. Failure to address these underlying constraints could risk the GH2 sector developing as an economic enclave, similar to some past experiences with extractive industries, with limited spillover effects and benefits for the wider Namibian population and economy²⁶⁸.

The table below provides a summary of key business capability gaps in Namibia's solar and wind value chains for GH2 and associated skills implications.

Table 25: Business Capability Gaps and Skills Implications- Solar & Wind Value Chains

Business Capability Gaps and Skills Implications- Solar & Wind Value Chains			
Value Chain Segment ²⁶⁹	Current Namibian Capability Level	Key Gaps Identified	Potential for Development (Short/Medium/Long Term)
Solar PV Manufacturing (Polysilicon, Ingots, Wafers, Cells)	Low (No significant local production; high import reliance; global market dominated by China)	Massive capital investment, advanced technology, economies of scale, specialized skills, R&D capacity.	Long Term (Very High Barrier)
Solar PV Module Assembly	Low to Medium-Low (Limited, if any, large-scale assembly; potential exists but not yet realized)	Scaled assembly lines, skilled labor for assembly, quality control systems, supply chain for sub-components, investment.	Medium Term
Solar PV BoS Component Manufacturing. (e.g., mounting structures, cables)	Medium-Low (Some local fabrication capacity for simpler structures may exist; complex electronics imported)	Advanced manufacturing for electronics (inverters), competitive production of standardized components, access to raw materials (e.g., aluminum, copper).	Medium Term (for select components)
Wind Turbine Component Manufacturing. (Concrete Towers)	Medium-Low (Potential identified; McKinsey study positive; no large-scale production yet)	Specialized molds and construction techniques for concrete towers, quality control, logistics for large segments, skilled labor for pre-casting and erection.	Medium Term
Wind Turbine Component Manufacturing. (Blades)	Low (Highly specialized composite manufacturing; McKinsey study suggests potential but high technical barrier)	Advanced composite materials expertise, large-scale molding facilities, precision engineering, skilled technicians, significant investment.	Long Term
Wind Turbine Component Manufacturing. (Nacelles, Gearboxes, Generators)	Very Low (Extremely complex, technology-intensive; reliant on global OEMs)	Advanced engineering design, precision manufacturing, complex assembly, specialized supply chains for sub-components, massive R&D and capital.	Very Long Term (Extremely High Barrier)

Footnotes

- ²⁶⁸ <https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
<https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>
<https://www.namibian.com.na/beyond-the-rush-namibias-green-hydrogen-strategy/>
<https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>
<https://miningandenergy.com.na/namibia-could-generate-n13-9bn-from-local-wind-turbine-production/>
- ²⁶⁹ <https://miningandenergy.com.na/driving-economic-sustainability-in-namibia-through-local-renewable-energy-manufacturing/>
<https://www.namibian.com.na/boosting-namibias-economy-through-renewable-manufacturing/>
<https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary>
<https://miningandenergy.com.na/namibia-could-generate-n13-9bn-from-local-wind-turbine-production/>
<https://www.iea.org/energy-system/renewables/wind>

Business Capability Gaps and Skills Implications- Solar & Wind Value Chains

Value Chain Segment ²⁶⁹	Current Namibian Capability Level	Key Gaps Identified	Potential for Development (Short/Medium/Long Term)
Large-Scale RE Project Development	Medium (Experience with smaller solar/wind projects; needs scaling for GH2 demands)	Capacity to manage multi-GW projects, complex financing, advanced resource assessment, large-scale ESIA management, international PPA negotiation skills.	Medium Term (with capacity building)
Large-Scale RE EPC & Installation	Medium (Local construction sector exists; experience with RE needs significant scaling)	Project management for mega-projects, specialized installation equipment (heavy-lift cranes), skilled workforce at scale (electricians, engineers, technicians), adherence to international safety/quality standards.	Medium Term (with significant upskilling)
Specialized RE O&M Services	Medium-Low (Some local capacity for existing plants; needs specialization for new tech & scale)	Advanced diagnostic skills, specialized technicians for new turbine/PV tech, remote monitoring expertise, predictive maintenance capabilities, spare parts management for large fleets.	Medium Term (critical for long-term success)
RE Component Recycling (Solar & Wind)	Low (NamiGreen for solar; limited national strategy/infrastructure, especially for wind blades)	Scaled collection & logistics, advanced recycling technologies (esp. for composites), regulatory framework, market for recycled materials, skilled workforce for dismantling/processing.	Medium to Long Term (growing importance)
Supporting Infrastructure (Grid, Ports, Transport, Water)	Medium-Low to Medium (Upgrades ongoing but significant expansion needed for GH2 scale)	Capacity for rapid, large-scale infrastructure build-out; smart grid tech; specialized logistics for oversized cargo; large-scale desalination capacity.	Continuous (Short to Long Term)
Access to Finance for Local SMEs	Low to Medium-Low (General constraints for SMEs; dedicated RE/GH2 SME finance nascent)	Tailored financial products for RE SMEs, risk mitigation instruments, capacity building for financial literacy and bankability.	Short to Medium Term (crucial for local content)

● Skills Implications

Cross-cutting

Skill Category	Specific Skill	Description & Link to Business Capability Gaps
Digital Literacy & Data Analytics	Data analysis, remote monitoring software (SCADA), IoT principles, cybersecurity awareness, proficiency in cloud-based collaboration tools.	Modern RE plants are data-intensive digital assets. All roles, from technician to manager, will require digital fluency for efficiency, predictive maintenance, and decision-making.
Project Management Fundamentals	Agile/Scrum methodologies, risk management, stakeholder communication, budgeting, scheduling, procurement principles.	While some roles need mega-project skills, a baseline understanding of project management improves efficiency and coordination for all teams, especially SMEs in the supply chain.
Health, Safety, & Environment (HSE)	International HSE standards (e.g., ISO 45001), risk assessment, working at heights, high-voltage safety, environmental compliance reporting.	The scale and nature of RE projects carry significant risks. A world-class safety culture is non-negotiable for attracting top-tier investment and partners.
Regulatory & Commercial Acumen	Understanding of Namibian grid codes, environmental regulations, international contracts, and Power Purchase Agreements (PPAs).	A broad understanding of the commercial and legal landscape empowers employees at all levels to make context-aware decisions and identify opportunities.
Soft Skills & Communication	Cross-cultural communication, problem-solving, critical thinking, adaptability, teamwork, and negotiation.	Projects will involve diverse international and local teams. Strong soft skills are the glue that holds complex, high-pressure projects together.

Business Capability Gaps and Skills Implications- Solar & Wind Value Chains

● Detailed Skills Implications by Value Chain Segment

Value Chain Segment ²⁷⁰	Potential Job Roles & Functions	Key Technical & Hard Skills	Essential Business & Soft Skills
Solar PV Module Assembly	Production Line Technician, Quality Control Inspector, Supply Chain Coordinator, Plant Manager	Electronics assembly, soldering, quality assurance protocols (e.g., Six Sigma), automated machinery operation, ERP systems.	Attention to detail, process optimization, teamwork, supplier management.
Solar PV BoS Component Manufacturing	Welder/Fabricator, CNC Machine Operator, Electrical Engineer, Industrial Designer	Certified welding, metal fabrication, CNC programming, CAD/CAM software, power electronics design, circuit board manufacturing.	Design thinking, problem-solving, quality focus.
Wind Turbine Component Manufacturing (Concrete Towers)	Precast Concrete Technician, Civil/Structural Engineer, Quality Assurance Manager, Heavy Lift Rigging Supervisor	Advanced concrete mix design, mold fabrication, post-tensioning techniques, non-destructive testing (NDT), crane operation planning.	Project coordination, stringent safety adherence, precision.
Large-Scale RE Project Development	Project Developer, Financial Analyst, PPA Negotiator, GIS Specialist, Environmental Scientist	Financial modeling (€, US\$), project finance structuring, international contract law, advanced GIS mapping, ESIA processes.	Negotiation, strategic thinking, stakeholder engagement, complex problem-solving.
Large-Scale RE EPC & Installation	Mega-Project Director, Construction Manager, HSE Officer, High-Voltage Electrician, Wind Turbine Installation Technician	PMP/PRINCE2 certification, advanced construction logistics, international safety standards (e.g., GWO), high-voltage commissioning.	Leadership, risk management, cross-cultural team management, communication.
Specialized RE O&M Services	Wind Turbine Technician, Solar Farm Technician, Data Analyst (O&M), SCADA Operator	Advanced diagnostics, blade repair, inverter maintenance, predictive maintenance algorithms, drone inspection piloting.	Analytical mindset, troubleshooting, independence, reporting.
RE Component Recycling	Decommissioning Technician, Materials Scientist, Logistics Manager, Process Engineer	Safe dismantling procedures, composite materials recycling, chemical separation processes, circular economy principles.	Environmental consciousness, innovation, systems thinking.
Supporting Infrastructure	Grid Modernization Engineer, Port Logistics Planner, Desalination Plant Operator, Civil Engineer (Roads/Water)	Smart grid technologies, substation engineering, heavy cargo logistics, hydraulics, large-scale water purification (Reverse Osmosis).	Systems thinking, long-term planning, inter-agency coordination.
Access to Finance for Local SMEs	Green Finance Specialist (in Banks), SME Business Advisor, Venture Capital Analyst	SME credit risk analysis, green bond frameworks, bankability assessments, financial literacy training.	Mentoring, communication, ethical governance.

Footnotes

²⁷⁰ <https://isa-ghic.org/countries/namibia-2>

<https://www.lithon.com/engineering-impact-on-namibias-economic-growth/>

<https://miningandenergy.com.na/major-wind-turbine-shipment-en-route-to-namibia-for-diaz-wind-farm/>

<https://researchleap.com/policy-framework-for-enhancing-energy-access-and-shift-toward-renewable-energy-sources-in-namibia/>

<https://olnnextury.com/about-us/>

6.2.3 Water Desalination Value Chain

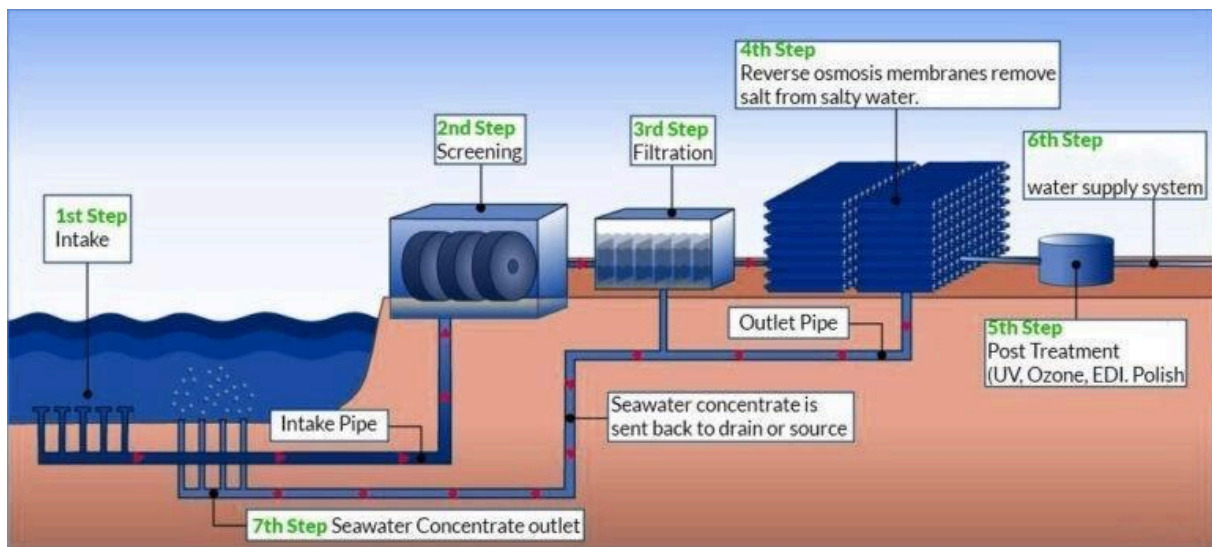


Figure 9: Water desalination value chain ²⁷¹

The production of green hydrogen via electrolysis, particularly using Proton Exchange Membrane (PEM) electrolyzers, is critically dependent on a reliable supply of high-purity water. PEM electrolyzers require ultrapure water (UPW) with extremely low conductivity (typically $<0.1 \mu\text{S/cm}$) and minimal contaminants to prevent damage to sensitive membranes and catalysts, ensuring efficiency and longevity. Given Namibia's arid climate and scarce freshwater resources, seawater desalination is the only viable source for the large volumes of water required. Estimates indicate that approximately 9-10 litres of UPW are consumed for every kilogram of green hydrogen produced, with some operational figures suggesting around 12 litres when accounting for process losses. To meet Namibia's GH2 production targets, a massive scale-up of desalination capacity will be essential²⁷².

The scale of this water demand implies that desalination will not merely be a support function but will evolve into a major industrial sector in its own right. Producing 10-15 million tonnes per annum (Mtpa) of H₂ would necessitate 100-150 million cubic meters per year (m³/year) of UPW. Considering the conversion factors from seawater to desalinated water (approximately a 2:1 ratio due to recovery rates) and from desalinated water to UPW (approximately a 1.5:1 ratio due to polishing losses), the total seawater intake required could reach 300-450 million m³/year. This volume dwarfs Namibia's current and planned desalination capacity (the existing Orano plant operates at 20-26 million m³/year, and the new NamWater plant is planned for 20 million m³/year), indicating the need for strategic planning for this new core economic activity, complete with its own infrastructure, workforce, and supply chain requirements²⁷³.

Footnotes

²⁷¹ Sourced from <https://www.chunkerowaterplant.com>

²⁷² <https://www.mdpi.com/2071-1050/17/2/385#:~:text=Similar%20to%20AWE%2C%20PEM%20requires,kWh%20%5B33%2C34%5D,https://pubs.rsc.org/en/content/articlehtml/2023/se/d2se01517j>

<https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>

<https://www.namwater.com.na/index.php/services/56-hydrological-services?showall=1>

https://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Namibia

²⁷³ <https://gasworld.tv/webinar-program/1-ultra-pure-water-for-electrolysis/>

<https://www.namwater.com.na/index.php/services/56-hydrological-services?showall=1>

https://en.wikipedia.org/wiki/Erongo_Desalination_Plant

<https://www.whyafrica.co.za/more-desalination-for-namibia/>

Water Desalination Value Chain:

A. Seawater Intake and Comprehensive Pre-treatment

The journey from seawater to UPW begins with the seawater intake system, which collects raw seawater and delivers it to the pre-treatment facility. Pre-treatment is a critical phase designed to protect the sensitive and expensive Reverse Osmosis (RO) membranes from fouling, scaling, and chemical degradation, thereby ensuring their longevity and operational efficiency²⁷⁴.

The Typical Pre-treatment Sequence Involves Several Steps

- i. **Screening and Straining:** Initial removal of large debris, seaweed, and marine organisms using coarse and fine screens.
- ii. **Coagulation and Flocculation:** Addition of chemicals like coagulants (e.g., ferric chloride, polyaluminium chloride, or specialised bio-organic polymers like Zeoturb) and flocculants to aggregate fine suspended particles, colloids, and some dissolved organic matter into larger, settleable, or filterable flocs²⁷⁵.
- iii. **Clarification/Separation**
 - Dissolved Air Flotation (DAF): Often used, especially if algal blooms are a concern. Tiny air bubbles attach to flocs, lifting them to the surface for skimming.
 - Alternatively, sedimentation or lamella clarification might be used.
- iv. **Filtration**
 - Multimedia Filtration (MMF) or Natzeo Filtration (NZF): Water passes through layers of granular media (e.g., anthracite, sand, garnet, or specialised media like Natzeo) to remove remaining suspended solids. Some plants may incorporate activated carbon for organic removal.
 - Cartridge Filtration: A final safety step using fine filters (typically 1-5 microns) to remove any fine particles that could damage RO membranes.
- v. **Chemical Dosing & Conditioning**
 - Chlorination/Disinfection: To control biological growth throughout the pre-treatment system and prevent biofouling of RO membranes. Chemicals like chlorine or Genclean may be used.
 - Dechlorination: Removal of residual chlorine (e.g., using sodium bisulfite or Granular Activated Carbon (GAC) filters) before water reaches the RO membranes, as chlorine can damage polyamide membranes.
 - Antiscalant Dosing: Add specific chemicals to prevent the precipitation of sparingly soluble salts (e.g., calcium carbonate, calcium sulphate) on the membrane surface.
 - pH Adjustment: May be required at various points.
- vi. **Ultrafiltration (UF) (Advanced Pre-treatment):** Increasingly used as a robust barrier before RO, UF membranes effectively remove fine particulates, colloids, bacteria, and viruses, providing high-quality feedwater to the RO system and reducing fouling potential²⁷⁶.

Footnotes

²⁷⁴ <https://www.keiken-engineering.com/news/what-are-the-7-steps-involved-in-effective-salt-water-desalination>

<https://www.fluencecorp.com/common-methods-used-for-desalination/>

<https://genesistwatertech.com/blog-post/seawater-ro-pretreatment-steps/>

²⁷⁵ <https://genesistwatertech.com/blog-post/seawater-ro-pretreatment-steps/>

²⁷⁶ <https://genesistwatertech.com/blog-post/seawater-ro-pretreatment-steps/>

<https://www.sait.ca/research-and-innovation-services/projects/hybrid-water-desalination-system-integration-for-hydrogen-production>

Critical control points in pre-treatment include monitoring turbidity, the Silt Density Index (SDI) – a key indicator of RO feed water fouling potential – and residual chlorine levels. The robustness and effectiveness of this stage are paramount for the economic viability of SWRO plants, directly impacting membrane lifespan, energy consumption, and overall operational costs. In Namibia's coastal environment, where water quality can fluctuate (e.g., due to seasonal algal blooms as noted in), pre-treatment systems must be designed with flexibility and incorporate advanced monitoring. The choice and sourcing of pre-treatment chemicals also present a dual consideration: an opportunity for local supply chain development if Namibian enterprises can meet stringent quality and volume requirements, or a logistical and cost challenge if these chemicals must be imported, affecting operational expenditure and supply security²⁷⁷.

Water Desalination Value Chain:

B. Primary Desalination Stage (Emphasis on Reverse Osmosis)

Following pre-treatment, the water enters the primary desalination stage, where the bulk of dissolved salts is removed. Seawater Reverse Osmosis (SWRO) is the dominant technology globally for large-scale seawater desalination due to its improved energy efficiency and modularity²⁷⁸.

In the RO process, high-pressure pumps raise the feedwater pressure significantly above its natural osmotic pressure (typically 55-70 bar for seawater). This pressurised water is then fed to RO membrane elements, typically spiral-wound modules containing semi-permeable polyamide thin-film composite membranes. These membranes selectively allow water molecules to pass through while rejecting the vast majority of dissolved salts, minerals, and other solutes. The process separates the feed stream into low-salinity product water (permeate) and a high-salinity waste stream (brine or concentrate). Modern SWRO plants often employ multi-stage RO configurations (e.g., two or three stages with inter-stage boosting) to enhance water recovery and optimise energy use²⁷⁹.

Technological advancements in membrane materials, module design, high-efficiency pumps, and particularly Energy Recovery Devices (ERDs) have dramatically reduced the specific energy consumption (SEC) of SWRO plants. ERDs, such as Pelton turbines or, more commonly now, isobaric pressure exchangers (e.g., PX devices), recover hydraulic energy from the high-pressure brine stream and transfer it to a portion of the incoming feedwater, significantly reducing the net energy input required from the high-pressure pumps. Modern SWRO plants can achieve SEC values in the range of 2.5 to 4.0 kilowatt-hours per cubic meter (kWh/m³) of permeate, with some state-of-the-art facilities reporting values as low as 1.6 kWh/m³. Given that energy can constitute a major portion of desalinated water costs (up to 80% along with capital amortisation), the selection and efficient operation of ERDs are critical for economic feasibility, especially for the large volumes needed for GH2 production. This makes ERD technology and its maintenance a key area for specialised technical expertise²⁸⁰.

While RO is the prevalent choice, alternative thermal desalination technologies like Multi-Effect Distillation (MED) and Multi-Stage Flash Distillation (MSF) exist. These processes involve evaporating seawater and condensing the steam to produce fresh water. MED, for instance, operates through a series of "effects" where steam generated in one effect is used to heat feedwater in the next, operating at successively lower temperatures and pressures.

Footnotes

²⁷⁷ <https://genesishwatertech.com/blog-post/seawater-ro-pretreatment-steps/>

<https://www.keiken-engineering.com/news/what-are-the-7-steps-involved-in-effective-salt-water-desalination/>

²⁷⁸ <https://www.fluencecorp.com/common-methods-used-for-desalination/>

https://en.wikipedia.org/wiki/Multi-stage_flash_distillation

²⁷⁹ <https://www.keiken-engineering.com/news/what-are-the-7-steps-involved-in-effective-salt-water-desalination/>

<https://www.fluencecorp.com/common-methods-used-for-desalination/>

²⁷⁹ <https://www.keiken-engineering.com/news/what-are-the-7-steps-involved-in-effective-salt-water-desalination/>

²⁸⁰ https://www.researchgate.net/publication/378034459_Practical_Minimum_Energy_Use_of_Seawater_Reverse_Osmosis_Facilities

<https://digitalcommons.usf.edu/etd/3135/>

Water Desalination Value Chain:

MED plants can operate at lower top brine temperatures (e.g., below 70-75°C) to mitigate scaling, especially with seawater feed, and are known for their robustness and ability to handle variations in feedwater quality. However, thermal processes are generally more energy-intensive than RO, particularly if dedicated fossil fuel-based heating is required. They become more competitive if low-cost waste heat is available, for instance, from adjacent industrial processes. While RO is likely to be the dominant technology for Namibia's large-scale GH2-related desalination needs due to energy efficiency considerations, the potential for hybrid systems (e.g., RO followed by MED for brine concentration) or niche MED applications (perhaps utilising waste heat from future GH2 derivative plants) should not be entirely discounted in long-term strategic planning, especially if very high water recovery rates or specific brine characteristics are desired²⁸¹.

C. Intermediate Post-Treatment of Desalinated Water

The permeate from the SWRO process, while significantly reduced in salinity, requires further conditioning before it is suitable as feed for the highly sensitive UPW polishing systems. This intermediate post-treatment typically includes:

1. **pH Adjustment:** RO permeate is often slightly acidic due to dissolved CO₂ passing through the membranes. The pH is typically adjusted to a neutral or slightly alkaline range (e.g., using sodium hydroxide or other alkalis) to prevent corrosion in downstream pipework and equipment, and to meet the inlet specifications of EDI units²⁸².
2. **Disinfection (if required):** If the desalinated water is stored for any period before UPW polishing, or if required by the UPW system design, a secondary disinfection step (e.g., UV irradiation or careful chlorination followed by thorough dechlorination) might be applied to prevent microbial regrowth. Remineralisation, typically done for potable water to improve taste and stability, is generally not required and often undesirable for UPW production for industrial processes like electrolysis

The interface between the SWRO plant output and the UPW plant input is critical. Clear, contractually defined quality specifications for parameters like conductivity, pH, TOC, silica, and absence of free chlorine (which can damage EDI membranes) are essential. Lack of coordination or deviations from these specifications can lead to operational inefficiencies, increased consumable use, or even damage to the sensitive UPW polishing units. If desalination plants and GH2 facilities are co-located but operated by different entities, the service level agreements (SLAs) governing intermediate water quality, quantity, reliability, and pricing will be complex and vital for the seamless operation of the entire GH2 production chain, necessitating specialised legal and commercial expertise²⁸⁴.

D. Ultrapure Water (UPW) Production for PEM Electrolysis

PEM electrolyzers demand UPW of exceptionally high purity to prevent contamination and degradation of their expensive membranes, catalysts, and other components, which would lead to reduced efficiency, shorter lifespan, and potential failure. The typical specifications for UPW for PEM electrolysis are extremely stringent²⁸⁵.

Footnotes

²⁸¹ <https://www.fluencecorp.com/common-methods-used-for-desalination/>

https://en.wikipedia.org/wiki/Multi-stage_flash_distillation

https://en.wikipedia.org/wiki/Multiple-effect_distillation

<https://en.wikipedia.org/wiki/Desalination>

²⁸² <https://www.fluencecorp.com/common-methods-used-for-desalination/>

²⁸³ <https://www.fluencecorp.com/common-methods-used-for-desalination/>

²⁸⁴ <https://www.fluencecorp.com/common-methods-used-for-desalination/>

<https://genesiswatertech.com/blog-post/seawater-ro-pretreatment-steps/>

²⁸⁵ <https://www.mdpi.com/2071-1050/17/2/385#:~:text=Similar%20to%20AWE%2C%20PEM%20requires,kWh%20%5B33%2C34%5D.>

<https://pubs.rsc.org/en/content/articlehtml/2023/se/d2se01517j>

<https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>

Water Desalination Value Chain:

- Conductivity: <0.1 micro siemens per centimetre ($\mu\text{S}/\text{cm}$) at 25°C, often aiming for <0.056 $\mu\text{S}/\text{cm}$ (the theoretical limit of pure water). This corresponds to a resistivity of >10-18 Megohm-centimetre ($\text{M}\Omega\cdot\text{cm}$)²⁸⁶.
- Total Organic Carbon (TOC): Typically, <50 parts per billion (ppb), with some systems aiming for <5 ppb²⁸⁷.
- Specific Ions: Extremely low levels (ppb or sub-ppb) of cations (e.g., Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Fe, Cu, other heavy metals) and anions (e.g., Cl^- , SO_4^{2-} , F^-).
- Silica: Very low levels, often <1-5 ppb, as silica can foul membranes and catalysts.
- Particles: Essentially free of particles, often filtered down to 0.05-0.2 microns.

Achieving this level of purity from RO permeate requires a multi-barrier polishing process. A typical UPW production train might include²⁸⁸.

1. **Second Pass RO (2PRO):** Often, the permeate from the primary SWRO is passed through another RO stage to further reduce dissolved solids and improve the feed quality for downstream ion exchange systems.
2. **Degasification (optional):** Membrane degasification may be used to remove dissolved gases like CO_2 , which can reduce the ionic load on subsequent ion exchange systems.
3. **Electrode ionisation (EDI):** EDI is a continuous, electrochemical deionisation process that uses ion exchange membranes, ion exchange resins, and an electric current to remove remaining dissolved ions. It produces high-purity water without the need for chemical regeneration of resins, making it a preferred technology for many UPW applications. EDI systems have specific feedwater requirements, including low conductivity (typically <20 $\mu\text{S}/\text{cm}$, sometimes <40 $\mu\text{S}/\text{cm}$), low hardness, low TOC, low silica, and absence of free chlorine²⁸⁹.
4. **Mixed-Bed Ion Exchange (MB-IX) Polishing:** Following EDI, or sometimes in place of it for smaller systems or as a final polisher, MB-IX units containing a mixture of strong acid cation and strong base anion resins are used to remove the last traces of ionic impurities to achieve the target resistivity/conductivity. These can be regenerable or, for the highest purity, non-regenerable "polishing" beds²⁹⁰.
5. **UV TOC Reduction/Sterilisation:** High-intensity ultraviolet (UV) lamps, often at specific wavelengths (e.g., 185 nm), are used to oxidise residual organic compounds (reducing TOC) and for disinfection²⁹¹.
6. **Final Particle Filtration:** Sub-micron cartridge filters or ultrafilters are used as a final step to remove any fine particles, including resin fines from MB-IX units²⁹².

It is also important to note that PEM electrolyser systems themselves often incorporate an internal water recirculation and polishing loop, typically using ion exchange resins, to maintain water purity within the stack during operation, as impurities can leach from system components over time²⁹³.

Footnotes

²⁸⁶ <https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>
<https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>

²⁸⁷ <https://pubs.rsc.org/en/content/articlehtml/2023/se/d2se01517j>
<https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>

²⁸⁸ <https://pubs.rsc.org/en/content/articlehtml/2023/se/d2se01517j>
<https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>
<https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>
<https://en.wikipedia.org/wiki/Electrodeionization>

²⁸⁹ <https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>
<https://en.wikipedia.org/wiki/Electrodeionization>

²⁹⁰ <https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>
<https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>

²⁹¹ <https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>
<https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>

²⁹² <https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>
<https://www.newwater.com/electrodeionization-edi-systems-for-ultrapure-water-treatment/>

²⁹³ <https://pubs.rsc.org/en/content/articlehtml/2023/se/d2se01517j>
<https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>

The production of UPW is a highly specialised, multi-barrier process. Failure at any stage, or inadequate monitoring and control, can lead to off-specification water reaching the electrolyzers, potentially causing irreversible damage and significant financial loss. This underscores the necessity for highly skilled operators, rigorous online and laboratory quality control, and advanced analytical capabilities for trace contaminant detection. Furthermore, the consumables for UPW polishing, such as high-purity ion exchange resins, specialised EDI membranes, and UV lamps, represent another area of potential local supply chain development or, more likely in the short term for Namibia, a significant import dependency. The handling, regeneration (if applicable), and ultimate disposal of spent ion exchange resins also carry environmental and cost implications that must be managed²⁹⁴.

Water Desalination Value Chain:

E. Brine Concentrate Management and Environmental Stewardship

Desalination processes, particularly SWRO, generate a significant byproduct: brine concentrate. This stream typically has a salinity about 1.5 to 2 times that of the feed seawater, and may also have a slightly elevated temperature and contain residual pre-treatment chemicals (e.g., antiscalants, though ideally these should not be toxic or persistent). The responsible management of this brine is a critical environmental consideration for any large-scale desalination project²⁹⁵.

Common brine management techniques include²⁹⁶.

- i. Direct Ocean Discharge:** The most common method for coastal plants involves discharging the brine back into the ocean through carefully designed outfall systems with diffusers. These are engineered to promote rapid mixing and dilution of the brine with ambient seawater to minimise the area of impact on marine ecosystems. This requires thorough environmental impact assessments, including hydrodynamic modelling and site-specific ecological studies, to ensure compliance with national and international environmental regulations.
- ii. Brine Treatment for Volume Reduction:** To reduce the volume of brine for disposal or to recover additional fresh water, further treatment steps can be employed. These may include:
 - Further RO Passes (Brine Concentrators): Specialised RO systems designed to treat brine and achieve higher overall recovery.
 - Electrodialysis (ED) / Electrodialysis Reversal (EDR): Membrane processes that use an electric field to transport ions.
- iii. Zero Liquid Discharge (ZLD) or Minimal Liquid Discharge (MLD):** These approaches aim to eliminate or drastically reduce liquid waste. They typically involve thermal evaporation and crystallisation processes (e.g., using mechanical vapour recompression (MVR) or multi-stage flash (MSF) type evaporators like Salt Maker systems) to recover remaining water and produce solid salts. While environmentally attractive, ZLD/MLD systems are capital-intensive and energy-intensive.

Environmental stewardship requires careful site selection for outfalls, ongoing monitoring of the discharge area, and adherence to all relevant Namibian environmental laws and guidelines. The potential for beneficial reuse of the extracted salts or minerals from brine (e.g., sodium chloride, magnesium, potassium) is an area of ongoing research and development, but economic viability is often challenging and site-specific.

Footnotes

²⁹⁴ <https://gasworld.tv/webinar-program/1-ultra-pure-water-for-electrolysis/>
<https://hydrogentechworld.com/keeping-the-water-ultrapure-inside-electrolyzers-challenges-and-solutions>

²⁹⁵ <https://www.fluencecorp.com/common-methods-used-for-desalination/>

²⁹⁶ <https://www.fluencecorp.com/common-methods-used-for-desalination/>
<https://www.saltworkstech.com/applications/brine-management/>
<https://samcotech.com/brine-waste-treatment-processes-for-reuse-or-disposal/>

As Namibia significantly scales up its desalination capacity to meet GH2 production demands, the cumulative volume of brine produced will become a substantial environmental management challenge. The current practice of ocean discharge, while common, will require increasingly sophisticated design and monitoring to ensure minimal ecological impact, especially with multiple large plants potentially operating along the coast. Proactive planning for advanced brine management strategies, potentially including volume reduction or even ZLD/MLD in environmentally sensitive areas or where economically feasible, will be crucial for long-term sustainability and maintaining public and regulatory acceptance. The concept of a "brine economy," involving the extraction and commercialisation of salts and minerals from brine, could offer a pathway to partially offset management costs and create new value chains. However, this would necessitate significant investment in research and development, specialised industrial capabilities, and market development—areas where Namibia currently has limited established capacity, making it a longer-term prospect²⁹⁷.

Water Desalination Value Chain:

F. Essential Supporting Infrastructure and Logistics

The successful operation of the entire seawater-to-UPW value chain relies on robust supporting infrastructure and efficient logistics:

- i. **Energy Supply:** Desalination and UPW purification are energy-intensive processes. A reliable and cost-effective electricity supply is paramount. For GH2 projects, this energy should ideally come from dedicated, additional renewable sources (solar, wind) to maintain the "green" credentials of the hydrogen produced and to avoid burdening the national grid. This integrated energy-water planning is crucial, as the energy demand for large-scale desalination could significantly strain Namibia's existing grid infrastructure if not independently supplied²⁹⁸.
- ii. **Water Conveyance and Storage:** Extensive networks of pipelines and pumping stations will be needed to transport seawater to the plants, and then to convey desalinated water and UPW to the electrolyser facilities and potentially to storage. Storage tanks for various grades of water (raw seawater, pre-treated water, RO permeate, UPW) will also be required to buffer against process fluctuations and ensure a continuous supply²⁹⁹.
- iii. **Process Control and Automation:** Modern desalination and UPW plants are highly automated, relying on sophisticated Supervisory Control and Data Acquisition (SCADA) or Distributed Control Systems (DCS) for process monitoring, control, and optimisation. This includes numerous online sensors for water quality parameters.
- iv. **Logistics and Supply Chain:** Efficient logistics are needed for the timely supply of bulk chemicals (coagulants, antiscalants, cleaning chemicals, pH adjustment agents), consumables (membranes, filter cartridges, ion exchange resins, UV lamps), and spare parts for pumps, motors, and instrumentation. This includes warehousing and inventory management. The logistical support for potentially numerous and geographically dispersed large-scale desalination and UPW plants will necessitate significant upgrades to Namibia's existing transport infrastructure (ports, roads) and warehousing capabilities, aligning with broader infrastructure development needs identified for the GH2 sector³⁰⁰.
- v. **Laboratory Facilities:** Well-equipped on-site and potentially central laboratories are needed for comprehensive water quality analysis, from raw seawater characterisation to trace contaminant analysis in UPW, and for environmental monitoring.

Footnotes

²⁹⁸ https://www.researchgate.net/publication/378034459_Practical_Minimum_Energy_Use_of_Seawater_Reverse_Osmosis_Facilities
<https://digitalcommons.usf.edu/etd/3135/>
<https://h2obuildingservices.co.uk/news/water-efficiency/water-efficiency-desalination/>
<https://www.sait.ca/research-and-innovation-services/projects/hybrid-water-desalination-system-integration-for-hydrogen-production#:~>

²⁹⁹ <https://africa-energy-portal.org/news/namibia-more-investment-hydrogen-required>

³⁰⁰ <https://economy.com.na/resource/deloitte-oil-gas-industrial-baseline-survey-namibia-summary-report-august-2024/>
<https://economy.com.na/wp-content/uploads/Deloitte-Oil-Gas-Industrial-Baseline-Survey-%E2%80%93-Namibia-Summary-Report-August-2024.pdf>
<https://africa-energy-portal.org/news/namibia-more-investment-hydrogen-required>

6.2.4 Business Capability Gaps and Skills Implications

The table below synthesises the key capability gaps identified across the desalination value chain, from initial policy to long-term operation. These gaps highlight areas requiring strategic development to support large-scale GH2 projects. A critical overarching challenge is the need for systems integration and the management of large, complex projects, which will likely necessitate significant international expertise, especially in the initial phases. The recommended strategy involves a phased approach to developing local content, starting with more attainable segments of the value chain.

Table 26: Business Capability Gaps and Skills Implications - Water Desalination

Business Capability Gaps and Skills Implications - Water Desalination				
Capability Area ³⁰¹	Key Business Capabilities & Description of Gaps	Current Namibian Capacity Assessment	Criticality for GH2	Identified Gap Level
Overall, Policy & Regulation	Developing a robust legal, policy, and regulatory framework specifically for large-scale desalination, Ultrapure Water (UPW), brine management, and associated water rights for the GH2 industry.	Existing water policies are in development but need significant adaptation to meet the scale and specific requirements of GH2 projects.	High	Moderate to Significant
R&D / Technology Development	Conducting applied research and development in water treatment, adapting technologies to local Namibian conditions, and finding innovative solutions for brine valorisation. The capacity for local R&D and technology adaptation is currently minimal.	Low to Very Low.	Medium (Long-term)	Significant
Seawater Intake & Pre-treatment	Capabilities include the design and construction of intake structures, manufacturing or supply of necessary equipment (e.g., screens, pumps), and providing specialised operation and maintenance (O&M) for these units.	Civil works capacity is medium, but the supply of specialised pumps, screens, and pre-treatment chemicals is low to very low. O&M skills are rated as low-medium.	High	Moderate to Significant (especially for chemicals and specialised equipment)
Primary Desalination (SWRO)	This stage requires advanced process engineering and design, EPC/EPCM for large Seawater Reverse Osmosis (SWRO) plants, and specialized O&M. It also involves manufacturing or assembling core components like RO membranes, pressure vessels, high-pressure pumps, and Energy Recovery Devices (ERDs). Namibia's capacity for manufacturing or assembling these complex components is limited, and they will likely need to be imported.	Component manufacturing is very low, advanced design and EPC/EPCM capabilities are low, and specialised O&M is also low.	Very High	Significant to Very Significant

Footnotes

³⁰¹ https://www.ctc-n.org/system/files/dossier/3b/namibia_technical_assistance_policy_review_1.pdf
https://newclimate.org/sites/default/files/2023-11/The%20landscape%20of%20green%20hydrogen%20in%20Namibia_nov2023.pdf
<https://africa-energy-portal.org/news/namibia-more-investment-hydrogen-required>
<https://economy.com.na/wp-content/uploads/Deloitte-Oil-Gas-Industrial-Baseline-Survey-%E2%80%93-Namibia-Summary-Report-August-2024.pdf>
<https://economy.com.na/resource/deloitte-oil-gas-industrial-baseline-survey-namibia-summary-report-august-2024/>

Business Capability Gaps and Skills Implications - Water Desalination

Capability Area	Key Business Capabilities & Description of Gaps	Current Namibian Capacity Assessment	Criticality for GH2	Identified Gap Level
Intermediate Post-Treatment	Involves the supply of chemicals for pH adjustment and the design and installation of dosing systems.	The supply of chemicals and capacity for installing dosing systems are both considered low-medium.	Medium	Low to Moderate
UPW Polishing	Key capabilities include manufacturing and supplying highly specialised components like EDI units, IX resins, UV systems, and sub-micron filters. It also requires expertise in designing complex UPW systems, employing ultra-clean construction methods, and specialized O&M. There is very limited local capacity for manufacturing or supplying this sophisticated equipment.	Component manufacturing/ supply, design, and specialised O&M are all assessed as very low. Ultra-clean construction practices are low.	Very High	Very Significant
Brine Management	Requires capabilities in the design and construction of advanced brine diffusers, technologies for brine concentration or Zero Liquid Discharge (ZLD), and environmental monitoring and modelling.	While environmental monitoring is at a medium level, the capacity for diffuser design/ construction is low-medium, and ZLD technology is very low.	High	Moderate to Significant (especially for advanced treatment)
Supporting Infrastructure	This includes the construction of pipelines and storage facilities, electrical and instrumentation works, SCADA/DCS integration, and specialised logistics for chemicals and spare parts.	Pipeline and storage construction and E&I works are at a medium level. SCADA/DCS integration and specialised logistics are rated low-medium.	High	Moderate
Cross-cutting: Engineering, Design & EPCM	Encompasses advanced process simulation and detailed engineering for complex plants (FEED). While local firms have general industrial project capabilities, expertise in specialized process design and EPCM for large-scale SWRO/UPW plants is nascent. The overall EPCM role for initial large-scale projects will likely require significant international partnership.	Low for specialised process plants and for managing projects of this scale and type.	Very High	Significant
Cross-Cutting: Specialised Construction & Manufacturing	Includes precision manufacturing and assembly of high-tech components, as well as specialised trades like high-spec welding and precision installation for process plants. Basic construction is well-developed, but advanced skills are lacking. Local manufacturing of high-tech components is generally low.	Specialized trade certifications are often lacking. Manufacturing capacity for complex components is limited.	High	Significant
Cross-Cutting: Plant Operation & Specialised Maintenance	Requires highly skilled teams with expertise in advanced water chemistry, membrane science, and predictive maintenance for complex SWRO/UPW facilities. While general industrial O&M exists, the specific demands of these plants represent a significant step up.	Developing, but experience with such specialised plants is limited.	Very High	Significant

Business Capability Gaps and Skills Implications - Water Desalination

Capability Area	Key Business Capabilities & Description of Gaps	Current Namibian Capacity Assessment	Criticality for GH2	Identified Gap Level
Cross-Cutting: HSSE, QA/QC & Logistics	HSSE: Implementing international HSSE standards and fostering the required safety culture. A substantial investment is needed to meet stringent process industry standards QA/QC: Having accredited labs and inspection services that adhere to international quality standards. Specialization for advanced water treatment may need enhancement Logistics: Managing complex international and local supply chains, especially for specialized and hazardous goods.	HSSE: Needs significant upskilling QA/QC: Basic services exist, but specialised capacity needs development Logistics: Basic logistics are good, but specialised areas need development.	High	Moderate
Cross-Cutting: Capital & Finance Access	The availability of local capital to finance large-scale infrastructure projects and support enterprise development.	Access to finance is limited for mega-projects, and Small and Medium-sized Enterprises (SMEs) also face challenges.	High	Moderate to Significant

● Skills Implications

Skill Category	Specific Skills/Roles	Required Proficiency (Illustrative)	Relevance to Value Chain Stage(s)	Key Competencies
Engineering	Process/Chemical Engineer	Advanced	All (Design, Ops, Optimization)	Process simulation, P&ID development, HAZOP, water chemistry, mass/energy balance
	Mechanical Engineer	Advanced	Design, Construction, O&M	Rotating equipment (pumps, ERDs), piping design, materials science, stress analysis, FEM
	Electrical Engineer	Advanced	Design, Construction, O&M	Power systems, VFDs, MCCs, high voltage, plant electrics, renewable energy integration
	Instrumentation & Control (I&C) Engineer	Advanced	Design, Construction, O&M	PLC/DCS/SCADA programming, sensor technology, control loop tuning, automation systems
	Civil/Structural Engineer	Advanced	Design, Construction	Foundations, marine structures (intakes/outfalls), buildings, corrosion protection
	Environmental Engineer	Advanced	Design, Permitting, O&M	EIA, brine dispersion modeling, waste management, regulatory compliance
Scientific	Water Chemist/Analyst	Advanced	Pre-treatment, RO, UPW, Brine	Advanced analytical techniques (ICP-MS, GC-MS, TOC), quality control, troubleshooting
	Microbiologist	Intermediate/Advanced	Pre-treatment, Disinfection	Biofouling assessment, microbial analysis

Business Capability Gaps and Skills Implications - Water Desalination

Skill Category	Specific Skills/Roles	Required Proficiency (Illustrative)	Relevance to Value Chain Stage(s)	Key Competencies
Technical Operations & Maintenance	Plant Operator (Control Room)	Intermediate/Advanced	RO, UPW, Support Infrastructure	SCADA/DCS operation, process monitoring, alarm management, emergency procedures
	Field Operator/Technician	Intermediate	All operational stages	Routine checks, minor adjustments, sampling, LOTO procedures
	Instrumentation Technician	Advanced	RO, UPW, Support Infrastructure	Calibration, troubleshooting, repair of sensors, analyzers, control valves
	Electrical Technician	Advanced	All stages	Maintenance of motors, switchgear, VFDs, cabling, troubleshooting electrical faults
	Mechanical Fitter/Technician	Advanced	All stages	Pump/ERD/compressor maintenance & overhaul, alignment, vibration analysis, pipework
	Laboratory Technician	Intermediate	Pre-treatment, RO, UPW, Brine	Sample preparation, routine analysis, QA/QC procedures
Specialized Trades (Certified)	High-Pressure Welder (e.g., Duplex/Super Duplex Stainless Steel)	Advanced	Construction, Maintenance	TIG/MIG welding to international codes (ASME, EN)
	Pipefitter (High-Alloy, Non-Metallic)	Advanced	Construction, Maintenance	Complex piping systems, UPW clean piping protocols
	Industrial Electrician	Advanced	Construction, Maintenance	Plant wiring, control panel assembly, hazardous area installations
	Rigger/Scaffolder	Intermediate	Construction, Maintenance	Safe lifting and access for large equipment
Project & Business Management	Project Manager (PMP or equiv.)	Advanced	Design, Construction	Scope, schedule, budget, risk, quality, stakeholder management for large projects
	Contract Manager	Advanced	Procurement, Construction	FIDIC/NEC contracts, claims management, supplier relations
	Supply Chain/Logistics Manager	Advanced	All stages	International procurement, hazmat logistics, inventory control
	HSSE Manager/Officer	Advanced	All stages	ISO 45001/14001, process safety, risk assessment, emergency response planning
	Quality Manager/Engineer	Advanced	All stages	ISO 9001, QA/QC plans, auditing, non-conformance management
Digital & Automation	Data Scientist/Analyst	Intermediate/Advanced	O&M, Optimization	Process data analysis, predictive modeling, machine learning for efficiency/maintenance
	Automation Engineer	Advanced	Design, O&M	Advanced process control strategies, system integration
	Cybersecurity Specialist (ICS/OT)	Advanced	O&M	Protecting industrial control systems from cyber threats
Green Skills / Sustainability	Renewable Energy Integration Specialist	Advanced	Design, O&M	Optimizing RE for desalination, microgrid management
	Water Resource Efficiency Specialist	Intermediate/Advanced	Design, O&M	Minimizing water losses, optimizing chemical use, life cycle assessment
	Brine Management Specialist	Advanced	Design, O&M	Technologies for brine treatment/valorization, environmental compliance

6.2.5 Green Hydrogen Production (Electrolysis Technologies) Value Chain

6.2.5.1 Understanding the Electrolyser Ecosystem

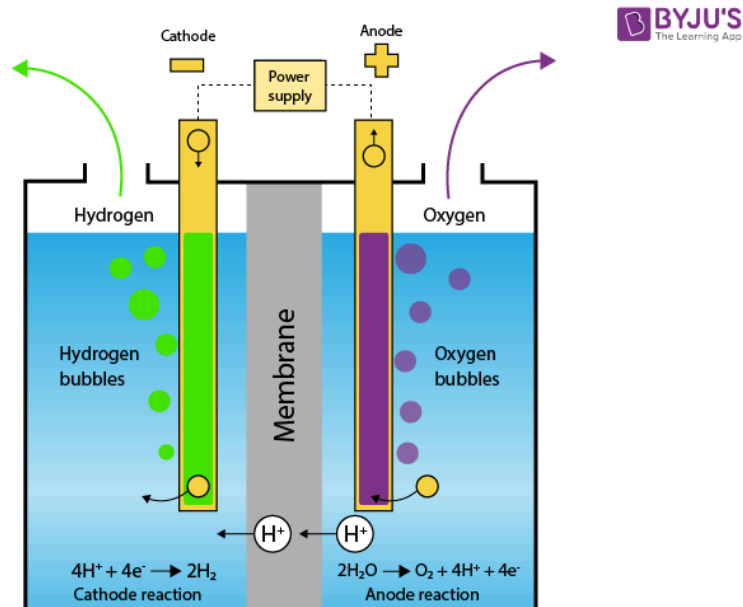


Figure 10: Water Electrolysis Process (BYJU'S) ³⁰²

Water electrolysis, the electrochemical process that splits water (H₂O) into hydrogen (H₂) and oxygen (O₂) using an electric current, is fundamental to the production of green hydrogen when the electricity is derived from renewable energy sources.¹ The choice of electrolysis technology is a critical decision in the development of green hydrogen projects, as each available method presents a unique combination of operational characteristics, cost implications, and maturity levels. Four primary types of electrolysis technologies are currently prominent: Alkaline Electrolysis (AEC), Proton Exchange Membrane (PEM) Electrolysis, Anion Exchange Membrane (AEM) Electrolysis, and Solid Oxide Electrolysis Cell (SOEC) Electrolysis³⁰³.

i. Alkaline Electrolysis (AEC)

Alkaline Electrolysis stands as the most established and widely deployed technology for commercial hydrogen production. AEC systems utilise a liquid alkaline electrolyte, typically a solution of potassium hydroxide (KOH) or, less commonly, sodium hydroxide (NaOH), at concentrations usually between 25-30% by weight. The electrodes are generally nickel-based, often with proprietary coatings to enhance catalytic activity and reduce energy consumption. These systems operate at temperatures typically ranging from 60°C to 80°C³⁰⁴.

Footnotes

³⁰² Sourced from <https://byjus.com/jee/water-electrolysis/>

³⁰³ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://www.mdpi.com/2673-4117/6/4/81>

³⁰⁴ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

AEC technology is particularly well-suited for large-scale, centralised hydrogen production facilities where operational cost-effectiveness is a primary driver and a consistent, stable supply of electricity is available. Consequently, it has been a common choice for integration into large industrial complexes, such as chemical plants and refineries, that require a continuous hydrogen supply. Its maturity and proven track record, spanning several decades, make it a reliable option, especially when ultra-high hydrogen purity is not an immediate critical requirement without additional purification steps³⁰⁵.

The principal advantages of AEC include its relatively low capital cost compared to other technologies, its robustness, and its long operational lifetime. However, traditional alkaline electrolyzers generally exhibit lower electrical efficiency compared to PEM and SOEC systems, particularly when operating under dynamic or partial load conditions, which can be a drawback when paired with intermittent renewable energy sources. The hydrogen produced may also contain traces of the alkaline electrolyte, necessitating downstream purification for certain high-purity applications. Despite these limitations, its cost-effectiveness and reliability ensure its continued relevance for bulk green hydrogen production, especially in scenarios where stable renewable energy inputs can be guaranteed³⁰⁶.

ii. Proton Exchange Membrane (PEM) Electrolysis

Proton Exchange Membrane (PEM) electrolysis represents a more recent, yet rapidly maturing, technology. PEM electrolyzers employ a solid polymer electrolyte, specifically a proton-conducting membrane, which separates the anode and cathode. The electrodes typically utilise platinum group metals (PGMs) as catalysts, with platinum often used at the cathode and iridium or iridium-ruthenium oxides at the anode, to facilitate the respective hydrogen and oxygen evolution reactions. Operating temperatures for PEM systems are generally in the range of 50°C to 80°C³⁰⁷.

A key characteristic of PEM technology is its compact design and its ability to respond rapidly to fluctuations in power input, making it highly compatible with variable renewable energy sources such as solar photovoltaic (PV) and wind power. This responsiveness makes PEM electrolysis an excellent choice for applications such as power-to-gas, grid balancing services, and projects where hydrogen is produced and stored during periods of peak renewable generation for later use. The technology is increasingly favoured for green hydrogen production in sectors like transportation (fuel cell vehicles), decentralised energy storage, and various industrial applications requiring high-purity hydrogen, as PEM systems inherently produce hydrogen with very low impurity levels³⁰⁸.

Advantages of PEM electrolysis include higher current densities leading to more compact stack designs, faster start-up and shutdown times, a wider dynamic operating range, and the production of high-purity hydrogen directly from the cell. However, relying on expensive PGM catalysts and specialised membrane materials contributes to higher capital costs than AEC, particularly for large-scale installations. The acidic operating environment also necessitates the use of corrosion-resistant materials, such as titanium, for components like bipolar plates and current collectors, further adding to the cost³⁰⁹.

Footnotes

³⁰⁵ <https://www.southernlights.io/industry/water-electrolysis-technologies/>

³⁰⁶ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

³⁰⁷ <https://epcland.com/electrolysers-types/>

³⁰⁸ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

³⁰⁹ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

iii. Anion Exchange Membrane (AEM) Electrolysis

Anion Exchange Membrane (AEM) electrolysis is an emerging technology that seeks to combine the benefits of both AEC and PEM systems. AEM electrolyzers utilise a solid polymer membrane that conducts hydroxide ions (OH⁻), similar to PEM but with anions instead of protons as the charge carrier. This allows AEM systems to operate with an alkaline environment, potentially enabling the use of less expensive, non-PGM catalysts similar to those used in AEC, while still offering the advantages of a zero-gap cell architecture and compact design associated with membrane-based systems. Operating temperatures are typically in the 60°C to 80°C range³¹⁰.

AEM technology is positioned as a promising solution for projects where cost-efficiency and sustainability are key priorities, but where the absolute highest hydrogen production rates or ultra-pure hydrogen (without further polishing) are not essential. Its ability to perform efficiently with variable power inputs also makes it well-suited for integration with renewable energy sources like solar and wind³¹¹.

The main potential advantages of AEM electrolysis lie in its ability to use cost-effective materials for catalysts and bipolar plates (avoiding or reducing the need for PGMs and titanium), which could lead to significantly lower capital costs compared to PEM. It aims to offer the operational flexibility of PEM systems without the associated high material costs. However, AEM technology is still in the earlier stages of commercial development compared to AEC and PEM. Key challenges include developing AEMs with sufficient ionic conductivity and long-term chemical stability in alkaline environments at operational temperatures, as well as optimising catalyst performance and durability. As research progresses and these technical hurdles are overcome, AEM electrolysis could become a highly competitive option³¹².

iv. Solid Oxide Electrolysis Cell (SOEC)

Solid Oxide Electrolysis Cell (SOEC) technology operates on a fundamentally different principle, utilising a solid ceramic material as the electrolyte, typically yttria-stabilised zirconia (YSZ) or other ion-conducting ceramics. SOEC systems function at very high temperatures, generally between 700°C and 1000°C. At these elevated temperatures, a significant portion of the energy required for water splitting can be supplied as heat, reducing the electrical energy demand and leading to potentially very high electrical efficiencies. The electrodes are typically based on complex metal oxides³¹³.

SOEC technology is considered a promising candidate for large-scale hydrogen production, particularly in applications where high-temperature heat sources are readily and economically available, such as integrated with industrial waste heat, geothermal energy, or next-generation nuclear power plants. The high operating temperature not only improves reaction kinetics and reduces electrical energy consumption but also allows for the direct electrolysis of steam, which is thermodynamically more favourable than liquid water electrolysis³¹⁴.

The primary advantage of SOEC is its potential for the highest electrical efficiency among all electrolyser types, especially when thermal energy can be effectively integrated. It can also co-electrolyse steam and carbon dioxide to produce syngas (H₂CO), a precursor for synthetic fuels. However, SOEC technology is still in the early stages of commercialisation and faces significant challenges. These include the high cost of materials capable of withstanding the extreme operating temperatures, system complexity, long start-up times, and concerns regarding long-term durability and degradation of cell components due to thermal cycling and material interactions at high temperatures³¹⁵.

Footnotes

³¹⁰ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

³¹¹ <https://www.southernlights.io/industry/water-electrolysis-technologies/>

³¹² <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

³¹³ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

³¹⁴ <https://www.southernlights.io/industry/water-electrolysis-technologies/>

³¹⁵ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

The specific nature of a country's renewable resource portfolio and its industrial infrastructure will significantly shape the optimal mix of electrolysis technologies. For example, nations with abundant and low-cost geothermal or industrial waste heat may find SOEC systems increasingly attractive as the technology matures, despite higher initial capital outlays, due to the potential for superior overall energy efficiency. Conversely, countries primarily relying on variable solar and wind resources, like Namibia, may favour PEM or AEM technologies due to their rapid response capabilities and operational flexibility. Namibia's strategy to initiate pilot projects to accumulate operational knowledge across different electrolyser types is a prudent approach to navigate these technological choices and gain firsthand experience. For very large-scale production, potentially for export markets, mature and cost-effective Alkaline electrolyzers could also play a role, especially if linked to dedicated, quasi-baseload renewable power generation or substantial energy storage solutions to ensure stable operation³¹⁶.

6.2.5.2 Electrolysis Value Chain

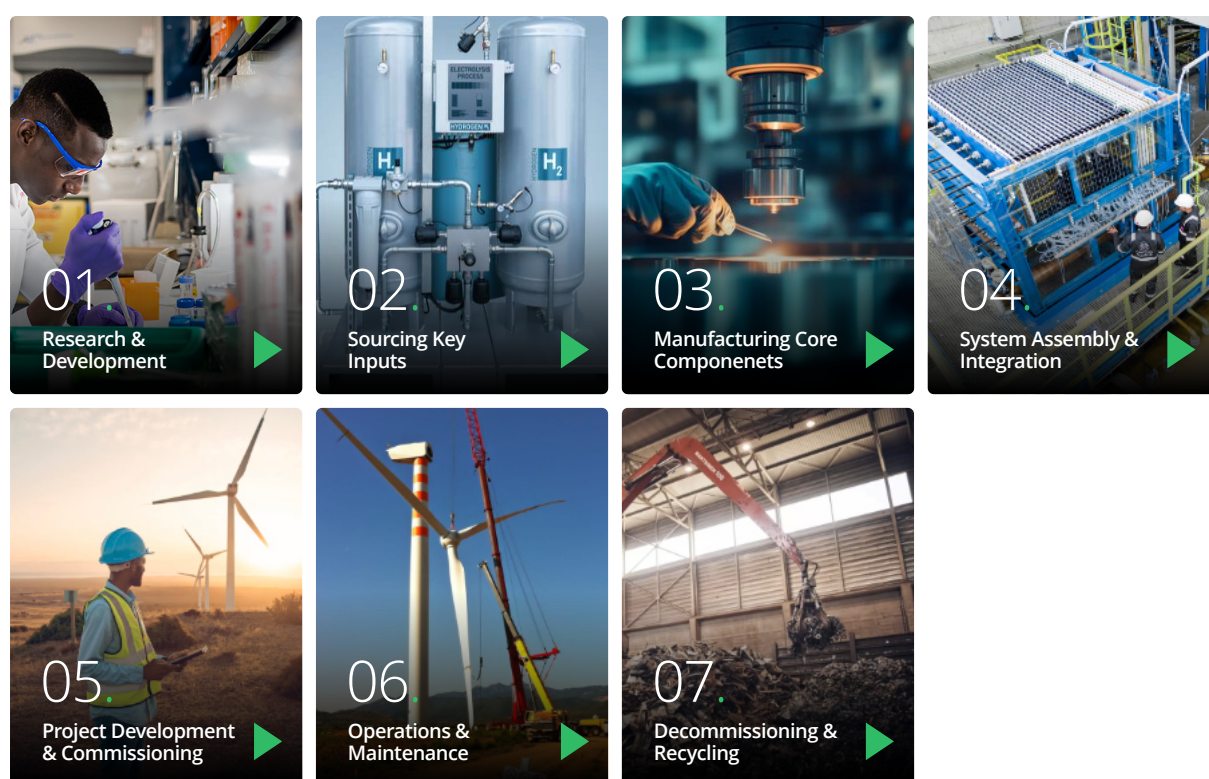


Figure 11: Electrolysis Value Chain

The journey of an electrolysis system from conception to disposal encompasses a multifaceted value chain involving diverse actors, sophisticated technologies, and significant capital investment. The global capacity for both electrolyser manufacturing and dedicated hydrogen production via electrolysis has witnessed substantial growth in recent years, signalling a rapidly evolving industrial landscape. Understanding this value chain is essential for identifying opportunities and challenges for new entrants like Namibia.

Footnotes

³¹⁶ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>
<https://ippr.org/na/wp-content/uploads/2024/09/Renewables-Policy-and-Practice-A-Look-at-Namibia-Web.pdf>
<https://www.lithon.com/renewable-energy-role-in-namibia/>
<https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>

A. Research, Development, and Innovation Frontiers

At the genesis of the value chain lies research, development, and innovation (R,D&I). This stage involves fundamental scientific inquiry and applied engineering focused on advancing electrolysis technologies. Key activities include the discovery and development of novel materials for catalysts, membranes, and electrolytes, aiming to improve performance and reduce reliance on scarce or expensive resources such as PGMs in PEM electrolyzers. Efforts are also directed towards optimising cell and stack designs for enhanced efficiency and durability, improving system integration for better overall performance, and developing more cost-effective manufacturing processes. A significant portion of R&D is dedicated to accelerating the commercial viability of less mature technologies like AEM and SOEC by addressing their current technical and cost hurdles³¹⁷.

Key actors in this domain include universities, public research institutions, national laboratories, and the dedicated R&D departments of electrolyser manufacturers and component suppliers. Continuous innovation is paramount, as it directly contributes to reducing the cost of electrolyzers and, consequently, the cost of green hydrogen, making it increasingly competitive against conventional hydrogen production methods and other energy carriers.

A discernible global R&D race is in progress, with nations and corporations investing heavily to overcome the existing limitations of electrolysis technologies. This competitive environment is fostering rapid advancements, particularly in AEM and SOEC systems, and in finding alternatives to critical raw materials like iridium and platinum for PEM systems to mitigate cost and supply chain vulnerabilities. The level of investment in R&D is a direct determinant of the pace of technological progress and cost reduction. For Namibia, while becoming a leader in fundamental R&D might be a long-term aspiration, strategic engagement through partnerships with international R&D consortia and focusing on applied research to adapt technologies to its unique local conditions (e.g., operating in arid, dusty environments, or optimising systems for desalinated water) presents a viable pathway. The establishment of the Namibia Green Hydrogen Research Institute (NGHRI) at the University of Namibia (UNAM) and related programs at the Namibia University of Science and Technology (NUST) are vital foundational steps in building this capacity

B. Sourcing and Processing of Key Inputs (Incl. Critical Raw Materials and Water)

This stage encompasses the extraction, processing, and refining of a wide array of raw materials essential for electrolyser construction and operation. These include base metals like nickel (for AEC and AEM electrodes), steel (for structural components and BoP), and titanium (for corrosion-resistant components in PEM systems). Critical raw materials (CRMs) are particularly significant, such as platinum group metals (PGMs) – platinum and iridium – which are vital catalysts for PEM electrolyzers. Other CRMs like cobalt and rare earth elements (REEs) may be used in specialised components or associated systems. High-purity quartz is essential for manufacturing semiconductors used in power electronics and for solar PV panels that might power the electrolyzers. Speciality polymers are needed for membranes, and ceramics for SOEC components³¹⁸.

A fundamental input is water, which must be of high purity to prevent contamination and degradation of the electrolyser stack. In many regions, including arid ones like Namibia, this necessitates large-scale water sourcing, often involving seawater desalination, followed by deionisation to achieve the required purity³¹⁹.

Footnotes

³¹⁷ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>

³¹⁸ <https://www.giz.de/en/worldwide/155834.html>

<https://marketwatch.com/na/energy/dutch-green-hydrogen-skills2025-05-20157792>

<https://www.nrf.ac.za/from-foundations-to-futures-strengthening-research-management-in-african-science-granting-councils/>

<https://www.nust.na/sites/default/files/NUST-Profile-2024.pdf>

<https://sasscal.org/namibia-delivers-on-sasscal-2-0-and-green-hydrogen-projects/>

³¹⁹ <https://epcland.com/electrolysers-types/>

<https://www.energy.gov/sites/default/files/2024-12/Fuel%2520Cells%2520%26%2520Electrolyzers%2520Supply%2520Chain%2520Report%2520-%2520Final%5B1%5D.pdf>

<https://www.miningweekly.com/article/south-africa-must-strengthen-key-iridium-status-sfa-oxford-2022-04-29>

<https://african.business/2022/03/energy-resources/namibia-eyes-green-hydrogen-future>

A. Research, Development, and Innovation Frontiers

A fundamental input is water, which must be of high purity to prevent contamination and degradation of the electrolyser stack. In many regions, including arid ones like Namibia, this necessitates large-scale water sourcing, often involving seawater desalination, followed by deionisation to achieve the required purity³²⁰.

The availability, cost, and supply chain stability of these materials are critical determinants of electrolyser manufacturing costs, scalability, and the overall economic viability of green hydrogen projects. The supply chain for electrolysers is intricately linked with those for renewable energy generation technologies (e.g., silicon for solar PV, REEs for wind turbines) and battery storage systems, creating cumulative demand and potential competition for certain CRMs. This interconnectedness can lead to supply bottlenecks or price volatility if not managed with foresight. Furthermore, the geopolitical concentration of mining and, more importantly, processing of many CRMs can create significant supply chain vulnerabilities and price fluctuations, impacting electrolyser manufacturers and project developers globally³²¹.

Namibia possesses notable deposits of several relevant minerals, including uranium, diamonds, gold, lithium, and potentially REEs. Reports also suggest the presence of PGMs, including iridium and platinum, as well as nickel resources. This indigenous resource base presents a strategic opportunity for local sourcing and, crucially, local beneficiation. By developing domestic processing capabilities, Namibia could supply higher-value materials to the electrolyser value chain, aligning with its "Growth at Home" strategy and the recent ban on the export of unprocessed critical minerals. The national "Green Industrialisation Blueprint" further envisages the possibility of importing CRMs from neighbouring countries for processing in Namibia, utilising locally produced green hydrogen as the energy source for these value-addition activities. For water, a robust strategy focusing on cost-effective desalination technologies and environmentally sound brine management is indispensable for Namibia's green hydrogen ambitions³²².

C. Manufacturing of Core Components (Electrolyser Stacks, Balance of Plant)

This stage involves the precision manufacturing of the heart of the electrolysis system – the electrolyser stack – and the various Balance of Plant (BoP) components. Stack manufacturing includes producing electrodes, membranes or diaphragms, bipolar plates, seals, and end frames. BoP components encompass a wide range of equipment, such as power supply and conditioning units (rectifiers, transformers), water purification systems (reverse osmosis, deionisation), gas separation and drying units (pressure swing adsorption, membrane separation), hydrogen compressors, cooling systems, and sophisticated control systems³²³.

Key actors are specialised electrolyser manufacturers (who may produce stacks and integrate systems) and a diverse range of suppliers for BoP components. Global electrolyser manufacturing capacity reached approximately 25 GW per year by the end of 2023, a significant increase, with China reportedly accounting for around 60% of this capacity. Projections based on company announcements suggest that global manufacturing capacity could exceed 165 GW per year by 2030. The stack itself is a high-value, technology-intensive sub-assembly, and its eventual replacement represents a major recurring investment over the plant's lifetime, potentially accounting for 30-50% of the initial total capital expenditure for an electrolysis system³²³.

Footnotes

³²⁰ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product%20Study%20-%20Water%20for%20GH2%20Production%20in%20Namibia.pdf>

³²¹ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>

³²² <https://african.business/2022/03/energy-resources/namibia-eyes-green-hydrogen-future>

<https://www.state.gov/reports/2024-investment-climate-statements/namibia/>

https://au.int/sites/default/files/documents/44539-doc-AGMS_Final_doc.pdf

<https://unu.edu/sites/default/files/2024-04/Poly%20Brief%20Africa-beyond-fossils-TA-Sep-2020.pdf>

<https://www.africangreenminerals.com/minerals/nickel>

³²³ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product>

Key actors are specialised electrolyser manufacturers (who may produce stacks and integrate systems) and a diverse range of suppliers for BoP components. Global electrolyser manufacturing capacity reached approximately 25 GW per year by the end of 2023, a significant increase, with China reportedly accounting for around 60% of this capacity. Projections based on company announcements suggest that global manufacturing capacity could exceed 165 GW per year by 2030. The stack itself is a high-value, technology-intensive sub-assembly, and its eventual replacement represents a major recurring investment over the plant's lifetime, potentially accounting for 30-50% of the initial total capital expenditure for an electrolysis system³²⁴.

A rapid scale-up of global manufacturing capacity is currently underway, driven by anticipated strong growth in demand for green hydrogen and supportive government policies worldwide. This expansion aims to leverage economies of scale and learning-by-doing effects to drive down electrolyser production costs. Increased manufacturing scale, coupled with automation and process optimisation, is a critical lever for reducing the capital cost of electrolysers, which in turn is a key factor in lowering the overall cost of green hydrogen production³²⁵.

For Namibia, directly competing in the mass-market manufacturing of electrolyser stacks against established global players with significant scale and experience, such as those in China, would present considerable challenges. However, Namibia's Green Hydrogen Strategy and its Green Industrialisation Blueprint identify local component manufacturing as a desirable long-term goal. The strategy includes launching pilot projects to cultivate the knowledge, skills, and capacity within local Engineering, Procurement, and Construction (EPC) businesses to potentially undertake component manufacturing and delivery. More immediate opportunities may lie in the manufacturing or assembly of certain BoP components, customised solutions for local conditions, or servicing the local and regional market. The significant local content target of 30% set for the Hyphen project provides an initial demand signal that could stimulate investment in local manufacturing capabilities. Furthermore, Namibia's Special Economic Zone (SEZ) policy is designed to provide incentives to attract and support manufacturing investments³²⁶.

D. System Assembly, Integration and Quality Assurance

Following the manufacturing of individual components, this stage involves assembling the electrolyser stacks with the various BoP components to create complete, functional electrolysis systems or turnkey plants. This requires careful engineering to ensure all subsystems work harmoniously. Rigorous testing and quality assurance (QA) procedures are conducted at various points during assembly and on the final system to verify performance against specifications, ensure operational safety, and guarantee reliability³²⁷.

The main actors in this segment are the electrolyser manufacturers themselves (who often offer integrated systems), specialised system integrators, and EPC companies. As green hydrogen projects grow in scale and complexity, particularly those involving direct integration with large, variable renewable energy plants and end-user production processes like ammonia synthesis, the role of specialised system integrators is becoming increasingly prominent. These integrators possess the expertise to manage the complex interfaces between various subsystems.

Proper system integration is crucial for achieving optimal performance, efficiency, and longevity of the electrolysis plant. Failures or shortcomings in integration or QA can lead to operational inefficiencies, increased maintenance burdens, safety incidents, and ultimately, can jeopardise the economic viability of a project. An electrolysis system is a complex interplay of power electronics, fluid dynamics, thermal management, chemical processes, and control logic; any weak link can compromise the entire operation³²⁸.

Footnotes

³²⁴ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>
<https://restservice.epri.com/publicdownload/000000003002031505/0/Product>

³²⁵ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>

³²⁶ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>
<https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>
<https://gh2.org/countries/namibia>
<https://gh2namibia.com/wp-content/uploads/2024/07/GH2-Documents-Final.pdf>
<https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>

³²⁷ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product>

³²⁸ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product>

Proper system integration is crucial for achieving optimal performance, efficiency, and longevity of the electrolysis plant. Failures or shortcomings in integration or QA can lead to operational inefficiencies, increased maintenance burdens, safety incidents, and ultimately, can jeopardise the economic viability of a project. An electrolysis system is a complex interplay of power electronics, fluid dynamics, thermal management, chemical processes, and control logic; any weak link can compromise the entire operation³²⁹.

E. Project Development, Deployment and Commissioning

This phase is where green hydrogen production concepts are transformed into physical realities. It encompasses a wide range of activities, starting with initial site selection and detailed feasibility studies, which assess technical viability, economic potential, and resource availability (renewable energy, water). Comprehensive Environmental and Social Impact Assessments (ESIAs) are conducted to identify and mitigate potential adverse effects. Securing necessary permits and licenses from regulatory authorities is a critical step, as is arranging project financing from investors, lenders, and development finance institutions. This is followed by the detailed engineering, procurement, and construction (EPC) of the green hydrogen plant, including civil works, installation of renewable energy generation capacity (if not sourced from the grid), water treatment facilities, the electrolyser systems themselves, hydrogen purification, compression, storage, and any end user production processing units (e.g., for ammonia or synthetic fuels). The final steps involve the commissioning of the entire plant, ensuring all systems operate as designed and meet performance guarantees.

Key actors in this phase include project developers (who may be specialised hydrogen companies, utility companies, or industrial conglomerates), EPC contractors, equipment suppliers (including electrolyser manufacturers), financial institutions, and regulatory bodies. Globally, installed electrolysis capacity for dedicated hydrogen production reached 1.4 GW by the end of 2023, with a significantly larger pipeline of projects announced or under development, indicating a strong growth trajectory³³⁰.

A notable trend is the move towards increasingly large-scale, often "gigawatt-scale," green hydrogen projects. These are frequently designed as integrated developments, combining massive renewable energy generation facilities (solar and wind) with large electrolyser capacities, often with a focus on producing hydrogen derivatives like green ammonia for export markets. The Hyphen Hydrogen Energy project in Namibia is a prime example of such an initiative. The availability of well-defined, "shovel-ready" flagship projects, supported by clear and stable regulatory frameworks and government backing, is crucial for mobilising the substantial investment required and for providing demand certainty to electrolyser manufacturers, thereby kick-starting the scaling up of the entire low-emissions hydrogen ecosystem³³¹.

Namibia is already a focal point for such large-scale project development, led by the Hyphen project and complemented by other initiatives like Hylron and the Dâures Green Hydrogen Village. This creates substantial opportunities for developing local expertise in all aspects of project development and execution, including project management, specialised EPC services, construction, logistics, and related support services. The Namibian government's role in providing access to land, facilitating the development of common user infrastructure (such as ports and pipelines), and streamlining permitting processes is critical to the success of these ventures³³².

Footnotes

³²⁹ <https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>
<https://gh2.org/countries/namibia>

³³⁰ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>

³³¹ <https://global-climatescope.org/highlights/namibia#:~:text=Namibia%20has%20ambitious%20green%20hydrogen,production%20target%20of%20350%2C000%20tons.https://economy.com.na/green-hydrogen>
<https://www.iea.org/energy-system/low-emission-fuels/electrolysers>

³³² <https://global-climatescope.org/highlights/namibia#:~:text=Namibia%20has%20ambitious%20green%20hydrogen,production%20target%20of%20350%2C000%20tons.https://economy.com.na/green-hydrogen>
<https://www.pv-magazine.com/2025/03/21/the-hydrogen-stream-hylron-starts-green-hydrogen-production-in-namibia/>
<https://ammoniaenergy.org/organization/hyphen-hydrogen-energy/>
<https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>

F. Operational Management and Maintenance Strategies

Once a green hydrogen plant is commissioned, the operational management and maintenance (O&M) phase begins, extending over the typical 20–30-year lifespan of the facility. This involves the day-to-day operation of the electrolysis plant, continuous monitoring of system performance parameters (efficiency, output, purity), and diligent execution of both planned (preventive) and unplanned (corrective) maintenance activities. Ensuring stringent adherence to safety protocols and environmental regulations is paramount. Efficient management of input supplies, primarily low-cost renewable electricity and purified water, and the reliable offtake or storage of the produced hydrogen are also key operational functions³³³.

A critical aspect of O&M is cost management. Electricity typically constitutes the largest single operational cost, often accounting for 85-90% or more of total O&M expenditures, especially for large-scale plants. Therefore, access to low-cost, reliable renewable electricity is the most significant factor influencing the final cost of green hydrogen. Another major financial consideration is the periodic replacement of electrolyser stacks, which have a finite operational life due to degradation. Stack replacement can represent a substantial recurring capital expenditure, potentially 30-50% of the initial system CAPEX. Maintaining the efficiency and longevity of the stacks also depends on the quality of input water and hydrogen, making robust water and gas purification systems essential. This phase requires a dedicated team of skilled personnel, including plant operators, maintenance technicians, engineers, and safety officers³³⁴.

The choice of electrolysis technology significantly influences O&M requirements, associated costs, and the specific skills needed. For instance, the very high operating temperatures of SOEC systems (700-1000°C) necessitate specialised materials, handling procedures, and maintenance expertise distinct from those required for lower-temperature AEC or PEM systems (50-80°C). While PEM systems operate at lower temperatures, their use of valuable PGM catalysts may require specific protocols during stack refurbishment or replacement to maximise the recovery of these materials³³⁵.

For Namibia, the development of a well-trained local workforce for all aspects of O&M is essential for the long-term sustainability of its green hydrogen industry and for maximising local job creation. This includes technicians proficient in electrical, mechanical, and chemical systems, process operators, instrumentation specialists, and safety and environmental compliance personnel. The nation's strategic focus on developing abundant, low-cost renewable energy resources is a fundamental enabler for competitive green hydrogen production. Furthermore, implementing effective strategies for optimising electrolyser stack lifetime, managing degradation, and planning for cost-efficient stack replacement will be critical for the long-term economic success of its projects.

G. End-of-Life Pathways: Decommissioning and Material Recovery

At the conclusion of an electrolysis plant's operational lifespan, the end-of-life (EoL) management phase commences. This involves the safe and environmentally responsible decommissioning of the facility. A key aspect of modern EoL strategies is the recovery, recycling, and reprocessing of valuable materials from the decommissioned electrolyser stacks and BoP components. Materials targeted for recovery can include PGMs (from PEM systems), nickel, titanium, copper, steel, and various polymers and ceramics. The remaining waste materials must be managed and disposed of in an environmentally sound manner³³⁶.

Actors in this segment include specialised demolition and decommissioning companies, e-waste and metal recycling firms, hazardous waste management services, and potentially the original equipment manufacturers (OEMs), who may offer take-back schemes or recycling services. The development of efficient and economically viable recycling pathways promotes circular economy principles by reducing the demand for virgin raw materials, mitigating resource depletion concerns, and minimising the environmental footprint of the electrolysis industry.

Footnotes

³³³ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product>

³³⁴ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product>

³³⁵ <https://www.southernlights.io/industry/water-electrolysis-technologies/>
<https://epcland.com/electrolysers-types/>

³³⁶ <https://www.iea.org/energy-system/low-emission-fuels/electrolysers>

<https://www.energy.gov/sites/default/files/2024-12/Fuel%20Cells%20%26%20Electrolyzers%20Supply%20Chain%20Report%20-%20Final%5B1%5D.pdf>

As the global deployment of electrolysis capacity accelerates, the volume of systems reaching their EoL will increase significantly in the coming decades. This will drive the need for and create opportunities for the development of specialised recycling infrastructure and technologies. The design of electrolyzers themselves plays a crucial role here; adopting "Design for Disassembly" and "Design for Recycling" principles during the manufacturing stage can greatly simplify the EoL processes and improve the efficiency and cost-effectiveness of material recovery.

While EoL management might seem a distant consideration for Namibia as it embarks on new green hydrogen projects, incorporating these aspects into initial project planning, technology selection, and regulatory frameworks is a prudent long-term strategy. There could be future opportunities for Namibia to develop specialised recycling facilities, particularly if it becomes a major regional hub for green hydrogen production. This would be especially relevant if the electrolyzers deployed contain significant quantities of materials that Namibia itself produces or could benefit from (e.g., PGMs, nickel). Such facilities would create additional local value, generate employment, and contribute to a more sustainable and circular green hydrogen economy.

6.2.6 Business Capability Gaps and Skills Implications

A comprehensive analysis of Namibia's business capability gaps within the electrolysis technology value chain reveals several critical areas that require strategic development. The following table synthesises these findings, detailing the required capabilities, the current status in Namibia, the specific gaps, the potential impacts of these deficiencies, and a priority level for addressing them.

Table 27: Business Capability Gaps and Skills Implications-Electrolysis Value Chain

Business Capability Gaps and Skills Implications -Electrolysis Value Chain				
Value Chain Stage ³³⁷	Specific Business Capability Required	Current Namibian Status/Level	Key Gap Description	Potential Impact on GH2 Sector Development if Gap Persists
Component Manufacturing (Stacks, BoP)	Precision manufacturing of electrolyser stacks, membranes, catalysts; Advanced Balance of Plant (BoP) components.	Low	A significant gap exists in the capacity to manufacture complex, high-precision electrolyser components. The existing manufacturing base is not geared towards advanced energy technologies, leading to a "missing middle" of medium-sized, technically competent local firms. This limits the production of sophisticated BoP items that require specialized materials or advanced techniques.	This deficiency can lead to over-reliance on imported technology, higher project costs, vulnerability to international supply chain disruptions, and missed opportunities for local value addition and job creation. Meeting the 30% local content target for projects like Hyphen will be challenging.

Footnotes

³³⁷ <https://tradingeconomics.com/namibia/manufacturing-value-added-percent-of-gdp-wb-data.html>
https://www.npc.gov.na/wp-content/uploads/2022/02/Manufacturing-paper-Nov_2017.pdf
<https://mit.gov.na/manufacturing-sector>
<https://etangonam.com/?p=561>
<https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>

Business Capability Gaps and Skills Implications -Electrolysis Value Chain

Value Chain Stage	Specific Business Capability Required	Current Namibian Status/Level	Key Gap Description	Potential Impact on GH2 Sector Development if Gap Persists
System Assembly, Integration & QA	Assembly of complex electrolyser systems, integration with Renewable Energy (RE) and production processes, robust Quality Assurance (QA).	Low to Medium	While some general assembly skills exist, there is limited experience with integrating GW-scale hydrogen systems.	Potential for inefficiencies, reliance on foreign integrators, and a slower rollout of projects.
Project Execution (EPCM)	Engineering, Procurement, Construction, and Management (EPCM) for GW-scale RE and chemical processing plants (H2/Ammonia).	Low	There is a scarcity of local firms with proven experience in executing large-scale, complex projects associated with green hydrogen and ammonia plants. The national strategy acknowledges the need to develop local EPC companies.	Continued dependence on international EPCM contractors could result in higher project costs and a slower transfer of critical know-how to Namibian entities.
Local Supply Chain Development	A network of local suppliers for specialized goods (e.g., specific alloys, chemicals, spare parts) and services (e.g., specialized logistics, maintenance).	Low	The broader industrial ecosystem to support a thriving green hydrogen sector is currently underdeveloped. There's a "missing middle" of capable SMEs and a lack of medium-sized, technically competent local firms to act as Tier 1 or Tier 2 suppliers. Integrating SMEs into these technologically advanced international supply chains is a considerable challenge.	An underdeveloped local supply chain makes it difficult to achieve widespread socio-economic benefits like job creation and SME development. Significant value leakage could occur if most goods and services are imported.
R&D Commercialization & Technology Absorption	Translating research into commercial products/services; Adapting imported technology to local conditions.	Low to Medium	Pathways from academic research to locally commercialized products are weak. Strong local technical and innovation capacity is necessary to absorb, adapt, and deploy imported technologies effectively. There is a need for greater industry participation in vocational training and curriculum development to foster applied innovation.	Without stronger linkages between research and industry, Namibia may remain a technology taker rather than an innovator, missing opportunities for customized solutions and local intellectual property.
Long-Term O&M Services	Specialized Operational and Maintenance (O&M) for large-scale electrolysers, RE plants, and chemical facilities.	Low	The specialized O&M skills required for these advanced and complex facilities are still nascent within the local workforce.	Heavy reliance on expatriate expertise for long-term O&M would limit sustainable local employment and skills development, and could lead to higher operational costs.
Critical Minerals Beneficiation	Local processing of indigenous Critical Raw Materials (CRMs) like Platinum Group Metals (PGMs), Nickel (Ni), and Lithium (Li) for use in electrolyser/RE value chains.	Low (for advanced processing)	Historically, Namibia has focused on exporting raw or semi-processed minerals. The ban on raw CRM export is a recent development aimed at changing this.	A missed opportunity for significant value addition and deeper integration into the global green hydrogen supply chain.

Business Capability Gaps and Skills Implications -Electrolysis Value Chain

● Skills Implications

Skill Category	Key Competencies and Expertise	Illustrative Job Titles	Current Availability in Namibia
Electrolyser & Component Manufacturing	Precision assembly, quality control for specialized materials (membranes, catalysts), automated manufacturing systems, lean manufacturing, and supply chain for high-tech components.	Manufacturing Engineer, Production Technician, Quality Assurance Inspector, Supply Chain Manager (Manufacturing)	Very Low / Nascent
Specialized Technical & Plant Operations	Deep knowledge of electrolyser technologies (AEC, PEM, AEM, SOEC), high-pressure hydrogen handling, process automation, and chemical safety protocols.	Electrolyser Operator, Control Room Technician, Hydrogen Plant Technician, Desalination Plant Operator	Low
Skilled Trades & Maintenance	Proficiency in high-voltage electrical systems, specialized welding, pipefitting, industrial mechanics, and instrumentation for plant construction and maintenance.	Electrician, Welder, Pipefitter, Industrial Mechanic, Instrumentation Technician	Low to Medium (General skills exist, but hydrogen-specific expertise is lacking)
Advanced Engineering & Scientific Research	Expertise in process design, power systems, equipment integrity, material science, R&D in catalysis and water treatment, and environmental science.	Chemical Engineer, Electrical Engineer, Mechanical Engineer, Materials Scientist, Research Scientist	Low (Especially with specialization in hydrogen)
Construction & Large-Scale Installation	Management of large, complex construction projects, including heavy equipment operation, high-pressure piping, and industrial-scale electrical installations.	Site Manager, Construction Supervisor, Civil Works Foreman, Specialized Equipment Installer	Low to Medium (Particularly for specialized aspects of hydrogen facilities)
Project Management & Business Operations	Skills in managing large-scale, multi-billion-dollar projects, supply chain logistics, financial modeling, contract negotiation, and business development for local enterprise growth.	Project Manager, Contracts Manager, Supply Chain Specialist, Business Analyst	Low (Especially for mega-scale energy projects)
Safety, Environmental & Regulatory Compliance	In-depth understanding of hydrogen-specific safety (HAZOP), environmental impact assessment, sustainable resource management, and adherence to national and international standards.	Environmental, Health & Safety (EHS) Officer, Environmental Scientist, Regulatory Compliance Specialist	Low (Particularly for hydrogen-specific expertise)
Digital, Automation & Data Analytics	Competence in industrial automation (PLC/DCS), data analytics for process optimization, IoT for predictive maintenance, and cybersecurity for industrial control systems.	Automation Engineer, Process Data Analyst, Industrial Cybersecurity Specialist	Low
Just Transition & Community Engagement	"Soft skills" for community consultation, socio-economic impact assessment, conflict resolution, and designing equitable benefit-sharing mechanisms.	Community Liaison Officer, Socio-Economic Impact Specialist, Stakeholder Engagement Manager	Not specified, but highlighted as a critical need.

These identified business capability gaps are often interconnected, where a weakness in one area, such as local manufacturing, directly hinders progress in another, like developing a robust local supply chain. Addressing these requires a long-term, integrated industrial policy approach to foster an environment conducive to investment, technology transfer, and the strategic nurturing of local enterprises. Foundational policies like the Special Economic Zone (SEZ) policy and the upcoming Synthetic Fuels Act are crucial in creating this environment. Prioritising these areas is essential for enhancing local participation, competitiveness, and the overall success of the green hydrogen sector in Namibia³³⁸.

6.2.7 Green Hydrogen Conversion Value Chains

For the purpose of this document, the focus will be on two specific value chains, which are currently earmarked for Namibia, namely Green Ammonia Production and Electricity Production.

6.2.7.1 Green Ammonia Value Chain

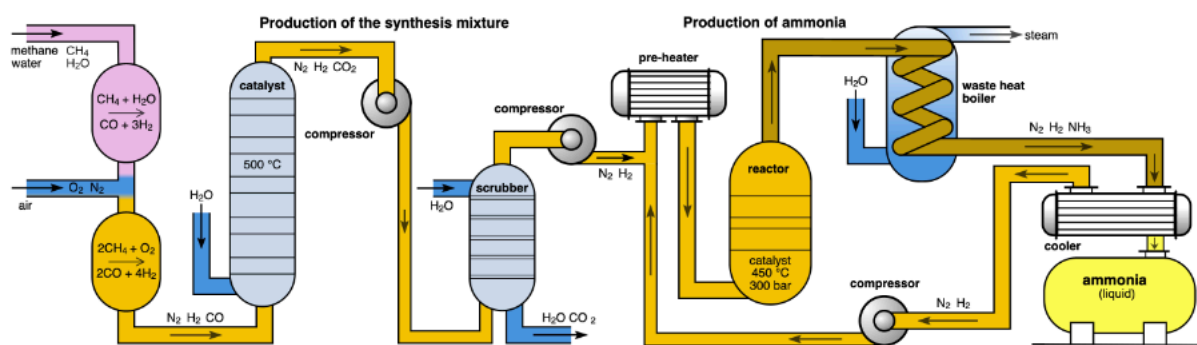


Figure 12: Green Ammonia Production Process³³⁹

Green ammonia (GNH₃) is increasingly recognised as a cornerstone of future decarbonised energy and industrial systems. Its strategic importance stems from its versatility: it can serve as a zero-carbon fuel, an efficient carrier for hydrogen, and a feedstock for various industrial processes. Unlike conventional "grey" ammonia, which is produced from fossil fuels (primarily natural gas) via Steam Methane Reforming (SMR) and is highly carbon-intensive, or "blue" ammonia, which also uses fossil fuels but incorporates carbon capture and storage (CCS), "green" ammonia is synthesised using green hydrogen. Green hydrogen itself is produced through the electrolysis of water powered entirely by renewable electricity sources, rendering the entire ammonia production pathway 100% renewable and carbon-free. This distinction is crucial for achieving deep decarbonisation goals across multiple sectors, including shipping, power generation, and agriculture³⁴⁰.

Footnotes

³³⁸ <https://www.monasa.org/wp-content/uploads/2023/09/National-Strategy-on-Green-Hydrogen.pdf>

<https://www.state.gov/reports/2024-investment-climate-statements/namibia/>

<https://energynews.biz/namibia-finalizing-green-hydrogen-tax-regime/>

³³⁹ <https://ammoniaenergy.org/presentations/the-green-and-blue-ammonia-value-chain/>

<https://ammoniaenergy.org/presentations/the-green-and-blue-ammonia-value-chain/>

³⁴⁰ https://www.ihc.co.jp/en/technology/techinfo/contents_no/1199389_13586.html

<https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/>

The conversion of renewable resources into green ammonia involves a sequence of distinct yet interconnected stages, spanning feedstock generation, chemical conversion, and end-user storage, transport, and application. For this section, we will start with the conversion processes.

Conversion Processes	• Green Hydrogen Production: Green hydrogen (H₂) is produced via water electrolysis, an electrochemical process that splits purified water into hydrogen and oxygen gases. Common electrolysis technologies include Alkaline Electrolysis Cells (AEC) and Proton Exchange Membrane (PEM) electrolyzers. The choice of technology often depends on operational requirements, cost considerations, and dynamic response capabilities to fluctuating renewable energy supply³⁴¹. • Nitrogen Production: Atmospheric nitrogen (N₂) is the second key reactant for ammonia synthesis. It is typically extracted from ambient air using an Air Separation Unit (ASU). ASUs commonly employ cryogenic distillation or pressure swing adsorption (PSA) technologies to separate nitrogen from oxygen and other atmospheric gases, ensuring high-purity nitrogen suitable for the Haber-Bosch process. Similar to hydrogen, nitrogen purity is critical to prevent catalyst poisoning in the subsequent ammonia synthesis stage³⁴². • Ammonia Synthesis (Haber-Bosch Process): The cornerstone of ammonia production is the Haber-Bosch process. In this catalytic reaction, green hydrogen and high-purity nitrogen are reacted at elevated temperatures (typically 400-500°C) and high pressures (150-250 bar or higher) to form ammonia (NH₃). The process is exothermic and requires specialised reactors and catalysts (often iron-based). The efficiency of this process is a key determinant of the overall energy consumption and cost of green ammonia. The energy required to maintain these high temperatures and pressures must also be derived from renewable sources for the ammonia to be classified as "green"³⁴³.
Storage and Transportation	• Ammonia Storage: Produced ammonia gas is typically cooled and liquefied for efficient storage. It can be stored as a refrigerated liquid at atmospheric pressure (around -33°C) or as a pressurised liquid at ambient temperature. Ammonia boasts a significantly higher volumetric energy density than compressed or liquefied hydrogen, making it easier and more cost-effective to store and transport in large quantities. Storage facilities require specialised tanks and safety systems due to ammonia's toxicity and corrosivity³⁴⁴. • Ammonia Transportation: Green ammonia can be transported via various modes, including dedicated pipelines, specialised ships (ammonia carriers), railcars, and trucks. The existing global infrastructure for ammonia transport, primarily developed for the fertiliser industry, can be leveraged and expanded for new energy applications, offering a distinct advantage over the nascent and more complex hydrogen transport infrastructure³⁴⁵.

Footnotes

³⁴¹ <https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/>
https://stargatehydrogen.com/wp-content/uploads/2021/11/StargateHydrogen_GreenAmmoniaWhitepaper_Oct2021-4.pdf

³⁴² https://stargatehydrogen.com/wp-content/uploads/2021/11/StargateHydrogen_GreenAmmoniaWhitepaper_Oct2021-4.pdf

³⁴³ <https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/>

³⁴⁴ https://www.ihl.co.jp/en/technology/techinfo/contents_no/1199389_13586.html

³⁴⁵ https://www.ihl.co.jp/en/technology/techinfo/contents_no/1199389_13586.html

End-Use Applications³⁴⁶	• Traditional: The largest historical and current use of ammonia is in the production of nitrogen-based fertilisers, vital for global agriculture. • Emerging: Green ammonia is gaining traction in several new applications: • Marine Fuel: As a zero-carbon fuel for maritime shipping, it helps the sector meet stringent emissions reduction targets. • Power Generation: Co-firing in existing coal or gas-fired power plants or used in dedicated ammonia-fired turbines or fuel cells to produce electricity. • Hydrogen Carrier: Ammonia can be transported to demand centres and then "cracked" back into high-purity hydrogen for use in fuel cells or industrial processes. This leverages ammonia's superior transportability compared to pure hydrogen. • Industrial Feedstock: For producing other chemicals and materials.
---	--

The intricate nature of this value chain underscores the importance of process efficiency and input purity at every step. For instance, the performance and longevity of catalysts in the Haber-Bosch process, as well as the electrolyzers themselves, are highly sensitive to contaminants in the hydrogen, nitrogen, and water streams. This necessitates rigorous quality control and sophisticated pre-treatment systems, which, while adding to capital and operational expenditure, are indispensable for ensuring the long-term economic and technical viability of green ammonia production. Furthermore, the "green" designation is not merely a label but a fundamental characteristic tied to the continuous and verifiable use of renewable electricity for all energy inputs, including both electrolysis and the energy-intensive Haber-Bosch synthesis. This creates an unbreakable link between green ammonia capacity development and the parallel, often preceding, massive-scale deployment of renewable energy generation and dedicated, reliable power transmission infrastructure. This interdependency presents a significant planning and investment challenge, particularly for nations embarking on new green ammonia ventures³⁴⁷.

6.2.7.2 Business capability gaps and skills implications

The successful establishment and scaling of a green ammonia industry in Namibia hinges on the concurrent development of several core business capabilities. Significant gaps currently exist across infrastructure, technological capacity, investment mechanisms, policy frameworks, and the local industrial base. Addressing these gaps is paramount for Namibia to realise its ambitious green energy vision.

Footnotes

³⁴⁶ <https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/>
https://www.ihl.co.jp/en/technology/techinfo/contents_no/1199389_13586.html

³⁴⁷ <https://ammoniaenergy.org/presentations/the-green-and-blue-ammonia-value-chain/>
https://www.ihl.co.jp/en/technology/techinfo/contents_no/1199389_13586.html
<https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/>

Table 28: Business Capability Gaps and Skills Implications - GH2 to Ammonia Conversion

Business Capability Gaps and Skills Implications - GH2 to Ammonia Conversion

Capability Area ³⁴⁸	Specific Gap Description	Impact on Green Ammonia Value Chain Development
Infrastructure	Energy: There is insufficient renewable energy generation (solar and wind) for gigawatt-scale hydrogen production. The national grid has limitations, relies on imports, and needs significant strengthening to handle the load.	This creates bottlenecks for green hydrogen production, increases project costs and timelines, and risks the reliability of the energy supply.
	Water: As an arid country, Namibia lacks the large-scale seawater desalination plants and water transport networks needed to supply high-purity water for electrolysis.	This limits hydrogen production capacity and raises concerns about sustainable water management.
	Ports & Logistics: Ports like Walvis Bay and Lüderitz require significant expansion for ammonia export, including specialised storage and handling equipment. Road and rail networks are not adequate to transport heavy construction components.	Inadequate port capacity constrains export volumes, while logistical shortfalls can delay project construction and increase costs.
Technology & Innovation	Namibia has limited local capacity for manufacturing or advanced maintenance of core technologies like electrolyzers and Haber-Bosch loops, relying on imports. The local innovation ecosystem, which should link academia and industry, is still in its early stages.	This leads to a dependence on foreign technology and expertise, slows adaptation to local conditions, and results in missed opportunities for local value creation.
Investment & Finance	The strategy is heavily reliant on Foreign Direct Investment (FDI). There is a scarcity of local risk capital, and Small and Medium-sized Enterprises (SMEs) lack the financial capacity to participate meaningfully in the value chain.	This creates vulnerability to external financial shocks and limits local ownership. As a result, SMEs struggle to engage in the sector.
Policy & Regulation	A comprehensive legal framework, such as the proposed Synthetic Fuels Act, is still under development. There is a need for better coordination among government bodies and for streamlined permitting processes.	This creates uncertainty for investors, may lead to project delays, and can pose risks to safety and environmental standards if policies are not robust or lag behind project announcements.
Local Industry & Entrepreneurship	There may be a shortage of local "Schumpeterian entrepreneurship," with few local firms willing to take risks in this new sector. SMEs have limited capacity for complex tasks beyond basic services, and industrial links to the broader economy are weak.	This can lead to low local content in projects, limited job creation in high-value areas, and the risk of creating an "enclave" industry with few benefits for the broader domestic economy.

● Skills Implications

Value Chain Segment ³⁴⁹	Occupational Profile	Required Key Skills (Technical & Soft)
Project Planning & Design	Chemical/Process Engineers (PtX specialized)	Process design, Chemical engineering principles, process simulation & optimization, PtX technologies, HAZOP, project management, problem-solving
	Electrical Engineers (High Voltage/Grid)	Power systems and grid integration
	Mechanical Engineers (Rotating/Static Equip.)	Equipment design and selection
	Civil Engineers	Site development and infrastructure
	Industrial Engineers	Plant layout and optimization

Footnotes

- ³⁴⁸ https://ptx-hub.org/wp-content/uploads/2023/08/International-PtX-Hub_202308_Namibia-PtX-skills-needs-assessment.pdf
<https://research.csiro.au/hyresource/policy/international/namibia/>
https://www.researchgate.net/publication/387750596_New_development_paths_through_green_hydrogen_an_ex-ante_assessment_of_structure_and_agency_in_Chile_and_Namibia
https://www.renac.de/fileadmin/user_upload/A_focus_on_Namibias_green_hydrogen_industry.pdf
<https://africasustainabilitymatters.com/namibia-achieves-historic-first-in-green-hydrogen-production/>
<https://www.energycornernamibia.com/post/developing-green-hydrogen-policy-for-namibia-a-look-at-the-uk-south-korea-germany-and-australia>
<https://esthinktank.com/2024/11/28/a-closer-look-at-the-strategic-green-hydrogen-partnership-in-namibia-emphasizing-its-economic-social-and-environmental-dimensions/>
- ³⁴⁹ https://www.renac.de/fileadmin/user_upload/A_focus_on_Namibias_green_hydrogen_industry.pdf
https://ptx-hub.org/wp-content/uploads/2023/08/International-PtX-Hub_202308_Namibia-PtX-skills-needs-assessment.pdf
<https://research.csiro.au/hyresource/policy/international/namibia/>
<https://hyphenafrika.com/hyphen-launches-skills-census-map-for-employment-skills/>

Business Capability Gaps and Skills Implications - GH2 to Ammonia Conversion

Value Chain Segment ³⁴⁹	Occupational Profile	Required Key Skills (Technical & Soft)
Project Planning & Design	Environmental Scientists	Impact assessments and permitting
	Legal & Financial Experts	Specialization in large-scale energy projects and PtX technologies
Infrastructure Construction	Construction Project Manager	Project planning & execution, budget/schedule control, risk management, stakeholder communication, leadership, knowledge of industrial construction
	Industrial Electrician (Hazardous Areas)	High-voltage systems, VSDs, PLCs, hazardous area installations, blueprint reading, safety compliance
	Specialized Welder (High Pressure/Specialized Alloys)	Advanced welding techniques (TIG, MIG for alloys), NDT, pressure vessel codes, safety
	Pipefitter (Industrial)	Piping layout/installation, blueprint reading, material handling (specialty pipes), pressure testing, safety
	Instrumentation Technicians	Installation of smart grid components and complex industrial piping systems
	Riggers, Crane Operators, Heavy Equipment Operators	
Nitrogen Production (O&M)	ASU Operator	Cryogenic processes/PSA technology, gas separation, equipment monitoring, safety protocols
Ammonia Synthesis (O&M)	Ammonia Plant Process Operator	Haber-Bosch process, high-pressure systems, catalyst handling, thermodynamics, chemical safety, emergency response
O&M	Maintenance Technicians (Mechanical, Electrical)	Rotating/static equipment, power distribution, motors, control systems, sensors, control loops, analytical equipment
Ammonia Storage & Transport (O&M)	Ammonia Terminal Operator	Cryogenic liquid handling, loading/unloading procedures, safety systems, emergency response
Cross-Cutting Roles	Safety Officer (Hydrogen/Ammonia Specialized)	Hazard identification, risk assessment, safety regulations (local/international), emergency preparedness, training delivery, incident investigation
	Instrumentation & Control Technician	Calibration, maintenance of sensors/transmitters/control valves, PLC/DCS troubleshooting, loop checking
	Environmental Compliance Specialist/Monitors	Environmental regulations, monitoring techniques, reporting, impact assessment, sustainability practices
	Quality Control Specialists & Laboratory Technicians	
	Data Analysts	Monitoring plant performance and predictive maintenance
	Digital/Automation Specialists (Industrial)	
	R&D Scientists/Technicians (PtX)	Support innovation and adaptation

6.2.7.3 Green Hydrogen to Electricity Production Value Chain

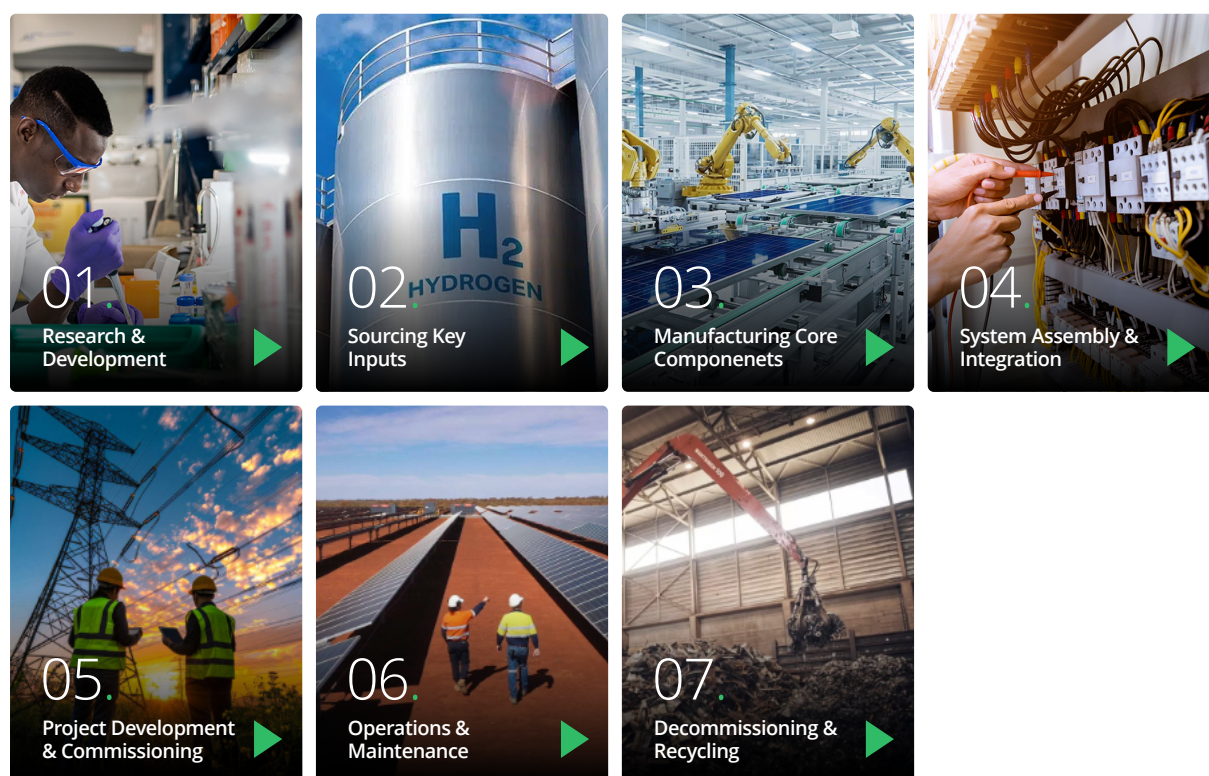


Figure 13: GH2 to Electricity Value Chain

The culmination of this specific value chain is the conversion of the chemical energy stored in green hydrogen back into electrical energy. This transformation step involves using the transported and/ or stored green hydrogen as a fuel source for power generation technologies. The primary inputs are green hydrogen and, for most technologies, air (as a source of oxygen). The desired output is electricity. Water is a common by-product, particularly from fuel cells. Heat is also generated and can be captured for combined heat and power (CHP) applications, improving overall system efficiency³⁵⁰. The following key technologies are employed in the conversion of hydrogen to electricity:

Fuel Cells:

These electrochemical devices directly convert hydrogen and an oxidant (typically oxygen from the air) into electricity, with water and heat as by-products. They operate with high efficiency and produce zero harmful emissions at the point of use. Common types include Proton Exchange Membrane Fuel Cells (PEMFCs), often used in transport and smaller-scale power, and Solid Oxide Fuel Cells (SOFCs), which operate at higher temperatures and can achieve very high efficiencies, suitable for stationary power and cogeneration³⁵¹.

Hydrogen Turbines:

These are gas turbines that have been modified or specifically designed to combust hydrogen, either in its pure form or blended with natural gas. The combustion drives a generator to produce electricity. This approach can potentially leverage existing gas turbine infrastructure, but burning hydrogen in air can lead to the formation of nitrogen oxides (NO_x), requiring advanced combustion control or post-combustion treatment systems³⁵².

Footnotes

³⁵⁰ <https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

³⁵¹ <https://www.energy.gov/eere/fuelcells/fuel-cells#:~:text=A%20fuel%2C%20such%20as%20hydrogen,creating%20a%20flow%20of%20electricity>
<https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

³⁵² <https://www.energy.gov/eere/fuelcells/fuel-cells#:~:text=A%20fuel%2C%20such%20as%20hydrogen,creating%20a%20flow%20of%20electricity>

Hydrogen Internal Combustion Engines (ICEs):

Similar to turbines, ICEs can be adapted to run on hydrogen. While potentially a lower-cost option for some applications, they generally have lower efficiencies than fuel cells or large turbines and also face challenges with NOx emissions³⁵³.

The choice between fuel cells and combustion-based technologies (turbines, ICEs) for power generation is contingent upon several factors, including the required scale of the application, desired electrical efficiency, operational flexibility needs, and the potential to utilize or adapt existing infrastructure. Fuel cells typically offer higher electrical efficiencies and greater modularity, making them suitable for a range of scales from distributed generation to utility-scale power plants. Hydrogen turbines, on the other hand, might be more economically viable for very large-scale, centralised power generation, especially if existing natural gas turbine assets can be retrofitted to accommodate hydrogen, though this presents its own set of technical and emission-related challenges. Additionally, conversion efficiency (hydrogen to electricity), capital costs of the generation equipment, operational and maintenance (O&M) costs, flexibility in operation (e.g., ramp-up and ramp-down rates to meet fluctuating demand or complement intermittent renewables), the emissions profile (especially NOx from combustion technologies), and the ease of integration with the existing electricity grid influence the type of technology used³⁵⁴.

This document will focus on fuel cells as the technology employed.

A. Fuel Cell Manufacturing

The manufacturing of fuel cell systems is a complex, multi-stage process involving specialised materials, precision component fabrication, and careful system integration.

Raw Material Sourcing:

This initial stage involves the extraction and refining of critical raw materials. For PEMFCs, this includes Platinum Group Metals (PGMs) like platinum and iridium for catalysts, and fluoropolymers (e.g., PFSA ionomers) for membranes. For SOFCs, ceramic powders (e.g., zirconia, ceria, perovskites) are essential for electrolytes and electrodes. Other materials include carbon for Gas Diffusion Layers (GDLs) and electrodes, graphite or stainless steel for Bipolar Plates (BPPs), and various polymers and metals for seals, housing, and Balance of Plant (BoP) components.

The cost and supply chain stability of these raw materials, particularly PGMs, are significant factors in the overall fuel cell system cost. The reliance on PGMs, which are expensive and have geographically concentrated sources, presents both an economic challenge and a potential supply chain vulnerability for PEMFC technology. This drives extensive research into reducing PGM loading (thrifting), developing more durable catalysts to extend lifespan, or creating PGM-free alternatives. The success of these efforts is pivotal for the widespread, cost-effective deployment of PEMFCs and also highlights the strategic importance of PGM recovery through recycling³⁵⁵.

Footnotes

³⁵⁴ <https://www.energy.gov/eere/fuelcells/fuel-cells#:~:text=A%20fuel%2C%20such%20as%20hydrogen,creating%20a%20flow%20of%20electricity.https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

³⁵⁵ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>
<https://astfortech.com/hydrogen-supply-chains-a-detailed-look-at-how-they-work/>
<https://www.energy.gov/eere/fuelcells/fuel-cells>

Key Component Fabrication

- Membrane Electrode Assembly (MEA) / Catalyst Coated Membrane (CCM): This is the electrochemical heart of the fuel cell. For PEMFCs, it involves preparing catalyst inks (PGM particles dispersed with ionomer) and coating them onto both sides of the polymer electrolyte membrane, or onto the GDLs, which are then pressed onto the membrane. For SOFCs, it involves fabricating dense electrolyte layers and porous electrode layers from ceramic materials, often through tape casting, screen printing, and sintering processes³⁵⁶.
- Catalysts: These materials facilitate the electrochemical reactions (hydrogen oxidation at the anode and oxygen reduction at the cathode). In PEMFCs, catalysts are typically based on platinum and other PGMs, finely dispersed on a carbon support and applied as a thin layer to the electrodes or the membrane. A major R&D focus is on reducing the PGM loading (thrifting) or developing PGM-free catalysts to lower costs³⁵⁷.
- Gas Diffusion Layers (GDLs): These components, typically made from carbon paper or carbon cloth, are placed between the MEA and the BPPs. They facilitate the diffusion of reactant gases to the catalyst layers, conduct electrons, and help manage water within the cell. Manufacturing involves treatments to impart hydrophobicity and create microporous layers³⁵⁸.
- Bipolar Plates (BPPs): BPPs physically separate individual cells in a stack, distribute reactant gases uniformly over the electrode surfaces through flow fields machined or stamped into them, conduct current from cell to cell, and facilitate heat removal. Materials include machined graphite, moulded polymer-carbon composites, or coated stainless steel. Manufacturing processes include precision machining, stamping, coating (for corrosion resistance and conductivity), and sealing³⁵⁹.
- Gaskets and Seals: These are used to create hermetic seals between the various components of the stack, preventing leakage of reactant gases and coolant³⁶⁰.

Fuel Cell Stack Assembly:

Individual cells (comprising MEA/CCM, GDLs, and BPPs) are stacked together in series to achieve the desired voltage and power output. This process involves careful alignment, application of seals or gaskets to prevent leaks, and integration of end plates, current collectors, and compression hardware to maintain proper contact and pressure within the stack³⁶¹.

System Integration (Balance of Plant - BoP):

- Various auxiliary components, collectively known as the Balance of Plant, to create a functional fuel cell system. BoP components include:
- Fuel (Hydrogen) Delivery System: Regulators, valves, sensors, and sometimes humidifiers.
- Air Management System: Blowers or compressors to supply oxygen, filters, and sometimes humidifiers.

Footnotes

³⁵⁶ <https://www.energy.gov/eere/fuelcells/fuel-cells>

<https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>

³⁵⁷ <https://semcouniversity.com/hydrogen-fuel-cell-production-process-from-raw-materials-to-clean-energy/>

<https://www.energy.gov/eere/fuelcells/fuel-cells>

³⁵⁸ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>

<https://www.fuelcellshop.com/fuel-cell-stack-assembly-and-operation-explained/t1371?currency=usd>

³⁵⁹ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>

³⁶⁰ <https://www.dynamicrep.com/blog/exploring-the-fuel-cell-manufacturing-process>

<https://hyfindr.com/en/hydrogen-knowledge/fuel-cell-stack>

³⁶¹ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>

- Thermal Management System: Cooling loops, heat exchangers, and fans to manage the heat generated by the fuel cell.
- Water Management System: To manage product water (in PEMFCs) and reactant humidification.
- Power Electronics: DC/DC converters to regulate stack voltage and DC/AC inverters to convert DC power to AC power for grid connection or AC loads.
- Control System (ECU): Sensors and a controller to monitor and manage system operation, ensuring safety and optimising performance.

While much attention is often focused on the fuel cell stack itself, the BoP components can constitute a significant portion of the overall system cost and can heavily influence its efficiency, durability, and footprint. Optimising these auxiliary components for size, weight, cost, and energy consumption (minimising parasitic loads) is crucial for the commercial viability of fuel cell systems. Innovations in BoP design and integration are therefore as critical as advancements in core stack technology³⁶².

Achieving economies of scale in manufacturing, coupled with increased automation and the adoption of advanced manufacturing techniques, is fundamental to driving down fuel cell system costs from their current levels. Presently, fuel cell production volumes are often relatively low compared to mature technologies like internal combustion engines. As demand grows, spurred by policy support and market adoption, manufacturers can invest in larger, more automated production lines. This allows for benefits such as bulk purchasing of materials, optimised and continuous processing, reduced labour costs, and improved quality control, all contributing to lower per-unit costs. This trajectory of cost reduction through manufacturing scale-up has been clearly demonstrated in other clean energy sectors, such as solar PV and batteries, indicating a similar potential for fuel cells. Consequently, policy measures that support manufacturing scale-up and R&D in advanced manufacturing processes are as vital as those focused on core cell technology improvements³⁶³.

B. Fuel Cell Operations

A fuel cell operates like a continuously fed battery, converting chemical energy from a fuel (in this case, green hydrogen) and an oxidant (typically oxygen from the air) into electricity through electrochemical reactions, with heat and water as the only byproducts when using pure hydrogen. This direct conversion process avoids the thermal bottlenecks of combustion engines, leading to significantly higher efficiencies and minimal to zero pollutant emissions at the point of use³⁶⁴.

The basic structure of a fuel cell consists of two electrodes—an anode (negative electrode) and a cathode (positive electrode)—separated by an electrolyte. A catalyst, often a platinum-group metal, is typically present at the electrodes to facilitate the reactions.

Footnotes

³⁶² <https://semcouniversity.com/hydrogen-fuel-cell-production-process-from-raw-materials-to-clean-energy/>

<https://hyfindr.com/en/hydrogen-knowledge/fuel-cell-stack>

<https://www.dynamicrep.com/blog/exploring-the-fuel-cell-manufacturing-process>

³⁶³ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>

<https://astfortech.com/hydrogen-supply-chains-a-detailed-look-at-how-they-work/>

³⁶⁴ <https://www.energy.gov/eere/fuelcells/fuel-cells#:~:text=A%20fuel%2C%20such%20as%20hydrogen,creating%20a%20flow%20of%20electricity.>

<https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

In a typical hydrogen fuel cell, such as a Proton Exchange Membrane Fuel Cell (PEMFC):

- i. Hydrogen gas (H₂) is fed to the anode. Here, the catalyst facilitates the splitting of hydrogen molecules into protons (H⁺) and electrons (e⁻): $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$.
- ii. The protons migrate through the electrolyte to the cathode. The electrolyte is specifically chosen to allow ion transport but block electron flow.
- iii. The electrons, unable to pass through the electrolyte, travel through an external circuit from the anode to the cathode, creating a flow of direct current (DC) electricity that can be used to power devices.
- iv. Oxygen (from air) is fed to the cathode. Here, the oxygen molecules react with the protons arriving from the anode (via the electrolyte) and the electrons arriving from the external circuit, forming water (H₂O): $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$ (or $2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}$).

Fuel cells can achieve electrical efficiencies exceeding 60% in some cases, significantly higher than traditional combustion-based power generation³⁶⁵.

Power Electronics (Inverters, Converters)

Fuel cells inherently produce DC electricity, often at a variable voltage level that may not be directly suitable for end-use applications or grid connection. Therefore, power conditioning systems are essential³⁶⁶.

- **DC/DC Converters:** These devices are used to step up or step down the fuel cell stack's voltage to a stable, regulated DC level suitable for specific loads or for input into an inverter.
- **DC/AC Inverters:** For applications requiring alternating current (AC) power, such as feeding electricity into the grid or powering standard AC appliances, inverters are used to convert the DC output of the fuel cell (or DC/DC converter) into AC power of the required voltage, frequency, and waveform³⁶⁷.

Grid Connection and Stability Considerations

When fuel cell systems are used for grid-tied power generation, their inverters must be designed to meet utility interconnection standards, ensuring power quality (e.g., low harmonic distortion, stable frequency and voltage) and safe operation in conjunction with the grid. Fuel cells can contribute positively to grid stability and resilience by providing consistent and reliable power output, which can be particularly valuable in grids with increasing penetration of intermittent renewable energy sources like solar and wind. Some advanced fuel cell systems, coupled with appropriate control and power electronics, can offer features like seamless transfer between grid-tied and standalone (island) mode, providing backup power during grid outages. Furthermore, fuel cells, when integrated with electrolyzers in reversible systems, can play a role in long-term energy storage for the grid, converting surplus renewable electricity to hydrogen and then back to electricity when needed³⁶⁸.

Footnotes

³⁶⁵ <https://www.energy.gov/eere/fuelcells/fuel-cells#:~:text=A%20fuel%2C%20such%20as%20hydrogen,creating%20a%20flow%20of%20electricity.https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

³⁶⁶ <https://www.dynamicep.com/blog/exploring-the-fuel-cell-manufacturing-process>

³⁶⁷ <https://www.secheron.com/applications/renewable-energy/electricity-production/fuel-cells/>
<https://www.dynamicep.com/blog/exploring-the-fuel-cell-manufacturing-process>

³⁶⁸ <https://www.secheron.com/applications/renewable-energy/electricity-production/fuel-cells/>
<https://www.energy.gov/eere/fuelcells/fuel-cells>

Deployment and Ancillary Systems

The practical deployment of a fuel cell power generation system involves its integration with various ancillary systems. These include hydrogen storage tanks or a direct hydrogen supply line, air intake and filtration systems, and overall power management and control units that orchestrate the operation of the fuel cell and its interface with the load or grid³⁶⁹. The effective integration of distributed power generation sources like fuel cells into the electricity grid often presupposes a modernised grid infrastructure. Such modernisation includes smart grid capabilities like advanced metering infrastructure (AMI), sophisticated communication networks, and automated control systems capable of managing bidirectional power flows and voltage fluctuations, as well as ensuring overall grid stability and reliability. National initiatives to strengthen transmission networks and incorporate energy storage solutions, such as Battery Energy Storage Systems (BESS), are crucial steps in preparing the grid for higher shares of renewable and decentralised generation technologies, including fuel cells³⁷⁰.

Fuel cells can significantly enhance a nation's energy security by diversifying the power generation portfolio and enabling decentralised power production. This reduces reliance on imported fossil fuels or on extensive, vulnerable long-distance transmission lines, an attribute particularly beneficial for electrifying remote communities or ensuring power supply to critical infrastructure³⁷¹.

Dominant Fuel Cell Types for Stationary Power

While various fuel cell technologies exist, Proton Exchange Membrane Fuel Cells (PEMFCs) and Solid Oxide Fuel Cells (SOFCs) are prominent for stationary power generation using green hydrogen. Other types like Alkaline Fuel Cells (AFCs), Phosphoric Acid Fuel Cells (PAFCs), and Molten Carbonate Fuel Cells (MCFCs) also have stationary applications, but PEMFCs and SOFCs are often highlighted for their evolving performance and suitability with pure hydrogen³⁷².

i. Proton Exchange Membrane Fuel Cells (PEMFCs)³⁷³:

- Operate at relatively low temperatures (typically 50-100°C).
- Utilise a solid polymer membrane (e.g., Nafion™) as the electrolyte.
- Offer high power density, rapid start-up times, and relatively compact systems.
- They typically require high-purity hydrogen as the platinum-based catalysts are susceptible to poisoning by impurities like carbon monoxide or sulphur compounds.
- Efficiency is typically in the 50-60% range for electricity generation alone.

Solid Oxide Fuel Cells (SOFCs)³⁷⁴:

- Operate at high temperatures (600-1,000°C).
- Employ a solid ceramic material (e.g. yttria-stabilised zirconia) as the electrolyte.
- Offer very high electrical efficiencies (60-65%), which can exceed 85% when configured for Combined Heat and Power (CHP) by utilising the high-quality waste heat.
- Can be more tolerant to fuel impurities than PEMFCs and can potentially use non-PGM catalysts due to high operating temperatures.
- Challenges include longer start-up times and material durability issues associated with high-temperature operation and thermal cycling.

Footnotes

³⁶⁹ <https://semcouniversity.com/hydrogen-fuel-cell-production-process-from-raw-materials-to-clean-energy/>

³⁷⁰ <https://www.mdpi.com/2673-4141/6/2/26>

<https://www.worldbank.org/en/news/press-release/2024/05/06/world-bank-loan-to-afe-namibia-supports-renewable-energy-integration>

<https://www.engineeringnews.co.za/article/nampower-grid-strengthening-and-battery-storage-project-secures-1385m-world-bank-backing-2024-05-07>

³⁷¹ <https://www.iea.org/news/harnessing-namibias-high-quality-renewable-resources-can-accelerate-the-countrys-socioeconomic-development>

<https://www.energy.gov/eere/fuelcells/fuel-cells>

³⁷² <https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

<https://www.fuelcellenergy.com/blog/benefits-of-fuel-cells>

³⁷³ <https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

³⁷⁴ <https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>

<https://www.fuelcellenergy.com/blog/benefits-of-fuel-cells>

The choice between PEMFCs and SOFCs (or other types) depends on the specific application requirements, such as load profile (baseload vs. peaking), need for rapid response, availability of waste heat utilisation, and tolerance for fuel impurities.

C. End-of-Life Management for Fuel Cells

As the deployment of fuel cell technology accelerates, establishing effective end-of-life (EoL) management strategies, including refurbishment and recycling, is crucial for both environmental sustainability and economic viability. This ensures that valuable resources are recovered and that the environmental impact of disposal is minimised.

Importance of Recycling and Refurbishment

Fuel cells, particularly PEMFCs, contain valuable and sometimes scarce materials, most notably Platinum Group Metals (PGMs) like platinum and iridium used in catalysts, as well as polymers, graphite, and various metals. Recycling these materials offers significant environmental benefits by reducing the need for virgin resource extraction (which is often energy-intensive and environmentally disruptive) and minimising landfill waste. Economically, the recovery of high-value PGMs can offset a portion of the initial fuel cell cost and contribute to a more stable supply chain for these critical materials. Refurbishment programs, where feasible, extend the operational life of fuel cell systems or their components, further enhancing resource efficiency³⁷⁵.

Recycling Processes for Fuel Cell Stacks and Systems³⁷⁶

The EoL management for fuel cells typically involves several steps:

- **Disassembly:** The fuel cell system is first dismantled into its major components: the fuel cell stack, BoP components (pumps, blowers, electronics, etc.), and housing.
- **MEA Recycling (Primarily for PEMFCs):** The Membrane Electrode Assembly (MEA) is the primary target for PGM recovery. Specialised hydrometallurgical or pyrometallurgical processes are employed to extract and refine the PGMs from the catalyst layers of the MEA. Companies like Ballard Power Systems report that typically more than 95% of the precious metals in the MEA can be reclaimed through these processes. This high recovery rate is vital for closing the loop on critical materials, thereby mitigating supply chain vulnerabilities associated with primary PGM sourcing and contributing to the long-term cost-competitiveness and sustainability of PEMFC technology. A robust and efficient PGM recycling infrastructure is thus a strategic imperative for a mature fuel cell industry.
- **Recycling of Other Stack Components:** Bipolar plates (graphite or metal), Gas Diffusion Layers (carbon-based), and end plates are typically recycled using more conventional recycling processes appropriate for their constituent materials. For instance, metals can be smelted and reprocessed, while research is ongoing to find effective recycling of carbon components and polymers like ionomers.
- **Recycling of Balance of Plant (BoP) Components:** Electronics, pumps, valves, hoses, and metal frames from the BoP are generally recycled through established streams for electronic waste (WEEE) and metal recycling. Many fuel cell manufacturers design their products to comply with directives like WEEE, which govern the end-of-life management of electrical and electronic equipment.

Footnotes

³⁷⁵ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>
<https://www.ballard.com/wp-content/uploads/2024/10/recycling-fuel-cells.pdf>

³⁷⁶ <https://astfortech.com/hydrogen-supply-chains-a-detailed-look-at-how-they-work/>
<https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>
<https://www.ballard.com/wp-content/uploads/2024/10/recycling-fuel-cells.pdf>

Recovery and Reuse of Valuable Materials³⁷⁷

The primary materials targeted for recovery due to their economic value and/or criticality include:

- **Platinum Group Metals (PGMs):** Platinum, iridium, and sometimes ruthenium are recovered and refined for reuse in new catalysts or other applications.
- **Polymers/Ionomers:** Research is exploring methods to recover and reprocess the ionomeric materials from PEMs, or to depolymerise them back to monomers.
- **Graphite and Metals:** Graphite from BPPs and various metals (stainless steel, aluminium) from BPPs, housing, and BoP components are recovered and recycled.

As the fuel cell market expands, the principles of "Design for Recycling" and "Design for Disassembly" are gaining importance. Proactively designing fuel cells for easier dismantling, component separation, and material identification can significantly enhance the efficiency and economic viability of EoL processes. This involves choices regarding materials, joining techniques (e.g., avoiding adhesives that contaminate materials), and modularity. Ballard, for example, states its products are designed so that no special equipment is needed to dismantle components. Such foresight requires collaboration between fuel cell manufacturers and recycling specialists early in the product development lifecycle to optimise for circularity³⁷⁸.

Refurbishment Programs

Several fuel cell manufacturers offer refurbishment programs as a cost-effective alternative to complete replacement and a preliminary step before full recycling. Ballard Power Systems, for instance, has a program where customers can return end-of-life fuel cell stacks. Ballard then replaces the MEA (the component most prone to degradation) while reusing the existing stack hardware, such as bipolar plates and end plates. The used MEA is then sent for PGM recovery. This refurbishment process can typically save customers around 30% compared to the cost of a new stack and is generally applicable for stacks up to about ten years old. Such programs effectively extend the life of many stack components, reduce overall waste, lessen the immediate demand for new raw materials, and provide a more affordable pathway for customers to maintain their operational capacity. This is a practical application of circular economy principles, maximising the value extracted from materials and components throughout their lifecycle³⁷⁹.

6.2.7.4 Business Capability Gaps and Skills Implications

A comprehensive overview of Namibia's business and industrial capabilities in the fuel cell value chain (in addition to the entire GH2 value chain) reveals significant gaps, alongside potential for future development. The nation is currently identified as a "technology taker," importing core technologies, with a long-term strategic decision to be made on transitioning towards becoming a "technology maker" in specific niche areas. A pragmatic, phased approach to developing these capabilities is recommended, initially focusing on areas like project management and renewable energy operations, and gradually moving towards local assembly and specialised manufacturing.

Footnotes

³⁷⁷ <https://www.apcuk.co.uk/knowledge-base/resource/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/>
<https://www.ballard.com/wp-content/uploads/2024/10/recycling-fuel-cells.pdf>

³⁷⁸ <https://www.ballard.com/wp-content/uploads/2024/10/recycling-fuel-cells.pdf>

³⁷⁹ <https://www.ballard.com/wp-content/uploads/2024/10/recycling-fuel-cells.pdf>

The following table details the current capabilities, identified gaps, and development potential across the fuel cell value chain.

Table 29: Business Capability Gaps and Skills Implication- GH2 to Electricity Production

Business Capability Gaps and Skills Implication- GH2 to Electricity Production		
Fuel Cell System Manufacturing & Assembly		
Value Chain Stage/Sub-stage ³⁸⁰	Identified Gaps	Impact on Green Ammonia Value Chain Development
MEA & Catalyst Manufacturing	Entire advanced materials and chemical processing chain	Long (highly specialized, R&D intensive)
Bipolar Plate Manufacturing	Advanced manufacturing techniques, material science	Long (could be a niche if specific material/design focus)
Fuel Cell Stack Assembly & Testing	Assembly lines, testing equipment, skilled technicians	Medium-Long (could start with assembly of imported components)
BOP Component Manufacturing (Specialized)	Design and manufacturing of FC-specific components	Medium (some components potentially, others long term)
Electricity Generation & Grid Integration (Fuel Cells)		
Fuel Cell Power Plant O&M	Trained O&M technicians and engineers for FCs	Medium (training programs crucial as plants are built)
Advanced Power Electronics (FC-specific)	Local manufacturing, specialized design expertise	Medium-Long (focus on integration expertise first, then niche manufacturing)
Grid Integration Expertise for FCs	FC-specific grid interaction knowledge	Medium (build on existing grid expertise, specialized training)
Cross-Cutting Capabilities³⁸¹		
R&D in H2 & Fuel Cells	Dedicated research facilities, funding, critical mass of researchers	Medium-Long (requires sustained investment, international collaboration)
Specialized H2/FC EPC Services	Local capacity for large, complex H2 projects	Medium (JV with international firms, gradual capacity building)
Standards, Testing, Inspection, Certification (TIC) for H2/FC	H2-specific TIC infrastructure and expertise	Medium (critical for safety and market access, needs urgent development)
Advanced Manufacturing Ecosystem Support	Broad gaps in supportive industries for high-tech manufacturing	Medium-Long (requires broad industrial policy interventions)

Footnotes

- ³⁸⁰ <https://semcouniversity.com/hydrogen-fuel-cell-production-process-from-raw-materials-to-clean-energy/>
<https://www.dynamicrep.com/blog/exploring-the-fuel-cell-manufacturing-process>
https://www.commonwealthofnations.org/sectors-namibia/business/industry_and_manufacturing/
<https://www.elitewholesale.group/post/supplying-namibia-s-growing-industries-the-role-of-elite-wholesale-group>
<https://www.wikinam.org/html/cat/cl/chemicals-manufacturers-and-suppliers/264/chemicals-manufacturers-and-suppliers.html>
- ³⁸¹ <https://www.lithon.com/engineering-programmes-and-universities-namibia/>
<https://www.we.com.na/mw-main/dutch-green-hydrogen-skills2025-05-20157792>
<https://stargatehydrogen.com/blog/hydrogen-fuel-cells/>
<https://www.fuelcellenergy.com/blog/benefits-of-fuel-cells>

Business Capability Gaps and Skills Implication- GH2 to Electricity Production

● Skills Implications

Job Category/Role ³⁸²	Occupation	Key Skills & Competencies Required
Engineers	Chemical Engineer (H2/Ammonia/FC Process)	Process design, optimization, and operation of hydrogen production plants, ammonia synthesis, and fuel cell systems. Skills in thermodynamics, reaction engineering, fluid mechanics, and separation processes are essential.
	Electrical Engineer (RE/Grid/FC Power Systems)	Design and O&M of large-scale renewable energy plants, grid integration, design and control of power electronics for electrolyzers and fuel cells, and plant automation.
	Mechanical Engineer (H2 Equipment/Piping/Thermal)	Design, selection, installation, and maintenance of rotating equipment, pressure vessels, and piping systems for hydrogen. This also includes thermal management for electrolyzers and fuel cells.
	Materials Engineer/Scientist (H2/FC Applications)	Selection and testing of materials for hydrogen compatibility, corrosion prevention, and development of advanced materials for electrolyzers and fuel cells.
	Safety Engineer (H2/Process Safety)	Specialized in process safety for facilities with highly flammable and high-pressure gases, risk assessment, and emergency response planning.
	Environmental Engineer	Environmental impact assessments, emissions monitoring, waste management, and sustainable water resource management.
Technicians	Fuel Cell System Technician	Assembly, installation, commissioning, O&M, and repair of fuel cell systems.
	Instrumentation & Control (I&C) Technician	Installation, calibration, and maintenance of automated systems in hydrogen plants. This includes PLC programming and sensor technology for H2 environments.
	Electrical Technician	Installation and maintenance of electrical systems in renewable energy farms, hydrogen plants, and fuel cell installations.
	Mechanical Technician/Fitter	Installation and maintenance of pumps, compressors, valves, and piping systems.
	Chemical Process Technician/Operator	Monitoring and operation of hydrogen production and purification units.
	Laboratory Technician	Performing quality control analyses, including hydrogen purity and water quality testing.
	HSE (Health, Safety, Environment) Technician/Officer	Implementing and monitoring on-site safety and environmental procedures.
Vocational/Trade Skills	High-Pressure H2 Welder	Specialized in welding techniques for high-pressure hydrogen service.
	H2 Pipefitter	Installation and testing of high-pressure piping systems for hydrogen.
	Electrician (Hazardous Areas - H2)	General electrical work with specific training for hazardous hydrogen environments.
	Logistics Personnel	Includes drivers certified for hazardous materials, and crane and specialized equipment operators.
Cross-Cutting Professionals and Managers	Project Managers	Experience in managing large, complex energy or industrial projects.
	Logistics and Supply Chain Managers	Expertise in managing complex supply chains for equipment and hydrogen products.
	Regulatory and Compliance Officers	Knowledge of national and international standards and safety regulations for the hydrogen and fuel cell industries.
	Data Analysts and System Optimizers	Analyzing plant performance data to optimize efficiency and support decision-making.
	R&D Personnel	Researchers in chemistry, physics, materials science, and engineering.

Footnotes

³⁸² <https://www.lithon.com/engineering-programmes-and-universities-namibia/>
<https://www.bachelorsportal.com/studies/195558/mechanical-engineering.html>
<https://www.topuniversities.com/courses/engineering-chemical/guide>
<https://www.qut.edu.au/courses/bachelor-of-engineering-honours-chemical-and-sustainable-process>

6.2.8 Green Hydrogen Storage and Transportation Value Chain

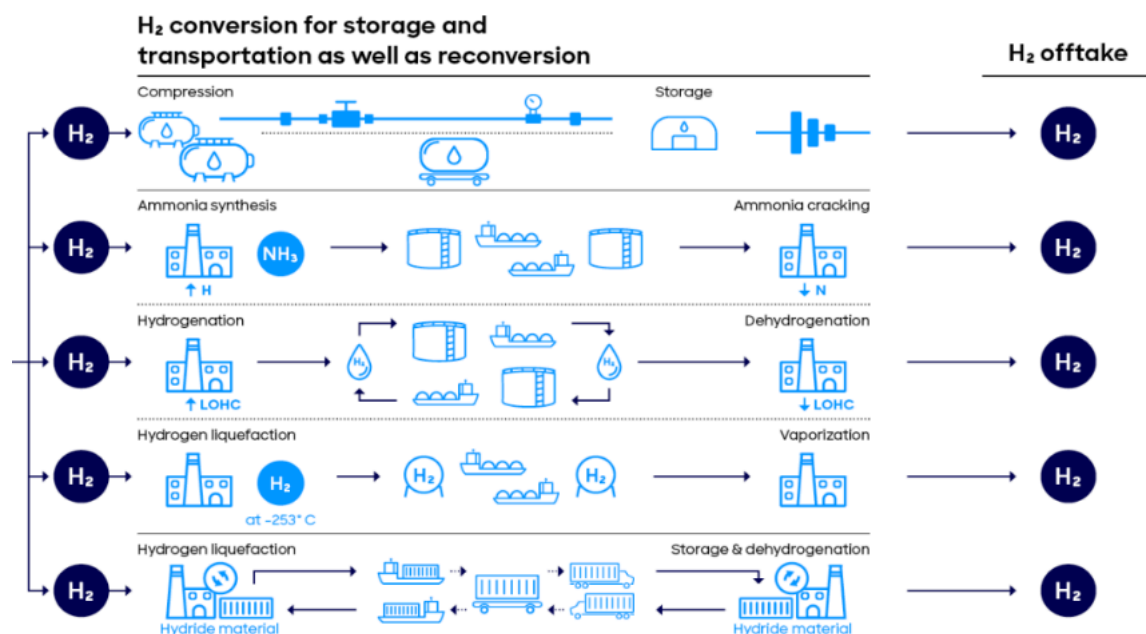


Figure 14: GH2 Transport & Storage Value Chain³⁸³

The journey of green hydrogen from its production to end-use necessitates sophisticated storage and transportation solutions. These stages are not mere logistical afterthoughts but integral components that significantly influence the overall viability, cost-effectiveness, and safety of green hydrogen projects. Understanding the intricacies of this segment of the value chain is critical for nations like Namibia aiming to become major players in the global green hydrogen market³⁸⁴.

The pathway for green hydrogen involves its movement from production facilities, typically co-located with large-scale renewable energy generation and electrolysis plants, to various domestic end-users or international export terminals. This journey requires intermediate storage to buffer supply and demand fluctuations and specialised transport to move the hydrogen, often in a densified or chemically converted form³⁸⁵.

Footnotes

³⁸³ Sourced from www.rolandberger.com

³⁸⁴ https://www.researchgate.net/figure/Green-hydrogen-value-chain-schematic-representation-adapted-from-4_fig1_381685969

https://www.researchgate.net/figure/Green-Hydrogen-Value-Chain-Functional-Representation-Adapted-from-4_fig1_381685969

https://www.researchgate.net/figure/Green-hydrogen-value-chain-schematic-representation-adapted-from-4_fig1_381685969

https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/

6.2.8.1 Storage Solutions

Gaseous Storage:	• Compressed Hydrogen (CHG): Hydrogen gas is compressed and stored in high-pressure tanks, typically made from composite materials. While a mature technology, it offers relatively low volumetric energy density, making it suitable for smaller quantities or shorter-duration storage. It is considered one of the more expensive options due to the robust tankage required, but its simplicity is an advantage for certain applications³⁸⁶. • Geologic Storage: This method involves storing large volumes of hydrogen gas in underground formations such as salt caverns, depleted oil and gas reservoirs, or aquifers. Geologic storage is considered one of the cheapest and largest-scale options available today, particularly suitable for long-term or seasonal storage to balance renewable energy intermittency. The Advanced Clean Energy Storage Hub in Delta, Utah, converting salt caverns for hydrogen storage, exemplifies this approach. However, its applicability is geographically constrained by the availability of suitable geological formations³⁸⁷.
Liquid Storage	• Cryogenic Liquid Hydrogen (LH2): Hydrogen is cooled to extremely low temperatures (-253 °C) to liquefy it, significantly increasing its volumetric energy density compared to compressed gas. This makes LH2 an attractive option for transporting large quantities of hydrogen, especially over long distances. The world's first long-distance shipment of LH2 has demonstrated its potential for establishing global supply chains. However, the liquefaction process is energy-intensive, and maintaining cryogenic temperatures requires specialised, well-insulated storage tanks and handling equipment³⁸⁸. • Cryo-compressed Hydrogen (CcH2): An emerging technology that combines cooling and compression to store hydrogen at higher densities than CHG but potentially at lower costs than full liquefaction. It aims to offer an economically viable solution for high-density hydrogen storage, particularly for heavy-duty transportation applications³⁸⁹.
Material-Based Storage	• Adsorption/Absorption: Hydrogen can be stored by chemically bonding it to or within solid or liquid materials (e.g., metal hydrides, complex hydrides, or advanced sorbents). These methods can offer high storage densities at relatively low pressures and ambient temperatures. However, many material-based storage technologies are still in the research and development phase, with challenges related to cost, scalability, kinetics (rate of hydrogen uptake and release), and material degradation over cycling³⁹⁰.
Chemical Storage (as a transport vector):	• Green Ammonia (NH3): Hydrogen is reacted with nitrogen (typically sourced from an air separation unit) via the Haber-Bosch process to produce ammonia. Green ammonia, produced using green hydrogen, is a carbon-free hydrogen carrier. It has a higher volumetric hydrogen density than LH2 (120.3 kg-H2/m³ for ammonia versus 70.8 kg-H2/m³ for LH2) and can be liquefied at moderate pressures and temperatures (-33 °C at atmospheric pressure). A significant advantage is the existing global infrastructure for ammonia production, storage, and transportation, primarily developed for the fertiliser industry³⁹¹. • Liquid Organic Hydrogen Carriers (LOHCs): These are organic compounds that can be catalytically hydrogenated to store hydrogen and dehydrogenated to release it. LOHCs can be stored and transported as liquids at ambient conditions, similar to conventional fuels. However, the hydrogenation and dehydrogenation processes can be energy-intensive and may require complex reactor systems³⁹².

Footnotes

³⁸⁶ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>

³⁸⁷ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>

³⁸⁸ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>
<https://www.mdpi.com/2071-1050/16/2/827>

³⁸⁹ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>

³⁹⁰ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>

³⁹¹ <https://www.mdpi.com/1996-1073/18/9/2292>

<https://www.mdpi.com/2071-1050/16/2/827>

³⁹² <https://www.mdpi.com/2071-1050/16/2/827>

Transportation Modalities:

Once stored or converted, green hydrogen must be transported to its point of use. The primary modes include:

Overland Transport:

- **Trucks:** Hydrogen can be transported by road in specialised "tube trailers" carrying compressed gas cylinders or in cryogenic tankers for liquid hydrogen or ammonia. Trucking offers flexibility and is suitable for supplying regions where demand is still developing or where pipeline infrastructure is absent³⁹³.
- **Pipelines:** For transporting large volumes of hydrogen over long distances (up to 5000 km according to the IEA). New pipelines can be constructed specifically for hydrogen, or existing natural gas pipelines could potentially be repurposed. However, repurposing presents challenges due to hydrogen embrittlement, where hydrogen atoms can degrade certain types of steel, necessitating careful material selection, pipeline integrity assessments, and potentially de-rating of operating pressures. For shorter distances (up to 500 km), pipeline transport is also considered cost-effective for both hydrogen and ammonia³⁹⁴.

Maritime Transport:

- **Ships for Liquid Hydrogen (LH2):** For intercontinental transport of large quantities of pure hydrogen, specialised cryogenic ships similar to LNG carriers are being developed and deployed. The CAPEX for LH2 tankers includes costs for liquefaction, onboard storage, and the ship itself³⁹⁵.
- **Ships for Green Ammonia (NH3):** Transporting ammonia by sea is a well-established practice, leveraging existing fleets of LPG/ammonia carriers and established port handling procedures. This existing infrastructure significantly lowers the barrier for ammonia as an internationally traded hydrogen carrier³⁹⁶.

Footnotes

³⁹³ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>

³⁹⁴ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>
<https://www.mdpi.com/1996-1073/18/9/2292>

³⁹⁵ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>
<https://www.mdpi.com/1996-1073/18/9/2292>

³⁹⁶ <https://www.mdpi.com/1996-1073/18/9/2292>

6.2.9 Business Capability Gaps and Skills Implications

Below is a summary of the business capability gaps identified for Namibia's green hydrogen storage and transportation sub-sector.

Table 30: Business Capability Gaps - GH2 Transport & Storage

Business Capability Gaps - GH2 Transport & Storage		
Capability Gap ³⁸⁷	Description of the Gap	Key Implications of the Gap
Infrastructure Development & Management	There is limited local experience in Namibia regarding the design, engineering, procurement, construction (EPC), and operational management of the highly specialized infrastructure needed for green hydrogen. This includes facilities for cryogenic liquids (LH2), high-pressure gas systems, large-scale ammonia production and storage, and dedicated pipelines. While Namibia has experience in general industrial construction, the technical specificity, scale, and strict safety rules for green hydrogen are new.	In the initial phases, a significant reliance on international EPC contractors and technology providers is unavoidable. Without a strategy for developing local skills, Namibia risks limited local value capture, potential project delays, higher operational costs due to dependence on foreign expertise, and missed opportunities for local firms in major contracts.
Technological Adaptation & Integration	A critical gap exists in the local capacity to operate, maintain, troubleshoot, and adapt the advanced and evolving technologies in the green hydrogen value chain. This includes large-scale electrolyzers, liquefaction plants, and complex ammonia synthesis loops. It also involves understanding material science challenges like hydrogen embrittlement.	This can lead to operational inefficiencies, increased downtime, higher maintenance costs due to reliance on Original Equipment Manufacturer (OEM) support, a slower adoption of new technologies, and a continued need for expatriate specialists in critical roles.
Logistics & Supply Chain Orchestration	Namibia has emerging capabilities in managing the complex, international supply chains required for exporting hazardous materials like green hydrogen or ammonia. This includes coordinating large-scale, multimodal logistics and adhering to strict international transport regulations for dangerous goods.	There is a potential for logistical bottlenecks that could impact delivery reliability, increase transport costs, and heighten safety risks. An inability to meet the demanding schedules of international buyers could affect Namibia's competitiveness.
Regulatory Compliance & Safety Management	There is insufficient local business capability to navigate and implement the complex web of international and national safety standards and regulations for hydrogen and ammonia. This includes the ability to develop and audit robust site-specific Safety Management Systems (SMS) and Emergency Response Plans (ERPs).	This gap increases the risk of industrial accidents with severe consequences. Shipments could be rejected by importing countries if they don't meet international safety standards. A significant safety incident could damage Namibia's reputation as a reliable supplier and lead to legal liabilities and shutdowns.
Project Finance & Investment Mobilization	The Namibian financial sector has limited experience in financing large-scale, capital-intensive, and technologically new energy projects like those for green hydrogen, which have unique risk profiles. While blended finance vehicles are being established, the broader local financial ecosystem's ability to assess these deals is still developing.	This results in an over-reliance on international financial institutions. This could lead to less favourable financing terms, slower project development, and limited growth in the domestic financial sector's capacity in this strategic area.
Local Content Development & SME Participation	Few Namibian Small and Medium-sized Enterprises (SMEs) currently have the specialised technical expertise, international certifications, or financial capacity to be significant suppliers or service providers in the hydrogen storage and transport sectors. Scaling up SME participation from successful pilot projects to giga-scale projects is a major challenge.	This could lead to limited direct economic benefits for the broader Namibian economy. It might also cause social discontent if the national investment is not seen as benefiting local communities and businesses, representing missed opportunities to build a local industrial ecosystem.

Footnotes

³⁸⁷ <https://www.mdpi.com/2673-4141/6/2/26>
<https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>
<https://www.fastechus.com/blog/hydrogen-fire-safety-standards-regulations/>
<https://ippr.org/na/wp-content/uploads/2024/09/Renewables-Policy-and-Practice-A-Look-at-Namibia-Web-.pdf>
<https://setcoin.group/esg/namibia-green-hydrogen-industr>
<https://economy.com.na/green-hydrogen>
https://international-partnerships.ec.europa.eu/news-and-events/news/global-gateway-namibia-becomes-pioneer-africas-green-transition-2025-04-11_en

Skills Implications

A detailed analysis of Namibia's workforce needs for its emerging green hydrogen (GH₂) storage and transport sector reveals significant skills gaps across various categories, from engineering to specialised trades and regulatory compliance. The development of a skilled local workforce is a critical success factor for realising the nation's green hydrogen ambitions and avoiding project delays and reliance on expatriate labour.

A multi-faceted approach to workforce development is necessary, focusing on cultivating new talent through foundational education and upskilling professionals from existing industries like mining and conventional energy. A deeply ingrained safety culture is paramount in all training and operational activities, given the hazardous nature of hydrogen and ammonia.

The following table provides a comprehensive overview of the key occupations, required skills, current availability of those skills in Namibia, and potential training pathways.

Table 31: Business Skills Implication- GH₂ Transport & Storage

Business Skills Implication - GH ₂ Transport & Storage			
Key Occupation Category ³⁹⁸	Specific Job Examples	Critical Skills/Knowledge Required (Technical, Safety, Regulatory)	Potential for Reskilling from Other Sectors
Engineering	Cryogenic Process Engineer, Ammonia Plant Engineer, Pipeline Integrity Engineer, Materials Engineer (H ₂ focus)	Expertise in thermodynamics, fluid mechanics, reaction engineering, material science (addressing issues like cryogenic effects and hydrogen embrittlement), process simulation, HAZOP, Process Safety Management (PSM), and relevant ISO/ASME codes.	Medium. Professionals from the oil & gas, chemical, or mining sectors would require significant retraining.
Specialized Technicians and Artisans	High-Pressure Welder (H ₂ /NH ₃ certified), Cryogenic Equipment Technician, Instrumentation & Control (I&C) Technician, Non-Destructive Testing (NDT) Technician	Includes advanced welding for specific alloys, maintenance of cryogenic equipment, PLC programming, sensor calibration, various NDT methods, understanding P&IDs, and safety protocols for hazardous environments.	Medium. Welders, electricians, and mechanics from other industrial sectors can be transitioned with intensive upskilling.
Logistics & Port Operations	HAZMAT Logistics Planner, LH ₂ /Ammonia Terminal Operator, Marine Loading Master	Knowledge of dangerous goods regulations (IMDG, ADR), port operations management, cryogenic/ammonia handling procedures, emergency spill response, supply chain software, and customs procedures.	Low to Medium. Logistics personnel from other sectors would need HAZMAT and product-specific training.
SHEQ Professionals	Hydrogen Safety Officer, Process Safety Engineer, Environmental Compliance Specialist (GH ₂)	Deep understanding of H ₂ /NH ₃ properties and hazards, risk assessment (QRA), PSM implementation, emergency response planning, environmental regulations, and standards like ISO 14001, ISO 45001, and ISO/TS 19870:2023.	Medium. SHEQ professionals from the oil & gas or chemical industries can be adapted with H ₂ /NH ₃ specific training.
Regulatory & Compliance	Synthetic Fuels Act Compliance Officer, International Standards Auditor	In-depth knowledge of the Namibian Synthetic Fuels Act, relevant ISO standards (TC 197 family), international maritime codes (IGF), GHG certification protocols, legal interpretation, and auditing skills.	Low. Legal and compliance officers would require deep, sector-specific knowledge.

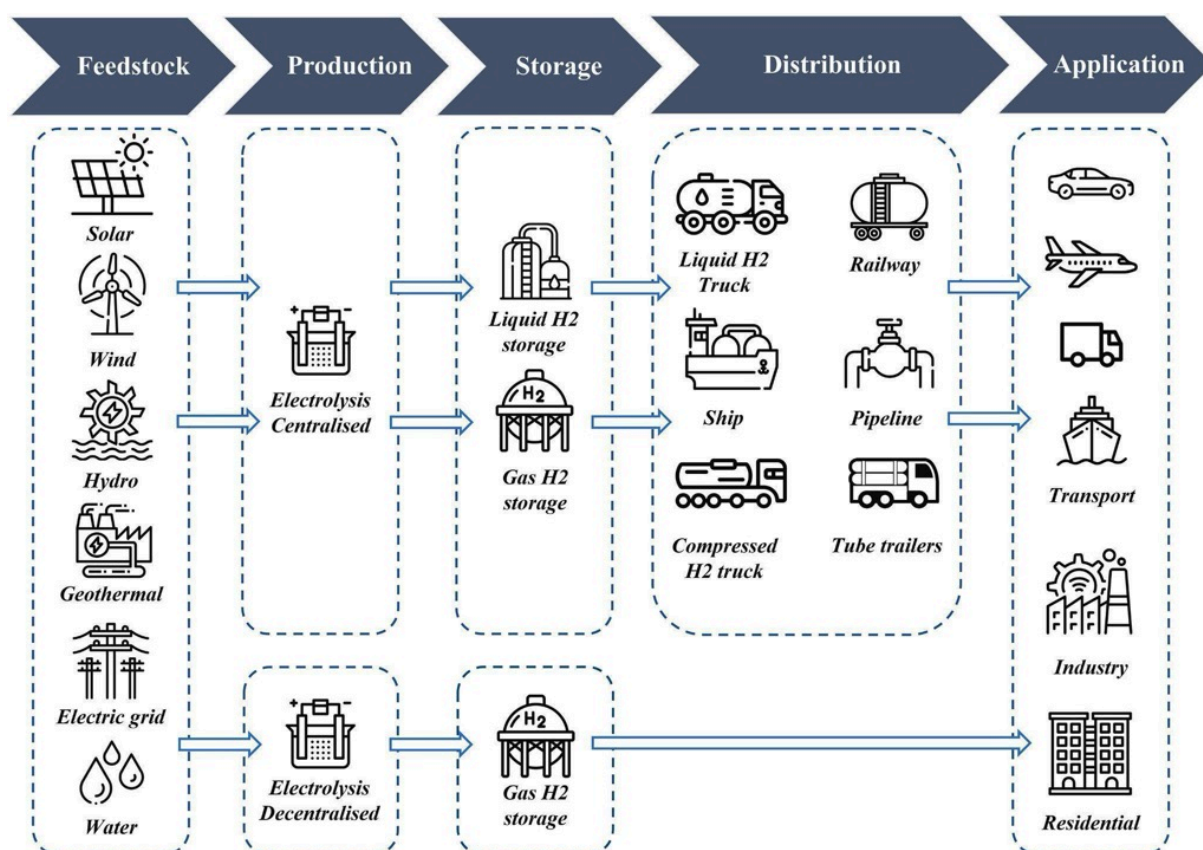
Footnotes

³⁹⁸ <https://www.breakthroughenergy.org/newsroom/articles/hydrogenstorage/>
<https://mg.co.za/the-green-guardian/2024-04-17-south-africa-faces-skills-gap-in-hydrogen-economy-report-finds/>
<https://workforcestaffingksa.com/achieving-the-promise-of-south-africas-green-hydrogen-economy-will-depend-on-a-highly-specialised-workforce/>
<https://carboncredits.com/green-hydrogen-and-ammonia-drive-maritime-decarbonization/>
<https://www.fastechus.com/blog/hydrogen-fire-safety-standards-regulations/>

Business Skills Implication - GH2 Transport & Storage

Key Occupation Category	Specific Job Examples	Critical Skills/Knowledge Required (Technical, Safety, Regulatory)	Potential for Reskilling from Other Sectors
Plant & Pipeline Operators	Electrolyzer Operator, Ammonia Plant Control Room Operator, Pipeline Controller	Skills in process control, equipment monitoring, startup/shutdown procedures, emergency protocols, understanding of chemical processes, and SCADA systems.	Medium. Operators from conventional power or chemical plants could be transitioned with retraining.
Business & Project Management	Entrepreneurs and Managers for local enterprises	Competencies in managing complex technical projects, financial literacy for investment and budgeting, marketing, business development for international engagement, and implementing quality management systems (e.g., ISO 9001).	Medium. Professionals from other sectors who have worked in similar projects can be repositioned for this sub-sector.

6.3 Skills in Demand in the Green Hydrogen Value Chain

Figure 15: Green Hydrogen Production Value Chain³⁹⁹

Footnotes

³⁹⁹ Fabio Sgarbossa, Simone Arena, Ou Tang, Mirco Peron, Renewable hydrogen supply chains: A planning matrix and an agenda for future research, International Journal of Production Economics, Volume 255, 2023.



Key findings indicate that the GH2 value chain demands a wide spectrum of skills. This begins with extensive engineering, design, and construction expertise needed to plan and build renewable energy plants, electrolysis facilities, storage solutions, and transport networks. It then extends from foundational trades in renewable energy installation and maintenance to highly specialised expertise in electrolysis, cryogenics, process safety, and advanced industrial applications like green ammonia production and electricity generation from green hydrogen. Furthermore, the end-of-life phase introduces requirements for skills in safe dismantling, hazardous material management, material recovery and processing, and site remediation, all of which also require engineering and planning. The success of Namibia's strategy, exemplified by large-scale projects such as Hyphen and Hylron, hinges on the timely development of a skilled local workforce, with job creation projections numbering in the tens of thousands across all project phases. The STED program, implemented by the Namibia Investment Promotion and Development Board (NIPDB) in collaboration with the International Labour Organisation (ILO), provides a crucial framework for aligning national skills development initiatives with the specific needs of this nascent industry, including those related to a circular economy for GH2 infrastructure. However, significant challenges remain, including the sheer scale of workforce upskilling required, the need for specialised training programs and trainers, and the importance of international collaboration for knowledge transfer and certification alignment across the full lifecycle of GH2 assets.

Realising this potential necessitates a proactive, coordinated, and adaptive approach to human capital development that considers the entire lifecycle of the industry, starting with robust engineering, design, and construction capabilities. Strategic investment in education, vocational training, robust industry-academia-government partnerships, and the integration of circular economy principles will be paramount in cultivating the expertise needed to establish Namibia as a leader in the global green hydrogen economy and achieve its economic diversification objectives.

Because of unique challenges in obtaining reliable data on demand in the sector, this report will not provide any insights into specific demand numbers in the GH2 sub-sector. Further work must be undertaken to identify specific demand numbers in collaboration with stakeholders in the sub-sector.

A. Engineering, Design, and Construction (Cross-cutting Initial Phase for All Infrastructure)

This foundational phase applies to every subsequent component of the value chain (Renewable Energy, H2 Production, Storage, Transport, Derivatives, End-Use Applications). It involves the conceptualisation, planning, detailed design, procurement, and physical building of all necessary facilities and infrastructure.

Table 32: Occupations, Skills, and Certifications for Engineering, Design, and Construction (Cross-Cutting)

Occupations, Skills, and Certifications for Engineering, Design, and Construction (Cross-Cutting)				
Occupation Title ⁴⁰⁰	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Project Development Manager (GH2)	Lead project from concept through feasibility, financing, and to Final Investment Decision (FID); manage stakeholder relations, permits, and early engineering studies.	Business development, financial modeling, risk assessment, contract negotiation, understanding of GH2 technologies and markets, environmental regulations, project finance.	PMP, MBA, relevant engineering degree.	High, for all major GH2 projects.
Civil/Structural Engineer	Design and oversee construction of foundations, buildings, roads, and other civil works for RE plants, H2 production facilities, storage sites, pipelines, and port infrastructure.	Structural analysis, geotechnical engineering, concrete/steel design, CAD/BIM software, construction management, knowledge of relevant building codes and standards (e.g., Eurocodes, ASCE). Safety: Construction site safety.	Professional Engineer (PE - Civil/Structural), Chartered Engineer (CEng).	Essential for all infrastructure development.
Mechanical Engineer (Plant & Equipment Design)	Design and specify mechanical equipment (turbines, compressors, pumps, pressure vessels, piping systems, electrolyzer BoP); oversee installation and commissioning.	Thermodynamics, fluid mechanics, heat transfer, material science (esp. for H2/cryogenic service), CAD/CAE software (e.g., SolidWorks, ANSYS), P&ID development, equipment sizing, knowledge of ASME/API standards.	Professional Engineer (PE - Mechanical), Chartered Engineer (CEng).	Critical for all process plants and RE facilities.
Electrical Engineer (System Design & Construction)	Design electrical systems (power generation, transmission, distribution, control systems, HV/MV/LV switchgear, grounding) for all facilities; oversee installation and commissioning.	Power systems analysis, electrical machine design, control systems, protection systems, CAD software (e.g., ETAP), knowledge of IEC/IEEE standards, grid codes. Safety: Electrical safety, arc flash analysis.	Professional Engineer (PE - Electrical), Chartered Engineer (CEng).	Foundational for all electrified components.
Chemical/Process Design Engineer	Design chemical processes for H2 production (electrolysis, SMR if applicable), ammonia synthesis, purification, and conditioning; develop PFDs, P&IDs; conduct process simulations, HAZOP studies.	Chemical reaction engineering, separation processes, process control, safety engineering (HAZOP, LOPA), simulation software (Aspen HYSYS/Plus), material and energy balances.	Professional Engineer (PE - Chemical), Chartered Engineer (CEng), CCPSC.	Core for H2 and derivatives production plants.

Footnotes

⁴⁰⁰ <https://www.sanjuacollege.edu/blog/types-of-jobs-in-energy/>
https://hyphenafrika.com/wp-content/uploads/2024/11/Hyphen-Hydrogen-Energy-SED-Framework-Factsheet_FINAL-as-of-Nov-2024-1.pdf
<https://www.lithon.com/engineering-programmes-and-universities-namibia/>
<https://engenuity.org/tools-and-resources/tech-explained/future-skills-hub/demystifying-hydrogen/what-skills-might-you-need>

Occupations, Skills, and Certifications for Engineering, Design, and Construction (Cross-Cutting)

Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Construction Manager	Plan, coordinate, and oversee all construction activities on site; manage contractors, schedules, budgets, quality control, and site safety.	Construction planning and scheduling, contract administration, cost control, quality assurance/quality control (QA/QC), site safety management (OSHA, NEBOSH Construction Cert.), leadership, communication.	Certified Construction Manager (CCM), PMP, relevant trade background or engineering degree.	Key for all project execution phases.
Procurement Specialist/Manager	Source and procure equipment, materials, and services for construction projects; manage supplier contracts, logistics, and inventory.	Negotiation, contract law, supply chain management, knowledge of technical specifications for energy equipment, ERP systems.	Certified Professional in Supply Management (CPSM), CIPS qualifications.	Supports all construction projects.
HSE (Health, Safety, Environment) Manager (Construction)	Develop and implement HSE plans for construction sites; ensure compliance with safety regulations, conduct risk assessments, incident investigations, and safety training.	Occupational health and safety regulations (OSHA, local laws), environmental regulations, risk assessment methodologies, emergency response planning, safety auditing.	NEBOSH National/International Diploma in Occupational Health and Safety, Certified Safety Professional (CSP), ISO 45001/14001 lead auditor.	Mandatory for all construction sites.
CAD/BIM Technician/Coordinator	Create detailed 2D/3D drawings and models for all engineering disciplines; manage BIM workflows and data integration.	Proficiency in CAD software (AutoCAD, Revit, Plant 3D, Civil 3D), BIM coordination, understanding of engineering drawings and standards.	Autodesk Certified Professional, relevant vocational training.	Supports all design and engineering teams.
Welding Engineer/Inspector	Develop welding procedures, qualify welders, inspect welds for critical components (pipelines, pressure vessels) ensuring compliance with codes (ASME, API).	Welding metallurgy, NDT techniques, welding codes and standards, quality control.	Certified Welding Inspector (CWI - AWS), International Welding Engineer (IWE).	Crucial for structural integrity of metal components.
Commissioning Engineer/Technician	Plan and execute pre-commissioning and commissioning activities to ensure systems are installed and operate according to design specifications before handover.	System testing, troubleshooting, understanding of process and control systems, P&ID interpretation, developing commissioning procedures.	Relevant engineering degree or technical diploma, vendor-specific training.	Ensures operational readiness of new plants/systems.

B. Renewable Energy Generation (Solar PV, Wind)

The production of green hydrogen begins with the generation of renewable electricity. Namibia's significant solar and wind resources are central to its GH2 ambitions, creating substantial demand for a skilled renewable energy workforce, including those involved in the initial engineering, design, and construction of these large-scale facilities.

Table 31: Occupations, Skills, and Certifications for Renewable Energy Generation (Solar & Wind) - Construction, Operation & Maintenance

Occupations, Skills, and Certifications for Renewable Energy Generation (Solar & Wind) - Construction, Operation & Maintenance				
Occupation Title ⁴⁰¹	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Solar PV Installation Technician	Install, assemble, test, and maintain rooftop and ground-mounted solar PV systems; connect panels to electrical systems; troubleshoot system issues.	Electrical wiring, use of hand and power tools, understanding of PV system components (panels, inverters, mounting structures, BOS), blueprint reading, problem-solving, attention to detail, data logging. Safety: Working at heights, electrical safety (lockout/tagout, arc flash awareness), manual handling, first aid/CPR.	NABCEP PV Installation Professional (PVIP), NABCEP PV Installer Specialist (PVIS), GWO Basic Safety Training (BST), OSHA 10/30, Local electrical licenses/certifications (e.g., NQF Levels 1-3 Electrical General). Manufacturer-specific installation training.	High demand due to large-scale solar projects planned.
PV System Designer	Design solar PV systems, including site assessment, system layout, component selection (modules, inverters, racking), performance modeling, electrical design (DC/AC), and interconnection studies.	CAD software (e.g., AutoCAD), PV performance simulation software (e.g., PVsyst, Helioscope), knowledge of electrical codes (NEC/IEC) and standards, analytical skills, project management, communication with clients and installers.	NABCEP PV Design Specialist (PVDS), NABCEP PV Technical Sales (PVTs) (for client-facing design roles).	Essential for optimizing solar farm output for GH2 plants.
Solar Project Manager	Oversee solar installation projects from planning and procurement to commissioning and handover; manage budgets, timelines, resources, contractors, and stakeholders; ensure quality and safety compliance.	Project management methodologies (e.g., PMP), contract management, leadership, communication, risk assessment, financial acumen, negotiation, scheduling software (e.g., MS Project).	Project Management Professional (PMP), NABCEP PV Installation Professional (PVIP) or other relevant NABCEP certs.	Crucial for managing the construction of large solar farms.
Wind Turbine Technician (WTG Technician)	Install, inspect, maintain, troubleshoot, and repair wind turbines and their components (blades, nacelle, gearbox, generator, tower, control systems, electrical systems).	Mechanical and electrical troubleshooting, hydraulic systems, control systems (PLCs), data analysis from SCADA systems, high-angle rescue, composite blade repair. Safety: Working at heights, confined space entry, electrical safety (LOTO), rescue training, first aid/CPR.	NFPA Certified Wind Turbine Technician-I (WTT-I), GWO Basic Safety Training (BST) & Basic Technical Training (BTT), GWO Advanced Rescue Training (ART), manufacturer-specific turbine certifications (e.g., Siemens Gamesa, Vestas, GE), Electronics Technician Certificate	Key for maintaining wind farms powering GH2 production.
Renewable Energy Engineer (Solar/Wind/Grid)	Plan, design, and oversee the development and construction of large-scale solar farms or wind parks; conduct feasibility studies, resource assessments (solar irradiation, wind speed), grid integration studies, and environmental impact assessments.	RE system design and modeling software, grid interconnection standards and studies (load flow, stability), geotechnical analysis (wind), aerodynamic principles (wind), strong analytical and problem-solving skills, knowledge of relevant standards (IEC, IEEE), construction oversight.	Professional Engineering (PE) license (country-specific), specialized Master's degrees in Renewable Energy, Chartered Engineer status.	High-level planning, design, and construction oversight for GW-scale RE projects.

Footnotes

⁴⁰¹ <https://www.nabcep.org/certifications/nabcep-board-certifications/>
<https://www.solarenergy.org/nabcep/>
<https://www.airswift.com/blog/hydrogen-certificates>
<https://www.ovtc.edu.na/>

Occupations, Skills, and Certifications for Renewable Energy Generation (Solar & Wind) - Construction, Operation & Maintenance

Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
SCADA/Control Room Operator (Renewables)	Monitor and control the operation of solar farms or wind parks from a central control room using SCADA systems; optimize performance, respond to alarms, coordinate with field technicians.	SCADA system operation, data analysis, understanding of power plant operations, communication protocols, grid codes, quick decision-making under pressure.	SCADA/DCS vendor-specific training, power plant operator certifications (potentially adapted).	Essential for efficient operation of large RE plants.
Site Assessor/Surveyor (Solar/Wind)	Conduct detailed site assessments to determine suitability for solar or wind installations, including topographical surveys, geotechnical investigations, shading analysis (solar), wind resource measurements, and environmental considerations.	Surveying equipment (GPS, anemometers, pyranometers), GIS software, understanding of local planning and environmental regulations, report writing.	Surveying licenses, GIS certifications.	Foundational for project development and design.
Grid Interconnection Engineer	Design and manage the technical and regulatory aspects of connecting renewable energy projects to the electrical grid; conduct grid impact studies, design substation interfaces, liaise with utility companies, ensure compliance with grid codes during design and construction.	Electrical engineering (power systems), knowledge of grid codes and protection systems, power flow analysis software (e.g., PSS/E), substation design, negotiation skills.	Professional Engineering (PE) license, specialized courses in power systems.	Critical for design and construction of large-scale RE projects.
Environmental Consultant (Renewables)	Conduct Environmental and Social Impact Assessments (ESIAs) for RE projects through design, construction, and operation; ensure compliance with environmental regulations, develop mitigation plans, manage permits.	Knowledge of environmental laws and regulations, ecological assessment, stakeholder engagement, report writing, construction environmental management.	Certified Environmental Professional, relevant degrees in Environmental Science/Management.	Increasingly important for sustainable project development.
Blade Repair Technician (Wind)	Inspect and repair wind turbine blades, often using rope access techniques; work with composite materials.	Composite materials repair, rope access skills, NDT techniques for blades, attention to detail. Safety: Advanced working at heights, rope access certifications (e.g., IRATA, SPRAT), GWO Blade Repair.	GWO Blade Repair module, composite repair certifications.	Specialized role for wind farm O&M.
High Voltage (HV) Electrician/Technician (Renewables)	Install, test, maintain, and repair high-voltage equipment in solar farms and wind park substations (transformers, switchgear, circuit breakers) during construction and operation.	HV electrical systems, substation construction and maintenance, protection systems, electrical safety for HV environments, cable jointing and termination. Safety: Specialized HV safety training, LOTO.	HV electrical qualifications, manufacturer training on HV equipment.	Essential for grid connection and plant safety.

Occupations, Skills, and Certifications for Renewable Energy Generation (Solar & Wind) - Construction, Operation & Maintenance

Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Construction Site Supervisor (Renewables)	Supervise daily construction activities for solar or wind farms, ensuring work is done safely, to quality standards, and on schedule; manage construction crews.	Leadership, understanding of RE construction methods, safety regulations, quality control, problem-solving.	Trade qualifications, site supervision certifications (e.g., SMSTS or equivalent).	Manages on-the-ground construction.

C. Green Hydrogen Production

This stage involves the core technology of electrolysis to produce hydrogen from renewable electricity and water. It requires significant engineering and construction to build the plant, followed by specialised operational and maintenance skills.

Table 32: Occupations, Skills, and Certifications for Green Hydrogen Production - Construction, Operation & Maintenance

Occupations, Skills, and Certifications for Green Hydrogen Production - Construction, Operation & Maintenance

Occupation Title ⁴⁰²	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Hydrogen Production Technician / Electrolyzer Operator	Operate and monitor electrolyzer systems (PEM, Alkaline, SOEC) and ancillary equipment (e.g., water purification, gas separation, compressors); perform routine maintenance, troubleshoot operational issues, collect data, ensure safety protocols.	Understanding of electrolysis principles, process control systems (DCS/SCADA/PLC), water chemistry, gas handling (H ₂ , O ₂), electrical safety (high voltage DC), mechanical aptitude, data logging, P&ID interpretation. Safety: Hydrogen properties and hazards, emergency shutdown procedures (ESD), LOTO, permit-to-work systems.	Specialized "Hydrogen Technician" diplomas/certificates (e.g., based on CNA model, NSQF Level 3, Green Hydrogen Production Technician), electrolyzer manufacturer-specific training (e.g., Siemens Energy, Topsoe), Process Safety Management (PSM) awareness/training, City & Guilds Certificate in Energy Efficiency Systems (hydrogen handling module), WHMIS.	Core operational role for all GH ₂ plants.
Process Engineer (Hydrogen)	Design, optimize, and troubleshoot hydrogen production processes; develop P&IDs and PFDs; ensure process efficiency, purity, and safety; conduct HAZOP/LOPA studies; scale-up studies; catalyst management (if applicable); oversee plant construction and commissioning from a process perspective.	Chemical engineering principles, thermodynamics, fluid dynamics, reaction kinetics, process simulation software (e.g., Aspen HYSYS/Plus), HAZOP/LOPA facilitation, material selection for hydrogen service, control philosophy development, construction oversight.	Chartered/Professional Engineer (Chemical), CCPS Certified Process Safety Professional (CCPSC), specialized hydrogen technology courses (e.g., IChemE Hydrogen Workshop, PetroSkills), TÜV Hydrogen Technologist/Expert.	Essential for plant design, construction, optimization, and safety.

Footnotes

⁴⁰² <https://www.cna.nl.ca/program/hydrogen-technician>
https://www.cstaricalcutta.gov.in/images/Green%20Hydrogen%20Production%20Tech_CTS1.0_NSQF-3.5.pdf
<https://petroskills.com/en/training/modules/hydrogen-process-safety-p18216>
<https://www.airswift.com/blog/hydrogen-certificates>
<https://www.sanjuancollege.edu/blog/types-of-jobs-in-energy/>

Occupations, Skills, and Certifications for Green Hydrogen Production - Construction, Operation & Maintenance

Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Electrical Engineer (Electrolyzer & Power Systems)	Design, specify, install, and maintain high-voltage/high-current AC/DC electrical systems for electrolyzers (rectifiers, transformers, switchgear, converters); ensure grid compliance, power quality, and protection coordination during design, construction, and operation.	Power electronics, HV/MV/LV systems, electrical protection systems, control systems integration, understanding of renewable energy intermittency impacts on electrolyzer operation, grounding and bonding, arc flash studies, construction supervision.	Chartered/Professional Engineer (Electrical), specialized training in industrial power systems, HV switching certification.	Critical for design, construction, and interfacing RE supply with electrolyzer stacks.
Instrumentation & Control (I&C) Technician/Engineer	Design, install, calibrate, maintain, and troubleshoot process instrumentation (sensors for pressure, temperature, flow, level, gas composition), control valves, PLCs, and DCS for the hydrogen plant; manage alarm systems and safety instrumented systems (SIS) through all project phases.	PLC programming (e.g., Siemens, Allen-Bradley), DCS configuration (e.g., Emerson, Honeywell, Yokogawa), network communication protocols (e.g., Profibus, Modbus), calibration techniques, understanding of process interlocks and SIS (IEC 61511), system design and installation.	Certified Control Systems Technician (CCST - ISA), vendor-specific DCS/PLC certifications, Functional Safety Engineer (TÜV Rheinland).	Vital for design, construction, and automated/safe plant operation.
Hydrogen Safety Specialist/Engineer	Develop, implement, and audit safety management systems (SMS) from design through operation; conduct risk assessments (QRA, HAZID, HAZOP); ensure compliance with hydrogen safety codes (e.g., ISO/TR 15916, NFPA 2) and standards; emergency response planning and training; incident investigation.	In-depth knowledge of hydrogen properties and hazards (flammability, embrittlement, asphyxiation), PSM principles (OSHA 1910.119, Seveso Directive), dispersion modeling, explosion protection (ATEX/DSEAR), incident investigation techniques (e.g., Root Cause Analysis), safety in design.	CCPSC, NEBOSH/IOSH Diplomas/Certificates, specialized hydrogen safety training (e.g., TÜV, PetroSkills IChemE), Certified Functional Safety Expert (CFSE).	Paramount for all hydrogen facilities, from design to decommissioning.
Plant Manager (Hydrogen Production)	Oversee all aspects of the hydrogen production facility, including construction oversight, commissioning, operations, maintenance, safety, environmental compliance, budget, personnel, production targets, and stakeholder relations.	Leadership, technical knowledge of hydrogen production, project management, financial management, regulatory understanding, strong communication, decision-making, problem-solving, and team management skills.	Engineering degree (Chemical, Mechanical, Electrical), extensive experience in chemical/process plant management (including construction/commissioning phases), MBA (optional), PSM leadership training.	Overall responsibility for GH2 plant lifecycle.

Occupations, Skills, and Certifications for Green Hydrogen Production - Construction, Operation & Maintenance

Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Water Treatment Specialist/ Technician	Design, install, operate, and maintain water purification systems (e.g., deionization, reverse osmosis) to supply ultra-pure water to electrolyzers; monitor water quality, manage chemical dosing.	Water chemistry, operation of water treatment equipment, analytical testing, troubleshooting, system design and installation.	Water treatment operator certifications, relevant engineering/technical diploma.	Critical for electrolyzer design, construction, efficiency, and longevity.
Mechanical Maintenance Technician (Hydrogen Plant)	Perform preventive and corrective maintenance on mechanical equipment in the hydrogen plant, including pumps, compressors, valves, piping, and heat exchangers; may assist with installation.	Mechanical fitting, alignment, vibration analysis, lubrication, seal replacement, understanding of material compatibility with hydrogen. Safety: LOTO, permit-to-work.	Millwright/Mechanical Fitter trade certification, manufacturer training on specific equipment.	Ensures plant reliability and availability; involved in later construction stages.
Quality Control (QC) Analyst/ Technician	Perform sampling and analysis of hydrogen products to ensure purity specifications are met; calibrate and maintain laboratory analytical equipment; implement QC procedures during construction and commissioning.	Analytical chemistry techniques (e.g., gas chromatography), laboratory best practices (GLP), operation of analytical instruments, data interpretation and reporting, QA/QC principles.	Chemistry degree/diploma, specific training on gas analysis.	Ensures product meets requirements throughout lifecycle.
Construction Supervisor (H2 Plant)	Directly oversee and coordinate the daily activities of construction crews building the hydrogen production facility, ensuring safety, quality, and adherence to engineering designs and schedules.	Understanding of H2 plant construction (civil, mechanical, electrical, piping), managing multidisciplinary teams, interpreting engineering drawings, construction safety (permit-to-work, LOTO), quality control.	Trade qualifications, construction supervision certifications, experience in industrial plant construction.	Manages on-site construction of H2 plants.

D. Hydrogen Storage and Conditioning

This segment involves preparing and storing hydrogen in various forms, each requiring specific technologies, safety considerations, and significant upfront engineering and construction for the storage and conditioning facilities. Material science is critical due to hydrogen's interaction with containment materials.

Table 33: Occupations, Skills, and Certifications for Hydrogen Storage and Conditioning - Construction, Operation & Maintenance

Occupations, Skills, and Certifications for Hydrogen Storage and Conditioning - Construction, Operation & Maintenance				
Occupation Title ⁴⁰³	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Cryogenic Systems Engineer/Technician (LH2)	Design, construct, operate, and maintain cryogenic storage tanks, liquefaction plants, and associated equipment for liquid hydrogen (LH2 at -252.9°C).	Cryogenics, vacuum technology, insulation systems, handling of cryogenic fluids, material properties at ultra-low temperatures, pressure relief systems, boil-off gas management, system design and installation. Safety: Cryogenic burns, asphyxiation risks, material embrittlement at low temperatures.	Specialized training in cryogenic engineering and safety (e.g., from industrial gas companies, specialized institutes), experience with LN2, LAr, or LNG.	Relevant if LH2 is chosen as a storage/transport vector.
High-Pressure Gas Systems Technician/Engineer (Compressed H2)	Design, install, operate, and maintain high-pressure hydrogen storage vessels (e.g., Type I-IV cylinders/tanks), compressors, and associated piping and safety systems.	High-pressure gas systems (up to 700 bar or higher), compression technology, material science (hydrogen embrittlement in metals, compatibility of composites), NDT for pressure vessels, pressure relief design, leak detection, system design and installation. Safety: High-pressure gas hazards, rapid depressurization risks.	ASME BPVC Section VIII/X knowledge, certifications in NDT (e.g., ASNT Level II/III), specialized courses on high-pressure systems and hydrogen effects on materials, manufacturer training on compressors and vessels.	Core for gaseous hydrogen storage design, build, and operation.
Materials Engineer/Scientist (Hydrogen Service)	Select, test, and specify materials for hydrogen containment (storage tanks, pipelines, valves, seals) considering hydrogen embrittlement, HTHA, permeability, and cryogenic effects; conduct failure analysis; advise on material selection during design and construction.	Metallurgy, polymer science, composite materials, fracture mechanics, corrosion, understanding of hydrogen-material interactions, NDT techniques, material specification for procurement.	Chartered/Professional Engineer (Materials/Metallurgical), NACE certifications (e.g., Corrosion Specialist), specialized courses on materials for hydrogen service.	Critical across the entire H2 value chain, from design to decommissioning.
LOHC (Liquid Organic Hydrogen Carrier) System Operator/Engineer	Design, construct, operate, and maintain LOHC hydrogenation and dehydrogenation units, manage LOHC storage and handling, ensure catalyst performance.	Chemical process operations, catalysis, heat transfer, fluid dynamics, handling of organic liquids, safety procedures for flammable/toxic LOHCs, plant design and construction principles.	Chemical process operator certifications, specific training on LOHC technology.	Relevant if LOHC is used for storage/transport.
Metal Hydride Storage System Technician/Engineer	Design, install, operate, and maintain metal hydride storage systems, including thermal management, hydrogen charging/discharging cycles, and safety monitoring.	Material science (metal hydrides), heat transfer, pressure systems, safety protocols for reactive metal powders, system integration.	Specialized training in metal hydride technology.	Relevant for specific niche storage applications.

Footnotes

⁴⁰³ <https://www.tuvsud.com/en-us/themes/hydrogen/explore-the-hydrogen-value-chain/hydrogen-storage-and-distribution>
<https://www.ziprecruiter.com/jobs/Hydrogen-Energy>
<https://engineuity.org/tools-and-resources/tech-explained/future-skills-hub/demystifying-hydrogen/what-skills-might-you-need>
<https://fleming.events/inspection-and-maintenance-of-hydrogen-installations/>
<https://www.sanjuancollege.edu/blog/types-of-jobs-in-energy/>

Occupations, Skills, and Certifications for Hydrogen Storage and Conditioning - Construction, Operation & Maintenance

Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Hydrogen Purification Specialist	Design, install, operate, and maintain hydrogen purification systems (e.g., PSA, membrane separation) to achieve required purity levels for storage or end-use.	Separation processes, gas analysis, adsorbent/membrane technology, process control, equipment installation and commissioning.	Training from purification system vendors.	Ensures H2 quality from design to operation.
Tank Farm Operator (H2/Ammonia)	Manage the safe storage of large quantities of gaseous/liquid hydrogen or ammonia in tank farms, including monitoring levels, pressures, temperatures, and coordinating loading/unloading operations; may be involved in commissioning.	Bulk liquid/gas storage operations, safety procedures for hazardous materials, emergency response, SCADA/DCS operation.	Hazmat handling certifications, specific training for H2/ammonia storage.	Essential for large-scale storage facilities.
Conditioning Plant Technician (Compression/Liquefaction)	Operate and maintain hydrogen compression or liquefaction units to prepare hydrogen for storage or transport; assist with installation and commissioning.	Rotating equipment (compressors, turbines), refrigeration cycles (for liquefaction), process control, mechanical and electrical maintenance, installation and startup procedures.	Trade certifications (millwright, electrician), manufacturer training on compressors/liquefiers.	Key for preparing H2 for different transport modes.
Civil Engineer (Storage Infrastructure)	Design and oversee construction of specialized foundations and containment structures for large-scale hydrogen storage (e.g., cryogenic tanks, high-pressure vessel arrays, underground caverns).	Geotechnical engineering, structural design for extreme temperatures/pressures, concrete technology, construction management for specialized infrastructure.	Professional Engineer (PE - Civil/Structural).	For design and build of storage facilities.

E. Hydrogen Transportation and Distribution

This segment covers the movement of hydrogen from production/storage sites to end-users, using various methods and forms, each with unique infrastructure (pipelines, terminals, specialised vehicles) requiring significant engineering, design, and construction efforts.

Table 34: Occupations, Skills, and Certifications for Hydrogen Transportation and Distribution - Design, Construction, Operation & Maintenance

Occupations, Skills, and Certifications for Hydrogen Transportation and Distribution - Design, Construction, Operation & Maintenance					
Occupation Title ⁴⁰⁴	Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Gaseous H2 Pipelines	Pipeline Design Engineer (Hydrogen)	Design hydrogen pipelines considering material compatibility (hydrogen embrittlement), operating pressures, flow rates, safety codes (e.g., ASME B31.12), route selection, and environmental impact.	Pipeline engineering principles, material science for H2 service, stress analysis, GIS, CAD software, knowledge of relevant standards, hydraulic modeling.	Professional Engineer (PE - Mechanical/Civil), specialized courses on hydrogen pipeline engineering (e.g., PetroEdge, Fleming).	Relevant for dedicated H2 pipeline networks.
	Pipeline Construction Supervisor/Inspector	Oversee the construction and installation of hydrogen pipelines, ensuring adherence to design specifications, welding procedures, NDT requirements, and safety standards.	Construction management, welding inspection (CWI), NDT interpretation (UT, RT, MT, PT), understanding of pipeline construction codes (ASME B31.12, API 1104), trenching and laying techniques.	API 1169 Pipeline Construction Inspector, Certified Welding Inspector (CWI), NACE coating inspector.	If new H2 pipelines are built.
	Pipeline Integrity Engineer/Technician	Monitor pipeline integrity, conduct inspections (in-line inspection tools - PIGs, direct assessment), manage corrosion control (cathodic protection), assess defects, and plan repairs for hydrogen pipelines.	NDT techniques (UT, MT, PT, RT, Phased Array UT), corrosion mechanisms in H2 environments, pipeline risk assessment, data analysis from ILI tools, knowledge of ASME B31.12 and API 570/579, fitness-for-service assessment.	NACE certifications (e.g., CP Technician/Specialist, Pipeline Integrity Management), API 570 Piping Inspector, ASNT NDT Level II/III.	Critical for safe pipeline operation.
	Pipeline Control Room Operator (Hydrogen)	Monitor and control hydrogen pipeline operations using SCADA systems, manage flow rates, pressures, detect leaks, and coordinate emergency responses.	SCADA/DCS operation, understanding of gas pipeline hydraulics, emergency procedures, communication skills.	SCADA vendor training, pipeline operator qualification programs.	For managing H2 pipeline networks.
Road/Rail Transport (Compressed Gas / LH2 / Ammonia)	Hazmat Transport Driver (H2/Ammonia)	Safely transport compressed gaseous hydrogen, liquid hydrogen (LH2), or liquid ammonia via road tankers or rail cars; adhere to hazardous materials regulations, perform vehicle checks, emergency procedures.	Defensive driving, knowledge of hazardous materials regulations (ADR/RID internationally, DOT in US), emergency response for H2/ammonia incidents, vehicle inspection, loading/unloading procedures.	Commercial Driver's License (CDL/HGV) with Hazmat endorsement (e.g., Class X in US), specific training on hydrogen/ammonia transport and properties.	For road/rail transport to end-users or ports.

Footnotes

⁴⁰⁴ <https://engenuity.org/tools-and-resources/tech-explained/future-skills-hub/demystifying-hydrogen/what-skills-might-you-need>
<https://petroedgeasia.net/subject/hydrogen-ammonia-methanol/>
<https://fleming.events/inspection-and-maintenance-of-hydrogen-installations/>
<https://www.tuvsud.com/en-us/themes/hydrogen/explore-the-hydrogen-value-chain/hydrogen-storage-and-distribution>

Occupations, Skills, and Certifications for Hydrogen Transportation and Distribution - Design, Construction, Operation & Maintenance

Occupation Title ⁴⁰⁴	Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
	Logistics Coordinator (H2 Transport)	Plan and manage the scheduling, dispatch, and tracking of hydrogen/ammonia shipments; optimize routes, ensure regulatory compliance for transport.	Logistics software, supply chain management, knowledge of transport regulations for dangerous goods, problem-solving.	Certified Supply Chain Professional (CSCP), dangerous goods transportation certifications.	Manages the fleet and delivery schedules.
Maritime Transport (Ammonia / LH2)	Marine Engineer/ Officer (Gas/ Chemical Tankers)	Design, oversee construction/ conversion, operate, and maintain propulsion, cargo handling (loading, unloading, containment), and safety systems on ships designed to transport liquefied ammonia or liquid hydrogen.	Marine engineering, naval architecture, gas/ chemical tanker design and operations, IGF Code (for H2/ammonia as fuel), IGC Code (for cargo), maritime safety (SOLAS, MARPOL), cryogenic handling (for LH2).	STCW certifications (Officer of the Watch, Chief Engineer, Master), specific endorsements for gas/chemical tankers (Basic & Advanced), RINA training on H2/ Ammonia as marine fuels.	For design, build, and operation of maritime export vessels for green ammonia or LH2.
	Port/Terminal Engineer (H2/ Ammonia)	Design and oversee construction of port facilities for H2/ ammonia, including jetties, loading arms, storage, and transfer systems.	Port and harbor engineering, structural design, material handling systems, cryogenic systems (for LH2/ammonia), safety engineering for hazardous materials.	Professional Engineer (PE - Civil/ Mechanical), specialized port engineering courses.	For developing export/import hubs.
	Port/Terminal Operator (Ammonia / LH2)	Manage the loading, unloading, storage, and handling of liquid ammonia or LH2 at port terminals; ensure ship-shore interface safety, emergency preparedness.	Bulk liquid hazardous material handling, cryogenic liquid handling (for LH2), emergency response for large spills/ releases, port safety regulations.	Specialized training in ammonia/ cryogenic liquid handling, port worker safety certifications.	Key for export/ import hubs.
Cross-Cutting (Transport/ Distribution)	Maintenance Technician (H2 Transport Equipment)	Maintain and repair hydrogen transport equipment, including tube trailers, cryogenic tankers, railcars, and associated valves, pumps, and instrumentation.	Mechanical and electrical skills, understanding of high-pressure and/or cryogenic systems, diagnostic skills, welding (for repairs).	Trade certifications (mechanic, electrician), manufacturer training on specific transport equipment.	Ensures transport fleet reliability.

F. Green Hydrogen Derivatives (Focus on Green Ammonia and Electricity Production)

Green hydrogen can be converted into other energy carriers or used directly to produce valuable commodities or generate power. This section focuses on green ammonia and electricity generation from green hydrogen, both of which require significant engineering and construction for their production facilities.

F.1. Green Ammonia Production

Ammonia (NH₃) is produced via the Haber-Bosch process, using green hydrogen and nitrogen separated from the air. The construction of green ammonia plants is a major engineering undertaking.

Table 35: Occupations, Skills, and Certifications for Green Ammonia Production - Design, Construction, Operation & Maintenance

Occupations, Skills, and Certifications for Green Ammonia Production - Design, Construction, Operation & Maintenance				
Occupation Title ⁴⁰⁵	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Ammonia Plant Operator	Monitor and control the ammonia synthesis loop (Haber-Bosch process), air separation unit (for nitrogen), purification, refrigeration, and storage systems; manage catalyst performance, handle high-pressure/temperature systems.	Haber-Bosch process knowledge, DCS/SCADA operation, understanding of catalysis, heat exchange, compression, refrigeration cycles, ammonia properties and hazards (toxicity, corrosivity), emergency response. Safety: PSM, LOTO, confined space entry.	Chemical plant operator certifications, specialized ammonia safety training (e.g., RINA, from fertilizer industry bodies), PSM qualifications, Topsoe operator training.	High, due to the Hyphen Project and other ammonia export plans.
Chemical Engineer (Ammonia Synthesis)	Design, optimize, and troubleshoot ammonia production processes; ensure safety, efficiency, and environmental compliance; catalyst selection and management; process modeling and simulation; oversee plant construction and commissioning.	Chemical engineering principles, reactor design, catalyst technology, thermodynamics, process simulation software (Aspen HYSYS/Plus), HAZOP/LOPA, material selection for ammonia service, construction oversight.	Chartered/Professional Engineer (Chemical), CCPSC, specialized courses in ammonia production technology.	High, for plant design, construction, and continuous improvement.
Process Control Engineer (Ammonia Plant)	Design, implement, and maintain process control strategies and systems (DCS, PLCs, SIS) for the ammonia plant; optimize control loops, manage alarm systems, ensure stable and efficient operation during design, build, and operation.	Advanced process control (APC), DCS/PLC programming and configuration, SIS design and maintenance (IEC 61511), control loop tuning, alarm management, system installation and commissioning.	Certified Control Systems Engineer, vendor-specific DCS/PLC certifications, Functional Safety Engineer (TÜV).	Ensures optimal and safe plant automation from design onwards.
Mechanical Engineer (Ammonia Plant Equipment)	Specify, design, oversee installation, and ensure reliability of critical mechanical equipment in ammonia plants (e.g., high-pressure reactors, compressors, turbines, heat exchangers, pumps, piping).	Rotating equipment expertise, static equipment design (ASME codes), material science for high-pressure/temperature and corrosive environments, vibration analysis, NDT, construction and installation supervision.	Chartered/Professional Engineer (Mechanical), API certifications (e.g., API 510/570/653), specialized training on high-pressure equipment.	Critical for equipment design, installation, integrity, and plant uptime.

Footnotes

⁴⁰⁵ <https://fertilizer.services/green-and-blue-ammonia/>
<https://www.rina.org/en/zero-emissions-fuels>
<https://www.aiche.org/ccps/resources/certified-process-safety-professional>
<https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/>

Occupations, Skills, and Certifications for Green Ammonia Production - Design, Construction, Operation & Maintenance

Occupation Title ⁴⁰⁵	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Ammonia Storage & Handling Specialist	Design, oversee construction, and manage the safe storage (refrigerated/pressurized tanks) and handling of liquid ammonia, including loading/unloading operations for transport (pipeline, ship, rail, truck).	Ammonia properties, cryogenic/refrigerated liquid handling, emergency response for ammonia releases, design and operation of ammonia storage and transfer systems, construction standards for ammonia storage.	Hazmat certifications, specific training in ammonia handling and safety (e.g., from fertilizer industry, RINA).	Essential for design, build, and management of large ammonia inventories.
Environmental Engineer (Ammonia Plant)	Ensure ammonia plant design and operations comply with environmental regulations, manage emissions (NOx, NH3), wastewater treatment, and waste disposal; implement environmental management systems (ISO 14001).	Environmental regulations, air pollution control technologies, wastewater treatment processes, environmental risk assessment, design for environmental compliance.	Chartered/Professional Engineer (Environmental), certified environmental auditor.	Ensures regulatory compliance and sustainability from design phase.
Construction Project Engineer (Ammonia Plant)	Manage specific engineering disciplines (civil, mechanical, electrical, piping) during the construction phase of an ammonia plant, ensuring adherence to design, schedule, and budget.	Relevant engineering discipline expertise, construction management, contract administration, QA/QC, problem-solving on site.	Professional Engineer (PE), PMP (optional).	Manages technical aspects of construction.

F.2. Electricity Production from Green Hydrogen

Green hydrogen can be used to generate electricity through fuel cells or by being combusted in turbines, providing dispatchable power. The construction of these H2 power plants is a key phase.

Table 36: Occupations, Skills, and Certifications for Electricity Production from Green Hydrogen (Fuel Cells & Turbines) - Design, Construction, Operation & Maintenance

Occupations, Skills, and Certifications for Electricity Production from Green Hydrogen (Fuel Cells & Turbines) - Design, Construction, Operation & Maintenance

Occupation Title ⁴⁰⁶	Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
Hydrogen Fuel Cells (Power Generation)	Fuel Cell System Design Engineer	Design fuel cell power plants, including stack selection, Balance of Plant (BoP) integration, thermal management, power conditioning, and control systems.	Fuel cell technology (PEMFC, SOFC), thermodynamics, electrical engineering, control systems design, CAD/simulation tools, safety standards for H2 systems.	Professional Engineer (PE - Electrical/Mechanical/Chemical), specialized fuel cell courses.	For designing fuel cell power solutions.

Footnotes

⁴⁰⁶ <https://www.sanjuancollege.edu/blog/types-of-jobs-in-energy/>

Occupations, Skills, and Certifications for Electricity Production from Green Hydrogen (Fuel Cells & Turbines) - Design, Construction, Operation & Maintenance

Occupation Title	Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
	Fuel Cell Power Plant Operator	Monitor and control fuel cell power plant operations (stacks, balance of plant, power conditioning); manage hydrogen supply, optimize performance, respond to alarms, conduct routine checks.	Understanding of fuel cell electrochemistry (PEMFC, SOFC etc.) , balance of plant (BoP) components (compressors, humidifiers, thermal management), power electronics (DC/AC inverters), SCADA/DCS operation, hydrogen safety.	Certified Fuel Cell Technician (CFCT) , manufacturer-specific fuel cell system training (e.g., Ballard , Bloom Energy) , power plant operator qualifications (adapted for H2).	For decentralized or utility-scale H2 power.
	Fuel Cell Technician/Maintenance Specialist	Install, commission, maintain, and repair fuel cell systems and BoP components; perform diagnostics, replace stacks/ components, ensure system reliability.	Electrical and mechanical troubleshooting, knowledge of fuel cell components and materials, diagnostic tools, preventive and corrective maintenance procedures, installation skills. Safety: Hydrogen handling, electrical safety (DC/AC).	CFCT , NAFTC Fuel Cell Technician Certification , ASE A1/A6 (if vehicle-related) , IAHE Certification.	Essential for installation, O&M of fuel cell installations.
	Electrical Engineer (Fuel Cell Systems)	Design and integrate electrical systems for fuel cell power plants, including power conditioning (inverters, converters), grid interconnection, protection systems, and control interfaces; oversee electrical construction.	Power electronics, grid integration standards (IEEE 1547), electrical protection, control theory, battery storage integration (if hybrid), construction supervision.	Professional Engineer (PE - Electrical), specialized courses in power electronics and grid integration.	For designing and connecting fuel cell plants.
Hydrogen Turbines (Power Generation)	Gas Turbine Design Engineer (H2-Ready)	Design or modify gas turbines and combustion systems for operation with high hydrogen blends or pure hydrogen; material selection for H2 compatibility.	Combustion science, aerodynamics, thermodynamics, material science (H2 embrittlement), CFD/FEA analysis, turbine design software.	Professional Engineer (PE - Mechanical/ Aerospace), specialized courses in turbine design and H2 combustion.	For developing H2-capable turbines.
	Gas Turbine Operator (H2-Ready/H2-Fired)	Operate and monitor hydrogen-ready or dedicated hydrogen-fired gas turbines and combined cycle power plants (CCGT); manage startup, shutdown, load changes, emissions control, and balance of plant.	Gas turbine theory and operation, combustion principles (especially with H2), HRSG operation (for CCGT), generator operation, SCADA/DCS control, emissions monitoring (NOx), hydrogen safety.	Power plant operator certifications, manufacturer-specific turbine training (e.g., Siemens Energy , GE , Topsoe) , TÜV SÜD H2-Ready Certification (for plant/personnel).	For large-scale H2 power generation.

Occupations, Skills, and Certifications for Electricity Production from Green Hydrogen (Fuel Cells & Turbines) - Design, Construction, Operation & Maintenance

Occupation Title	Occupation Title	Key Responsibilities	Essential Skills (Technical, Managerial, Safety)	Relevant Certifications & Training	Namibian Relevance
	Power Plant Engineer (H2-Ready/H2-Fired)	Oversee the engineering aspects of H2-fired power plants from design through operation, including performance optimization, efficiency monitoring, emissions compliance, modification projects, and long-term asset management.	Thermodynamics, power plant engineering, combustion science, materials science (for H2 service), environmental regulations, project engineering.	Professional Engineer (PE - Mechanical/Electrical), specialized courses in power generation technologies.	Technical oversight for H2 power plants lifecycle.
	Instrumentation & Control Engineer (H2 Power Plant)	Design, implement, and maintain I&C systems for H2-fired power plants, including turbine controls, generator controls, emissions monitoring systems, and plant-wide DCS.	Control systems engineering, PLC/DCS programming, sensor technology for H2 environments, cybersecurity for industrial control systems, system installation and integration.	Certified Control Systems Engineer, vendor certifications, Functional Safety Engineer (TÜV).	Critical for safe and efficient plant automation from design.
	Construction Manager (H2 Power Plant)	Oversee the construction of hydrogen-based power generation facilities (fuel cell or turbine plants), managing contractors, schedules, budgets, and ensuring compliance with engineering designs and safety standards.	Experience with power plant construction, understanding of H2-specific safety requirements, project management, contract administration.	PMP, relevant engineering degree or construction management qualification.	Manages building of H2 power plants.

G. Cross-cutting Roles and Skills (Applicable Throughout the Lifecycle including Design & Construction)

Beyond the specialised technical roles, a range of cross-cutting professions and skills are essential for the overall development, design, construction, management, and sustainability of the green hydrogen ecosystem, including its end-of-life phase.

Table 37: Occupations, Skills, and Certifications GH2 Production- Cross Cutting

Occupations, Skills, and Certifications GH2 Production- Cross Cutting		
Job Role ⁴⁰⁷	Description & Responsibilities	Relevant Certifications/Notes
Project Managers	Oversee the comprehensive planning, engineering, procurement, construction (EPC), execution, and completion of complex GH2 projects, including the final decommissioning phase.	PMP
Environmental Scientists and Compliance Officers	Conduct Environmental Impact Assessments (EIAs) for all project phases: design, construction, operation, and decommissioning. They ensure continuous regulatory compliance throughout the project's lifecycle.	ISO 14001
Policy Analysts and Regulatory Specialists	Develop and analyse policies, regulations, and standards for the GH2 sector. This includes managing construction permits, ensuring operational compliance, and overseeing end-of-life management and circular economy aspects.	
Data Analysts and Scientists	Analyse data from various project stages, including design simulations, construction progress, and GH2 operations. The goal is to optimize processes, enable predictive maintenance, and track materials at the end-of-life.	
Automation and AI Specialists	Design and implement automation solutions for GH2 facilities, covering all stages from construction and operation through to the recycling processes.	
R&D Scientists and Engineers	Focus on innovating and improving GH2 technologies. This encompasses design for manufacturing, enhancing construction efficiency, developing new recycling methods, and improving existing ones.	
Energy System Modelers	Develop sophisticated models for the integration of GH2 into the broader energy system. This includes conducting lifecycle assessments and techno-economic analyses to determine project feasibility.	
Health and Safety Managers	Develop and oversee comprehensive Health & Safety (H&S) management systems for all project phases. Their responsibilities start with ensuring safety in the initial design (inherently safer design) and continue through construction, operation, decommissioning, and the handling of materials for recycling.	NEBOSH/IOSH
Business Development Specialists and Financial Analysts	Identify new market opportunities, develop robust business cases, and secure the necessary financing for GH2 projects, including funding for circular economy initiatives.	
Supply Chain Managers	Design and manage the end-to-end supply chain for GH2 projects. This includes sourcing equipment and materials for construction and managing reverse logistics for recycling and reuse of materials.	CSCP
Training Coordinators and Educators	Design and deliver specialized training programs for the GH2 workforce. This training covers engineering, construction, operation, and end-of-life management practices.	
Legal Experts (Energy, Construction & Environmental Law)	Provide legal counsel on contracts (such as EPC and offtake agreements), navigate the permitting process, and ensure regulatory compliance across all project phases.	
Cybersecurity Specialists (Industrial Control Systems)	Protect the automation and control systems of GH2 plants from cyber threats, ensuring security from the design phase through to ongoing operation.	
Technical Writers	Develop and maintain all technical documentation. This includes creating engineering specifications, construction manuals, operational procedures, and other technical documents for all stages of the project lifecycle.	
Community Liaison Officers	Act as the primary point of contact with local communities. They manage engagement regarding all project phases, from initial site selection and addressing construction impacts to the final decommissioning process.	
Circular Economy Specialists	Design and implement strategies that promote resource efficiency, waste minimization, recycling, and reuse across the entire GH2 value chain, starting from the very beginning in the design phase (design for circularity).	

Footnotes

⁴⁰⁷ https://hyphenafrika.com/wp-content/uploads/2024/11/Hyphen-Hydrogen-Energy-SED-Framework-Factsheet_FINAL-as-of-Nov-2024-1.pdf
<https://engineuity.org/tools-and-resources/tech-explained/future-skills-hub/demystifying-hydrogen/what-skills-might-you-need>
<https://www.sanjuancollege.edu/blog/types-of-jobs-in-energy/>
<https://www.lithon.com/engineering-programmes-and-universities-namibia/>
<https://www.nit-edu.org/bachelor-of-technology-in-renewable-energy-technologies/>
https://www.reddit.com/r/energy/comments/1i53sbw/is_a_career_in_green_steelgreen_hydrogen_worth_it/

H. End-of-Life Management: Decommissioning, Refurbishment, Recycling, and Reuse

This critical phase ensures the sustainable management of GH2 assets after their operational lifespan, requiring careful engineering and planning for dismantling, material recovery, and site remediation, aligning with circular economy principles.

H.1. Renewable Energy Infrastructure (Solar PV, Wind)

Table 38: Occupations, Skills, and Certifications for End-of-Life Management of Renewable Energy Infrastructure

Occupations, Skills, and Certifications for End-of-Life Management of Renewable Energy Infrastructure				
Occupation Title	Key Responsibilities	Essential Skills (Technical, Environmental, Safety, Logistical)	Relevant Certifications & Training	Namibian Relevance
Decommissioning Project Manager (Solar/Wind)	Plan, manage, and execute the decommissioning of solar farms or wind parks, including engineering studies for dismantling, site remediation, waste management, and regulatory compliance.	Project management, knowledge of decommissioning regulations, environmental remediation techniques, contract management, stakeholder liaison, budgeting. Safety: Construction safety management.	PMP, Environmental Management certifications (e.g., ISO 14001 auditor), specific decommissioning training.	Growing need as early projects age.
Site Remediation Specialist	Assess and remediate land post-decommissioning, ensuring soil and water quality, revegetation, and return to former use, often involving engineering solutions.	Soil science, hydrology, ecological restoration, knowledge of environmental regulations, operation of remediation equipment, civil engineering basics.	Certified Environmental Professional, hazardous waste operations (HAZWOPER if applicable).	Essential for land restoration.
Heavy Equipment Operator (Dismantling)	Operate cranes, excavators, and other heavy machinery for dismantling solar panel arrays, wind turbine towers, and foundations according to engineering plans.	Heavy equipment operation, rigging and lifting, adherence to safety protocols for dismantling large structures. Safety: Equipment operator licenses, crane operator certification, GWO Basic Safety.	Relevant heavy machinery operation licenses, GWO training.	Needed for physical removal.
Solar Panel Recycling Technician	Dismantle solar panels, separate components (glass, aluminum, silicon, metals), and operate recycling process equipment.	Understanding of solar panel composition, material separation techniques (mechanical, thermal, chemical), operation of recycling machinery, hazardous material handling (e.g., lead in older panels). Safety: Chemical handling, PPE use.	Waste management certifications, specific solar panel recycling training (e.g., from recyclers like SOLARCYCLE), ISO 45001 awareness.	Key for a circular economy.
Wind Turbine Blade Recycling Technician	Process decommissioned wind turbine blades using methods like mechanical shredding, pyrolysis, or chemical recycling to recover materials (fiberglass, carbon fiber, resins).	Knowledge of composite materials, operation of specialized recycling equipment (shredders, kilns), understanding of different recycling processes (mechanical, thermal, chemical). Safety: Handling large composite structures, dust control, chemical safety if applicable.	Training from blade recycling technology providers (e.g., REGEN Fiber), composite materials handling.	Addresses a major recycling challenge.

Occupations, Skills, and Certifications for End-of-Life Management of Renewable Energy Infrastructure

Occupation Title	Key Responsibilities	Essential Skills (Technical, Environmental, Safety, Logistical)	Relevant Certifications & Training	Namibian Relevance
Asset Recovery & Reuse Specialist (RE)	Identify, assess, and manage the refurbishment, resale, or reuse of decommissioned RE components (e.g., inverters, transformers, turbine gearboxes, usable solar panels), often requiring engineering assessment.	Technical knowledge of RE components, market valuation for used equipment, logistics for component handling and transport, contract negotiation, basic engineering assessment.	Relevant technical certifications (e.g., electronics for inverters), business/sales skills.	Maximizes value from old assets.
Environmental Compliance Officer (Decommissioning)	Ensure all decommissioning and recycling activities comply with national and local environmental laws and permit conditions, manage waste manifests and reporting.	In-depth knowledge of environmental regulations (waste, hazardous materials, site remediation), auditing skills, report writing.	Environmental law/management qualifications, certified environmental auditor.	Critical for legal and responsible closure.

H.2. Hydrogen Production and Derivatives Plants (Electrolysers, Ammonia Plants, H2 Power Plants)

Table 39: Occupations, Skills, and Certifications for End-of-Life Management of H2 Production & Derivatives Plants

Occupations, Skills, and Certifications for End-of-Life Management of H2 Production & Derivatives Plants

Occupation Title	Key Responsibilities	Essential Skills (Technical, Chemical, Safety, Logistical)	Relevant Certifications & Training	Namibian Relevance
Plant Decommissioning Engineer (H2/Ammonia)	Plan and oversee the safe shutdown, decontamination, dismantling, and site remediation of hydrogen, ammonia, or H2-power plants, including detailed engineering for dismantling sequences.	Chemical/process plant decommissioning procedures, hazardous material management (H2, ammonia, catalysts, chemicals), pressure system depressurization and purging, structural dismantling, project management. Safety: PSM principles, LOTO, confined space entry.	Professional Engineer (Chemical/Mechanical), PSM expertise, Hazmat certifications (e.g., HAZWOPER), specialized decommissioning training (e.g., RINA for offshore principles, IAEA for nuclear principles - adaptable).	Future need as plants age.
Electrolyzer/Fuel Cell Recycling Specialist	Manage the dismantling of electrolyzer/fuel cell stacks, and oversee the recovery of valuable materials, especially Platinum Group Metals (PGMs) and ionomers, potentially involving chemical engineering processes.	Knowledge of electrolyzer/fuel cell construction, PGM recovery processes (hydrometallurgy, pyrometallurgy), chemical handling, material science. Safety: Handling of catalysts, acids, and specialized equipment.	Chemistry/Materials Science background, training from PGM refiners (e.g., Johnson Matthey's HyRefine process), specific recycling technology courses.	Critical for PGM circularity.

Occupations, Skills, and Certifications for End-of-Life Management of H2 Production & Derivatives Plants

Occupation Title	Key Responsibilities	Essential Skills (Technical, Chemical, Safety, Logistical)	Relevant Certifications & Training	Namibian Relevance
Hazardous Waste Management Specialist (H2 Plants)	Identify, categorize, handle, transport, and dispose of hazardous wastes generated during plant decommissioning (e.g., spent catalysts, contaminated materials, process chemicals).	Hazardous waste regulations (local and international), chemical compatibility, waste treatment methods, emergency response for spills/releases.	Certified Hazardous Materials Manager (CHMM), Hazmat transportation (DOT/ADR), waste management certifications.	Ensures safe and compliant disposal.
Refurbishment Technician (Electrolyzers/Fuel Cells)	Inspect, test, repair, and refurbish components or entire stacks of electrolyzers or fuel cells for reuse.	Detailed knowledge of specific electrolyzer/fuel cell technology, diagnostic skills, component replacement, testing and validation procedures.	Manufacturer-specific refurbishment training (e.g., Ballard's program), electronics/mechanical technician skills.	Extends asset life.
Turbine Decommissioning/Refurbishment Specialist	Oversee dismantling or refurbishment of hydrogen-fired turbines, including component assessment for reuse/recycling, requiring engineering evaluation.	Gas turbine mechanics, material assessment, safe dismantling of large rotating equipment, coordination with recycling facilities, NDT.	Gas turbine maintenance certifications, OEM training, NDT certifications.	For H2 power plants.

H.3. Hydrogen Storage and Transportation Infrastructure

Table 40: Occupations, Skills, and Certifications for End-of-Life Management of H2 Storage & Transport Infrastructure

Occupations, Skills, and Certifications for End-of-Life Management of H2 Storage & Transport Infrastructure

Occupation Title	Key Responsibilities	Essential Skills (Technical, Safety, Logistical)	Relevant Certifications & Training	Namibian Relevance
Pipeline Decommissioning Engineer	Plan and execute the decommissioning of hydrogen pipelines, including engineering studies for purging, cleaning, segmentation, removal, or abandonment in-situ, and site restoration.	Pipeline engineering (ASME B31.12), hydrogen purging and inerting procedures, material assessment for recycling/reuse, environmental regulations for pipeline corridors, NDT techniques.	Professional Engineer (Mechanical/Civil), API certifications (e.g., pipeline inspection relevant for assessment), specialized courses on pipeline decommissioning.	For future pipeline end-of-life.
Storage Tank Decommissioning Specialist (H2/Ammonia)	Manage the safe emptying, purging, cleaning, dismantling, and disposal/recycling of high-pressure hydrogen tanks or cryogenic ammonia/LH2 tanks, following engineered procedures.	Properties of H2/ammonia, procedures for depressurizing/warming cryogenic tanks, inert gas purging, material cutting and handling (especially composites or specialized alloys), confined space entry, hazardous material handling.	Confined Space Entry, Hazmat certifications, pressure vessel inspection/dismantling training, welding/cutting certifications (for dismantling).	Critical for safe removal of storage.
Material Recovery Technician (Infrastructure)	Sort, process, and prepare materials from decommissioned pipelines and storage (steel, composites, valves) for recycling or disposal.	Material identification, operation of cutting/shredding equipment, understanding of scrap metal markets and composite recycling challenges.	Basic mechanical skills, waste handling training.	Supports circularity of infrastructure materials.

H.4. Cross-Cutting End-of-Life Management Role

Many cross-cutting roles listed below are also vital during the end-of-life phase, with a specialised focus. Examples include:

Table 41: Occupations, Skills, and Certifications for End-of-Life Management- General

Occupations, Skills, and Certifications for End-of-Life Management - General	
Occupation Title	Key Responsibilities
Environmental Health & Safety (EHS) Manager (Decommissioning Focus)	Overseeing safety protocols specific to dismantling, hazardous material handling, and site remediation.
Logistics Coordinator (Waste & Recyclables)	Managing the transport of dismantled components, hazardous waste, and materials destined for recycling facilities.
Regulatory Affairs Specialist (End-of-Life)	Ensuring compliance with all decommissioning, waste management, and environmental remediation regulations.
Circular Economy Analyst/Manager	Developing strategies to maximise material recovery, reuse, and recycling from decommissioned assets, integrating these into overall project lifecycle planning, starting from the initial design phase.

6.4 Skills Supply in Green Hydrogen

Namibia's educational and vocational training landscape provides a foundational platform upon which specialised Green Hydrogen (GH2) skills can be built. Key institutions are beginning to align their offerings and research activities with the emerging needs of the GH2 sector, supported by targeted national and international initiatives.

6.4.1 Higher Education Landscape

The country's two primary public universities, the Namibia University of Science and Technology (NUST) and the University of Namibia (UNAM), are central to developing the high-level engineering, scientific, and research expertise required for the GH2 industry.

A. Namibia University of Science and Technology (NUST)	As a premier technological university, NUST is well-positioned to contribute significantly to GH2 skills development. Its Faculty of Engineering and the Built Environment (FEBE) offers a range of Bachelor of Engineering degrees crucial for the GH2 value chain, including specialisations in civil, mining, metallurgy, electrical, mechanical, and chemical engineering. These programs provide the core engineering disciplines necessary for infrastructure development (civil engineering), materials processing and electrolyser technology (chemical and metallurgical engineering), and the design and maintenance of energy systems and plant equipment (electrical and mechanical engineering). At the postgraduate level, FEBE offers Master's degrees in fields such as civil engineering, mining engineering, metallurgical engineering, environmental engineering, and, notably, Sustainable Energy Systems, the latter being particularly pertinent to the renewable energy inputs for GH2 production ⁴⁰⁸ .
--	---

Footnotes

⁴⁰⁸ <https://www.nust.na/>
<https://www.unwto.org/affiliate-member-organization/45351>
<https://febe.nust.na/>

NUST's Faculty of Health, Natural Resources and Applied Sciences (FHNRS) provides foundational Bachelor of Science degrees in Biology, Chemistry, Physics, and Mathematics, along with corresponding postgraduate options. These core scientific disciplines are vital for R&D in areas such as catalysis, materials science for electrolyzers and storage, and understanding the complex electrochemical processes involved in hydrogen production⁴⁰⁹.

The Namibia Energy Institute (NEI), housed within NUST, plays a significant role in energy-related research and is expected to contribute to specialised training. NEI includes entities like the Centre for Renewable Energy and Energy Efficiency (CREEE). The institute is also involved in initiatives such as the SOLTRAIN+ project, offering bursaries for Master's and PhD students in renewable heating and cooling, with a focus on solar thermal energy. While solar thermal is distinct from the PV and wind anticipated for GH2, this demonstrates NEI's engagement in renewable energy research and postgraduate capacity building⁴¹⁰.

B. University of Namibia (UNAM)

UNAM, as the national university, also plays a critical role in higher education and research. The Faculty of Agriculture, Engineering & Natural Sciences (FAENS) houses the School of Engineering & the Built Environment, which offers Bachelor of Science Honours degrees in civil, mining, electrical, mechanical, metallurgical, and electronics & computer engineering. These programs provide a similar range of foundational engineering skills as those at NUST. Master of Science programs in these engineering fields are also available, typically by thesis, allowing for specialised research⁴¹¹.

A pivotal development at UNAM is the establishment of the Namibia Green Hydrogen Research Institute (NGHRI). NGHRI's mandate is comprehensive, encompassing research and development, capacity building for the GH2 economy, fostering entrepreneurship, supporting policy formulation, and acting as a science and technology park to facilitate university-industry-government collaboration. A key function of NGHRI is "training of a skilled and versatile workforce capable of innovating in energy and new materials". The institute is actively involved in pilot projects, such as a hydrogen refuelling station in Walvis Bay (inaugurated in May 2024) and a hydrogen dual-fuel locomotive project, often in collaboration with international partners like the German Federal Ministry of Education and Research (BMBF), SASSCAL, and the Federal Institute for Materials Research and Testing (BAM). Crucially, NGHRI offers Green Hydrogen Masterclasses, sometimes in partnership with the Namibia Investment Promotion and Development Board (NIPDB) and the Hanns Seidel Foundation, targeting students and researchers and indicating direct GH2-focused educational activities⁴¹².

While both NUST and UNAM provide strong foundational engineering and science programs essential for the GH2 sector, a closer examination reveals a current scarcity of dedicated, specialised undergraduate or postgraduate degrees explicitly titled "Green Hydrogen Engineering" or similar. Much of the current GH2-specific learning appears concentrated at the research level within NGHRI, through scholarship-driven specialisations within existing degrees, or via short courses and masterclasses. NUST's Master's in Sustainable Energy Systems is highly relevant but broader than GH2 alone. This points towards an ongoing evolution where GH2 content is being integrated into existing structures and supported by targeted initiatives, rather than a widespread offering of fully dedicated GH2 degree programs at this stage. This suggests a future need for more explicit GH2 specialisation pathways as the industry matures and specific expertise demands become more clearly defined⁴¹³.

Footnotes

⁴⁰⁹ <https://fhnras.nust.na/>

⁴¹⁰ <https://febe.nust.na/>
<https://nei.nust.na/home>

⁴¹¹ <https://www.unam.edu.na/>
<https://www.unam.edu.na/wp-content/uploads/2022/09/List-of-Courses-on-Offer-Faculty-of-Agriculture-Engineering-Natural-Sciences-2023.pdf>
https://en.wikipedia.org/wiki/University_of_Namibia

⁴¹² <https://www.unam.edu.na/nghri>
<https://gh2namibia.com/wp-content/uploads/2024/12/Traction-2.pdf>
<https://www.we.com.na/energy-we/green-hydrogen-bridging-academia-and-industry2025-02-27>

⁴¹³ <https://www.unam.edu.na/nghri>
<https://www.we.com.na/energy-we/green-hydrogen-bridging-academia-and-industry2025-02-27>
<https://etangonam.com/?p=549>
<https://neweralive.na/greenhydrogen-powers-opportunity-for-namibias-youth/>
<https://febe.nust.na/>

Table 42: Current GH2 relevant programmes at UNAM and NUST

Current GH2 relevant programmes at UNAM and NUST						
Institution ⁴¹⁴	School	Department	Programme Title	NQF Level	Key GH2 Relevance	Typical Duration
NUST	Engineering & the Built Environment (FEBE)	Civil, Mining & Process Engineering	Bachelor of Engineering in Chemical Engineering	8	Core Engineering Discipline – Chemical (electrolysis, synthesis)	4 Years
NUST	Engineering & the Built Environment (FEBE)	Civil, Mining & Process Engineering	Bachelor of Engineering in Civil Engineering	8	Core Engineering Discipline – Civil (infrastructure)	4 Years
NUST	Engineering & the Built Environment (FEBE)	Civil, Mining & Process Engineering	Bachelor of Engineering in Metallurgy	8	Core Engineering Discipline – Metallurgy (materials, catalysts)	4 Years
NUST	Engineering & the Built Environment (FEBE)	Mechanical, Industrial & Electrical Engineering	Bachelor of Engineering in Electrical Engineering	8	Core Engineering Discipline – Electrical (RE integration, power systems)	4 Years
NUST	Engineering & the Built Environment (FEBE)	Mechanical, Industrial & Electrical Engineering	Bachelor of Engineering in Mechanical Engineering	8	Core Engineering Discipline – Mechanical (plant equipment, H2 systems)	4 Years
NUST	Engineering & the Built Environment (FEBE)	Various	Master of Engineering in Civil Engineering	9	Advanced infrastructure development for GH2	2 Years
NUST	Engineering & the Built Environment (FEBE)	Various	Master of Engineering in Metallurgy	9	Advanced materials science, catalyst development for GH2	2 Years
NUST	Engineering & the Built Environment (FEBE)	Various	Master of Environmental Engineering	9	Environmental management for GH2 projects	2 Years
NUST	Engineering & the Built Environment (FEBE)	Mechanical, Industrial & Electrical Engineering	Master of Sustainable Energy Systems	9	Specialized RE Focus, relevant for GH2 feedstock	2 Years
NUST	Health, Natural Resources & Applied Sciences (FHNRS)	Biology, Chemistry and Physics	Bachelor of Science (Biology, Chemistry, Physics, Mathematics)	7-8	Core Science – Chemistry/Physics (electrochemistry, materials)	3-4 Years
NUST	Health, Natural Resources & Applied Sciences (FHNRS)	Biology, Chemistry and Physics	Bachelor of Science Honours (Biology, Chemistry, Physics, Mathematics)	8	Advanced Core Science for R&D	1 Year (Post BSc)
NUST	Namibia Energy Institute (NEI)	-	SOLTRAIN+ Bursaries (MSc/PhD in RE heating/cooling)	9-10	Research Area at NEI, RE capacity building	Variable
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Bachelor of Science in Civil Engineering Honours	8	Core Engineering Discipline – Civil (infrastructure)	4 Years
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Bachelor of Science in Mining Engineering Honours	8	Relevant for materials sourcing, potential geological storage	4 Years

Footnotes

⁴¹⁴ <https://febe.nust.na/>
<https://fhnras.nust.na/>
<https://nei.nust.na/home>
<https://www.unam.edu.na/>
<https://www.unam.edu.na/wp-content/uploads/2022/09/List-of-Courses-on-Offer-Faculty-of-Agriculture-Engineering-Natural-Sciences-2023.pdf>
https://en.wikipedia.org/wiki/University_of_Namibia
<https://www.unam.edu.na/ngfri>

Current GH2 relevant programmes at UNAM and NUST

Institution	School	Department	Programme Title	NQF Level	Key GH2 Relevance	Typical Duration
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Bachelor of Science in Electrical Engineering Honours	8	Core Engineering Discipline – Electrical (RE integration, power systems)	4 Years
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Bachelor of Science in Mechanical Engineering Honours	8	Core Engineering Discipline – Mechanical (plant equipment, H2 systems)	4 Years
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Bachelor of Science in Metallurgical Engineering Honours	8	Core Engineering Discipline – Metallurgy (materials, catalysts)	4 Years
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Bachelor of Science in Electronics and Computer Engineering Honours	8	Core Engineering Discipline – Electronics/Computer (control systems, automation)	4 Years
UNAM	Agriculture, Engineering & Natural Sciences (FAENS)	School of Engineering & the Built Environment	Master of Science (MSc) in various engineering fields (by thesis)	9	Research Area, specialized engineering for GH2	2-3 Years
UNAM	Namibia Green Hydrogen Research Institute (NGHRI)	-	Green Hydrogen Masterclasses	N/A	Specialized GH2 Focus, capacity building	Short Course
UNAM	Namibia Green Hydrogen Research Institute (NGHRI)	-	Research in H2 production, storage, safety, applications	9-10	Research Area at NGHRI	PhD/ Postdoc

6.4.2 Technical Vocational Education and Training (TVET) Sector

The VET sector is crucial for supplying the skilled technicians and artisans who will form the backbone of the GH2 industry's operational workforce.

A. Namibia Training Authority (NTA)

The NTA holds a central mandate as the regulator, funder, and provider of Technical and Vocational Education and Training (TVET) in Namibia. It is responsible for the development of national VET qualifications and unit standards, which are then registered on the National Qualifications Framework (NQF). A key feature of the NTA's approach is its emphasis on industry involvement through Industry Skills Committees (ISCs), which aim to ensure that training programs meet current and future industry needs. Existing NQA-accredited vocational qualifications, such as National Vocational Certificates in Automotive Engineering (relevant for H2 mobility), Electrical General (foundational for all electrical work in GH2 plants), Business Services (Office Administration for project support), and Hospitality (for supporting large project workforces), provide a baseline of transferable skills. These foundational trades are critical prerequisites upon which specialised GH2 technical skills can be built⁴¹⁵.

Footnotes

⁴¹⁵ <https://www.nta.com.na/about-us/>
<https://www.nta.com.na/qualifications/>
<https://www.nta.com.na/unit-standards/>

B. National Institute of Technology (NIT) Namibia	NIT Namibia offers a suite of qualifications specifically focused on renewable energy technologies. These include a Certificate in Renewable Energy Technologies (NQF Level 4), Diplomas in Renewable Energy Technologies (NQF Levels 5 and 6), and a Bachelor of Technology in Renewable Energy Technologies. The curriculum for these programs is designed with Namibia's National Development Plan 6 (NDP6) and the needs of Industry 4.0 in mind, emphasising practical skills for roles such as Solar Installation Technologist and Wind-farm Technologist. These qualifications are highly relevant to the GH2 sector, as green hydrogen production is intrinsically linked to the availability and efficient operation of renewable energy sources ⁴¹⁶ .
C. Other Vocational Training Centres (VTCs)	Various VTCs across Namibia, regulated and funded by the NTA, are anticipated to play a role in GH2 skills training. Their inclusion in Namibian delegations for a green hydrogen skills study tour to the Netherlands and other countries signifies their future involvement and the intent to build their capacity for GH2-related training programs ⁴¹⁷ .

The TVET sector offers numerous foundational trade qualifications (e.g., electrical, mechanical, automotive) that are indispensable building blocks for GH2 technicians. However, specific VET qualifications explicitly titled "Green Hydrogen Plant Technician" or "Electrolyser Maintenance Technician" are not yet apparent and represent an area for future development. While NIT's Renewable Energy Technology programs are a significant step in the right direction, they may also require augmentation with GH2-specific modules to fully address the nuanced requirements of hydrogen production, storage, and safety. The Sectoral Review Study's identification of demand for "electrolysis technicians," "hydrogen systems engineers," and "hydrogen production managers" further underscores the need for such specialised VET and higher education pathways. Without the NTA spearheading the development and recognition of these specific GH2-related VET qualifications, Namibia risks facing unstandardised or lower-quality training, or an over-reliance on less efficient on-the-job upskilling of general tradespersons for complex GH2 operational roles⁴¹⁸.

Table 43: Current GH2-Relevant TVET Qualifications in Namibia

Current GH2-Relevant TVET Qualifications in Namibia				
Awarding Body/ Provider Type ⁴¹⁹	Qualification Title or Field	NQF Level	Key GH2 Relevance	Typical Duration
NTA-developed	National Vocational Certificate in Electrical General	2-3	Electrical Trade (foundational for plant wiring, RE systems, electrolyser power supply)	1-3 Years
NTA-developed	National Vocational Certificate in Automotive Engineering (Mechatronics)	2-3	Automotive Technician (relevant for H2 fuel cell vehicles, maintenance of H2-related transport equipment)	1-3 Years

Footnotes

⁴¹⁶ <https://www.nit-edu.org/bachelor-of-technology-in-renewable-energy-technologies/>

<https://www.nit-edu.org/certificate-in-renewable-energy-technologies-level-4/>

⁴¹⁷ <https://www.nta.com.na/about-us/>

<https://trainingproviders.nta.com.na/>

<https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>

<https://etangonam.com/?p=619>

⁴¹⁸ <https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>

<https://www.nit-edu.org/bachelor-of-technology-in-renewable-energy-technologies/>

⁴¹⁹ <https://www.nta.com.na/about-us/>

<https://trainingproviders.nta.com.na/>

<https://namqa.org/wp-content/uploads/2025/04/Namibian-accredited-Institutions-as-at-13-March-2025.pdf>

<https://www.nit-edu.org/bachelor-of-technology-in-renewable-energy-technologies/>

Current GH2-Relevant TVET Qualifications in Namibia

Awarding Body/ Provider Type	Qualification Title or Field	NQF Level	Key GH2 Relevance	Typical Duration
NTA-developed	National Vocational Certificate in Welding and Metal Fabrication	2-3	Mechanical Trade (fabrication and repair of H2 plant components, pipelines, storage tanks – requires H2 specialization)	1-3 Years
NTA-developed	National Vocational Certificate in Plumbing and Pipefitting	2-3	Mechanical Trade (installation of H2 piping systems – requires H2 specialization)	1-3 Years
NTA-developed	Instrumentation (where available or as specialization)	1-4	Plant I&C, sensor installation and calibration during construction and operation	1-3 years
NTA-developed	Civil Construction Trades (e.g., Bricklaying, Carpentry - where applicable for plant buildings/foundations)	1-4	Construction of plant buildings, foundations, support structures.	1-3 years
National Institute of Technology (NIT) Namibia	Certificate in Renewable Energy Technologies	4	RE Technician (solar/wind installation & maintenance for H2 feedstock)	1 Year
National Institute of Technology (NIT) Namibia	Diploma in Renewable Energy Technologies	5 & 6	Advanced RE Technician/Technologist (supervisory roles in RE for H2)	1-2 Years
National Institute of Technology (NIT) Namibia	Bachelor of Technology in Renewable Energy Technologies	7	RE Technologist/Engineer (design, management of RE systems for H2)	3-4 Years
VTCs (NQA Accredited, general examples)	National Vocational Certificate in Business Services (Office Admin)	2-3	Administrative support for GH2 projects and companies	1-2 Years

6.4.3 Specific Green Hydrogen Skills Initiatives

Beyond formal degrees and VET programs, several targeted initiatives are underway to build GH2-specific capacity in Namibia.

A. Youth for Green Hydrogen (Y4GH2) Scholarship Programme

This flagship program specifically targets Namibian youth aged 18-35, providing comprehensive scholarships for studies directly relevant to the green hydrogen industry. The scholarships cover a wide range of expenses, including full tuition fees, travel, accommodation, monthly stipends, laptops, and even protective equipment or toolboxes where required for the field of study. Supported by the German Government and coordinated by the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL), the program enables students to pursue relevant qualifications both locally and internationally, including research placements in Germany. Fields of study pursued by scholars include engineering disciplines (such as Electrical and Electronic Engineering), core sciences (physics, mathematics), and Master's degrees in renewable energy with a specialisation in green hydrogen. This initiative is a direct measure to cultivate a pipeline of qualified young Namibians for the emerging GH2 sector⁴²⁰.

Footnotes

⁴²⁰ https://www.renac.de/fileadmin/user_upload/A_focus_on_Namibias_green_hydrogen_industry.pdf
<https://www2.fundsformgos.org/fellowships/namibian-youth-for-green-hydrogen-scholarship-programme/#:->
<https://etangonam.com/?p=549>
<https://neweralive.na/greenhydrogen-powers-opportunity-for-namibias-youth/>
<https://www.youtube.com/watch?v=cCPuTdoFUZo>

B. International Study Tours

A cornerstone of Namibia's efforts to build domestic GH2 expertise was the Green Hydrogen Skills Study Tour to the Netherlands, which took place over four days in May 2025. This mission was a collaborative effort, coordinated by the Namibia Green Hydrogen Programme (NGH2P) in partnership with the Netherlands Embassy and the Dutch Consulate in South Africa. The study tour was strategically timed, following the release of a 2024 report commissioned by the Netherlands specifically on Namibia's green hydrogen skills landscape. This report identified key areas for development and recommended targeted engagements to support capacity building, ensuring a just and inclusive energy transition. This sequence demonstrates a responsive and evidence-based approach: a need was formally identified through research (the skills gap), and a specific, targeted action (the study tour) was implemented to address this identified deficiency.

The value of such focused study tours extends beyond immediate knowledge acquisition. For nations like Namibia, which are aiming to rapidly develop new and technologically complex industries, these missions are crucial. They facilitate direct learning from established leaders, foster vital international partnerships, and enable the adoption of international best practices. This, in turn, helps to de-risk national development efforts, enhance the probability of project success, and attract the necessary investment. The proactive approach demonstrated by the Netherlands tour, building on prior research and involving a wide array of stakeholders, serves as a robust model⁴²¹.

The positive outcomes and the operational model of the Netherlands study tour could well inform future targeted missions. As Namibia continues to develop its GH2 ecosystem, further specialised knowledge exchange with other leading GH2 nations or specific technology providers will be beneficial. Existing strong partnerships with Germany and the European Union provide fertile ground for continued collaboration, and expressed interest in learning from Asian leaders like Japan and South Korea suggests avenues for diversifying Namibia's knowledge base further.

C. Green Hydrogen Masterclasses

The educational initiatives broadly termed "masterclasses" in Namibia's GH2 sector manifest in various formats, each tailored to specific audiences and objectives:

- **Roadshows:** These are mobile awareness campaigns designed to reach broader audiences, often with a focus on youth, across different geographical regions. The NYEF Green Hydrogen Masterclass Roadshow, with stops in Tsumeb, Ongwediva, and Rundu, is a prime example of this approach, aiming to bring GH2 education directly to communities in northern Namibia⁴²².
- **Targeted Technical Workshops:** These are more intensive sessions designed for specific professional groups. Examples include the GIZ-hosted masterclass for media practitioners, aimed at enhancing the accuracy of public reporting on GH2, and a similar GIZ initiative for the Lüderitz Town Council and regional officials, focusing on local implications of GH2 development⁴²³.
- **Integrated Academies/Training Centres:** These represent more formalised, facility-based programs offering structured courses and practical skills development. Cleanergy Solutions Namibia's Hydrogen Academy at its Walvis Bay plant, which includes training on GH2 production and use in heavy machinery, and the research lab with advanced training tools at the Daures Green Hydrogen Village, fall into this category. The emergence of such "academies" and dedicated training facilities signals a significant progression from general awareness campaigns towards more institutionalised and practical skills development. This shift indicates a maturing educational ecosystem, moving beyond purely informational masterclasses to initiatives directly embedded within operational projects and geared towards creating a skilled workforce⁴²⁴.

Footnotes

⁴²¹ <https://etangonam.com/?p=619>

<https://marketwatch.com.na/energy/dutch-green-hydrogen-skills2025-05-20157792>

https://www.linkedin.com/posts/kingdom-of-the-netherlands-in-south-africa_netherlands-namibian-hydrogen-activity-7326223954715553792-jD_v

⁴²² <https://economist.com.na/91304/human-resources/youth-energy-forum-organises-green-hydrogen-masterclasses-in-the-north/#>

<https://www.facebook.com/NIPDB/posts/register-now-for-the-green-hydrogen-masterclass-in-partnership-with-the-hanns-s/634541558869747/#>

⁴²³ <https://www.luderitz-tc.com/?p=2053#:~:text=The%20preparedness%20of%20the%20L%C3%BCderitz,%20to%20co%20exist>

⁴²⁴ <https://www.cleanerynamibia.com/hydrogen-academy>

<https://daures.green/>

- **Summit-Based Masterclasses:** These are specialised educational sessions offered as part of larger conferences or summits, often featuring international experts. The masterclass led by GIZ and the H2 Business Alliance at the Global African Hydrogen Summit, covering GH2/PtX fundamentals and economics, is an example⁴²⁵.
- **Community Empowerment Workshops:** These are participatory sessions, primarily facilitated by CSOs, that focus on community rights, the potential socio-economic and environmental impacts of GH2 projects, and ensuring that community voices are integral to the development process. The CSO & Affected Communities Green Hydrogen Workshop is a key example, emphasising dialogue and equipping communities to navigate the complexities of the burgeoning sector⁴²⁶.

The geographical distribution of these initiatives—such as NYEF's focus on northern Namibia, GIZ's engagement in Lüderitz, Cleanergy's academy in Walvis Bay, and Hyphen's skills development concentration in the southern regions of Hardap and Ikaras—largely mirrors the locations of current and planned GH2 projects. While this localised targeting is logical for immediate project needs, it also underscores the importance of a comprehensive national outreach strategy. Ensuring equitable access to information and opportunities for all Namibians, including those in regions not immediately adjacent to current GH2 hubs, is crucial for realising the national vision of shared benefits from the green hydrogen economy.

The significant reliance on international collaboration—evidenced by German funding for Y4GH2 scholarships, the skills study tour to the Netherlands, NGHRI's partnerships with German institutions like BAM, and the reference to UNIDO's methodologies for GH2 skills assessment—is a prominent feature of Namibia's current GH2 skills development approach. While this is highly beneficial for knowledge transfer, accessing global best practices, and benchmarking national efforts against international standards, it also underscores the current capacity limitations within Namibia. A sustainable long-term strategy must therefore focus on progressively internalising this external expertise, building robust local training capacity (including "train the trainer" programs), and developing indigenous curriculum development capabilities⁴²⁷.

6.4.4 Analysis of Skills Gaps in the Namibian Green Hydrogen Sub-sector

Namibia has articulated an ambitious vision to become a significant global producer and exporter of green hydrogen (GH2) and its derivatives, positioning this nascent industry as a cornerstone for economic diversification, green industrialisation, and sustainable development. Central to realising these aspirations is the cultivation of a highly skilled and adaptable national workforce.

The analysis reveals that while Namibia possesses foundational engineering and science programs within its universities and a framework for vocational training, dedicated GH2-specific qualifications are emergent, primarily appearing at the research, scholarship, or short-course level.

Footnotes

⁴²⁵ <http://globalafricanhydrogensummit.com/conference/2024-strategic-conference-agenda/>
<https://www.globalafricanhydrogensummit.com/conference/strategic-conference/>

⁴²⁶ <https://www.civic264.org.na/news/general-news/green-hydrogen-from-below-and-from-above-providing-a-reality-check-while-sharing-experiences>
<https://www.facebook.com/Youth4CAN/posts/shared-energy-futures-civil-society-and-community-voices-on-green-hydrogen-green/842112314727646/>

⁴²⁷ <https://gh2namibia.com/jcoi-programme/>
https://jcoinamger.sasscal.org/wp-content/uploads/2022/03/Youth-for-Green-Hydrogen-Y4H2-NAMIBIA-Scholarship_Call_Final.pdf
<https://hydrogen.unido.org/namibia#:~:text=Namibia's%20geographical%20location%2C%20existing%20port,local%20uptake%20of%20clean%20hydrogen.>
<https://www.unam.edu.na/nghri>
<https://forumonline.unam.edu.na/unam-bam-collaboration-begins-training-of-green-hydrogen-workforce/>

A significant talent gap is projected, necessitating a rapid expansion and reorientation of the nation's education and training ecosystem. Key recommendations focus on the development of new and enhanced vocational qualifications for specialised technicians (e.g., electrolyser operations, H2 systems installation, GH2 plant safety), the introduction of GH2-focused specialisations and degree programs at the higher education level, and the promotion of internationally recognised professional certifications. Furthermore, the report underscores the importance of cross-cutting skills in digitalisation, circular economy practices, policy, and project management. A strategic framework emphasising agile curriculum development, institutional capacity building, robust stakeholder collaboration, quality assurance, and pathways for lifelong learning is proposed to guide the implementation of these recommendations, ensuring Namibia can effectively harness its human capital to achieve its green hydrogen objectives.

Namibia's vision is not merely about energy production; it encompasses a broader ambition for green industrialisation, significant job creation, and sustainable economic diversification, all while contributing to national and global decarbonisation goals. The ambitious production targets and the extensive job creation forecasts signal an impending rapid and large-scale demand for a diverse array of skills. This demand will likely extend beyond the immediate operational needs of GH2 plants to encompass a comprehensive ecosystem of supporting industries and services. This includes a substantial workforce for constructing the necessary infrastructure, skilled personnel for logistics and transportation, manufacturing specialists for components such as solar panels and electrolysers (a key aspect of Namibia's green manufacturing aspirations over the long term), and experts in legal, financial, and policy domains, as well as dedicated safety professionals.

The "green industrialisation" component of Namibia's vision, which includes the local manufacturing of renewable energy components and electrolysers, signifies a strategic move beyond merely operating imported technology. This ambition necessitates the development of advanced manufacturing capabilities, expertise in materials science, and proficiency in industrial process engineering. Successfully establishing local manufacturing will not only reduce reliance on imports and create a wider range of job roles but also enable Namibia to capture greater domestic value. This, however, demands a more sophisticated and broader skills base than would be required for simply operating GH2 production facilities⁴²⁸.

Moreover, the emphasis on a "just transition" and "inclusive growth" within the GH2 strategy carries profound implications for skills development. It necessitates that training and educational opportunities are accessible and equitable, specifically targeting youth, women (who are currently underrepresented in technical roles in the energy sector), and potentially workers from sectors that may decline as the green economy grows. Initiatives like the "Youth for Green Hydrogen Scholarships" are direct responses to this need. To achieve these inclusivity goals, curriculum design, delivery methodologies, and outreach strategies must be carefully considered. This involves not only determining what skills are needed but also ensuring that who acquires these skills and how they are delivered aligns with national objectives for broad-based social and economic advancement. Educational institutions at all levels, from universities to vocational training centres, must therefore urgently assess their capacity—in terms of faculty, infrastructure, and curriculum agility—to meet this unprecedented surge in demand for a skilled and diverse workforce⁴²⁹.

Footnotes

⁴²⁸ https://www.renac.de/fileadmin/user_upload/A_focus_on_Namibias_green_hydrogen_industry.pdf

⁴²⁹ <https://www.ilo.org/sites/default/files/2024-06/RFQ%20STED%20Namibia.pdf>
<https://www2.fundsforngos.org/fellowships/namibian-youth-for-green-hydrogen-scholarship-programme/>

Synthesising the findings from the Sectoral Review Study and the projected workforce needs, several key skills gaps become apparent:

A. Skills Gaps⁴³⁰

- **Specialised Technical Skills for GH2:** There is a clear need for personnel with expertise in emerging fields like green hydrogen production (electrolysis technology, hydrogen handling, ammonia synthesis), advanced renewable energy technologies (beyond basic installation), energy storage solutions, and Power-to-X applications.
- **Vocational Skills Deficiencies:** While foundational trades exist, there's a gap in specialised vocational training for roles like electrolysis technicians, hydrogen systems installers, and maintenance personnel proficient in H2-specific equipment and safety. The quality and relevance of existing TVET curricula are also concerns, with calls for regular updates to reflect technological advancements and reduce skills mismatches.
- **Engineering Expertise:** Shortages of locally qualified engineers in specialised areas such as chemical, electrical (with power systems focus), mechanical (with high-pressure/cryogenic systems focus), and industrial engineering, particularly those with experience in large-scale energy projects, are anticipated.
- **Construction Management & Supervision:** Experienced construction managers and supervisors familiar with large industrial and energy projects, particularly those with H2-specific safety and quality requirements.
- **Project Management and Professional Skills:** A significant demand for project managers skilled in planning, risk management, stakeholder engagement, and financial oversight for complex energy projects is highlighted.
- **Digital and Data Skills:** The increasing digitalisation of the energy sector, including smart grids and data analytics for operational efficiency, requires a workforce with strong digital literacy and data analysis capabilities.
- **Environmental and Sustainability Skills:** Expertise in environmental management, sustainability practices, and regulatory compliance is crucial, given the environmental considerations of large-scale GH2 projects.
- **Process Safety Professionals:** Engineers and specialists with deep knowledge of PSM in H2 environments, from design (inherently safer design) through construction, operation, and decommissioning.
- **Advanced NDT and Material Science Specialists:** These are for quality assurance during construction, operational integrity, and end-of-life assessment.
- **Regulatory and Permitting Experts:** Professionals familiar with standards for GH2 project development, construction, operation, and decommissioning. Hyphen's planned national skills audit will be crucial for detailed gap analysis. The global demand for these skills means Namibia must rapidly develop domestic capacity.
- **Cross-cutting and Soft Skills:** Beyond technical competencies, there's a need for enhanced soft skills such as communication, teamwork, problem-solving, adaptability, and leadership across all levels of the workforce.
- **End-of-Life Management Skills:** As a nascent field globally, skills related to the decommissioning, refurbishment, recycling (e.g., of solar panels, wind turbine blades, electrolyzers, and fuel cells), and reuse of GH2 infrastructure are likely underdeveloped. This includes specialised dismantling techniques, hazardous material management, material recovery science (e.g., PGM recovery from catalysts), and site remediation engineering.

B. Curriculum and Training Program Deficiencies:

VTC Curricula Gaps: Existing vocational training in trades like electrical work, welding, and plumbing provides a foundational base but lacks the specific "green skilling" and specialisation required for GH2. For example:

- Electricians need training in high-voltage DC systems specific to electrolyzers and fuel cells, as well as advanced grid integration techniques.
- Welders require skills for working with specialised materials resistant to hydrogen embrittlement and for high-pressure applications.
- Pipefitters need expertise in handling high-pressure hydrogen and hazardous substances like ammonia.
- The specific role of an "Electrolyser Technician" or "Hydrogen Plant Operator" is new and not typically covered in standard VTC offerings.
- **University Curricula Gaps:** While UNAM and NUST offer relevant engineering and sustainable energy programs, there is a pressing need for more dedicated GH2 modules, specialisations, or even full degree programs. Key areas for development include:
 - GH2 process engineering (electrolysis, ammonia synthesis).
 - Design of H2-specific infrastructure (storage, pipelines).
 - Fuel cell and H2 turbine design, operation, and integration.
 - Advanced materials science for H2 applications.
 - Process safety engineering tailored to H2 facilities.
 - Circular economy principles and end-of-life management for energy systems.
- **Lack of "Train-the-Trainer" Programs:** A significant bottleneck is the availability of qualified instructors and lecturers at both VTCs and universities. These educators need to possess current, in-depth knowledge and practical experience in the rapidly evolving GH2 technologies and their full lifecycle management. Without dedicated programs to upskill educators, the quality and relevance of training will be compromised⁴³¹.
- **Insufficient Focus on Practical and Work-Integrated Learning:** While initiatives like the NIPDB's internship and apprenticeship programs exist, there's a need for much broader and more deeply integrated work-based learning opportunities specific to the GH2 sector to bridge the gap between theoretical knowledge and practical industry requirements.

C. Systemic and Institutional Gaps:

- **Pace of Adaptation and System Agility:** The GH2 industry is characterised by rapid technological advancements and shifting market dynamics. Namibia's education and training system must become highly agile to adapt curricula, develop new programs, and respond swiftly to the industry's emerging and evolving skill requirements. While the STED program aims to facilitate this, its effectiveness will depend on the rapid implementation of its findings and continuous industry feedback.
- **National Certification and Standards:** For many new and specialised GH2 roles, there is likely an absence of established national certification pathways in Namibia. Aligning with or developing internationally recognised certifications for technical competencies and safety is crucial for ensuring workforce quality, facilitating worker mobility, and meeting the standards of international project developers and financiers.
- **Awareness and Attractiveness of GH2 Careers:** There may be a gap in public awareness, particularly among youth, regarding the diverse and technologically advanced career opportunities within the GH2 sector. Concerted efforts are needed to showcase these pathways and attract talent.

Footnotes

⁴³¹ https://international-partnerships.ec.europa.eu/news-and-events/news/global-gateway-namibia-becomes-pioneer-africas-green-transition-2025-04-11_en

- **Coordination and Collaboration:** While some industry-academia collaboration exists, a more structured and intensive collaboration mechanism is needed between the government, educational institutions, and the GH2 industry (including international investors and technology providers) to ensure skills development efforts are demand-driven and effectively coordinated.

Addressing these multifaceted skills gaps through targeted interventions in education, training, policy, and collaboration will be fundamental to Namibia's success in establishing a thriving and sustainable green hydrogen economy.

6.4.5 Recommended Qualifications, Courses, and Certifications for Namibia's GH2 Future

To meet the anticipated skills demand and bridge the identified gaps, a multi-pronged approach to developing and enhancing qualifications, courses, and certifications is essential. Recommendations span vocational, higher education, professional development, and cross-cutting skills areas, tailored to Namibia's specific context and GH2 ambitions.

A. Vocational Level

The NTA, in collaboration with industry stakeholders and VTCs, should spearhead the development and adaptation of vocational qualifications to create a cadre of skilled technicians for the GH2 industry.

i. Specialised Technician Training Programmes (New or Adapted NTA Qualifications)⁴³²

- **Electrolyser Operations & Maintenance Technician (NQF Level 4-6):** This program should cover the principles of various electrolyser technologies (PEM, Alkaline, SOEC), process control systems, water quality management for electrolysis (including operation of demineralised water systems), routine and preventative maintenance procedures, troubleshooting common faults, and specific safety protocols for electrolyser environments.
- **Hydrogen Systems Installation & Commissioning Technician (NQF Level 4-6):** Training should focus on the correct installation, testing, and commissioning of GH2 production components (electrolysers, rectifiers, purification units), storage systems (high-pressure tanks, potentially cryogenic systems in the future), and distribution infrastructure, including piping, valves, sensors, and integrated safety systems.

Footnotes

⁴³² <https://yyskilltech.com/sample-skills-profiles/electrolysis-operation>
<https://restservice.epri.com/publicdownload/000000003002031505/0/Product>
<https://www.libertyspecialtymarkets.com/article/green-hydrogen-designing-for-reliability-and-maintainability>
<https://careercenter.sspatoday.com/career/electrolysis-operator/job-descriptions>
<https://kresogroup.com/job-description-templates/electrolyser-engineer/>
<https://h2tools.org/bestpractices/maintenance-and-inspection/maintenance-requirements-for-vessels>
<https://cryospain.com/compressed-hydrogen>
<https://www.horizon-europe.gouv.fr/advanced-materials-hydrogen-storage-tanks-34822>
<https://www.nit-edu.org/bachelor-of-technology-in-renewable-energy-technologies/>
https://cogentskills.com/wp-content/uploads/2025/04/HSA_Hyd_skills_framework_v3.pdf
<https://engineuity.org/tools-and-resources/tech-explained/future-skills-hub/demystifying-hydrogen/what-skills-might-you-need>
<https://www.centuracollege.edu/blogs/trades-industry/trades-industry-wind-farm-technican-courses/>

- **GH2 Plant Safety Technician/Officer (NQF Level 5-6):** This advanced vocational qualification or specialisation should provide in-depth knowledge of H2-specific hazards (e.g., flammability, invisible flame, asphyxiation, material embrittlement, high pressures, cryogenic temperatures), risk assessment methodologies, the application of relevant safety codes and standards (e.g., NFPA 2, ATEX directives), emergency response procedures, selection and use of appropriate PPE, and the operation and maintenance of gas detection and fire suppression systems. The development of such specialised safety qualifications is paramount given the unique and high-consequence hazards associated with hydrogen, which extend beyond general industrial safety. A strong safety culture, underpinned by well-trained personnel, will be critical for the industry's viability and public acceptance.
- **Water Treatment Technician for Electrolysis (NQF Level 4-6):** This qualification would focus on the operation and maintenance of industrial water purification systems, such as reverse osmosis (RO) and deionisation (DI) plants, ensuring the consistent supply of high-purity feedwater essential for electrolyser efficiency and longevity. Skills would include water quality monitoring, chemical handling for treatment processes, and troubleshooting of purification equipment.
- **Renewable Energy (Solar PV & Wind) Technician with GH2 Interface (NQF Level 4-6):** Building upon existing renewable energy technician training, such as programs offered by NIT, this specialisation would add modules on the specific requirements of powering large-scale electrolyser plants, including understanding load profiles, grid stability considerations for dedicated RE-to-H2 facilities, and the interface between RE control systems and electrolyser management systems.
- **Pipefitter/Welder with Specialisation in Hydrogen Systems (NQF Level 4-6):** This program would provide advanced skills beyond standard pipefitting and welding, focusing on materials suitable for hydrogen service (e.g., specific stainless-steel grades), specialised welding techniques required for high-pressure hydrogen environments, understanding and mitigating hydrogen embrittlement, and non-destructive testing (NDT) methods for H2 pipelines and vessels.
- **Instrumentation and Control Technician for GH2 Processes (NQF Level 4-6):** This qualification would focus on the calibration, maintenance, programming, and troubleshooting of sensors (pressure, temperature, flow, H2 concentration), control valves, programmable logic controllers (PLCs), and supervisory control and data acquisition (SCADA) systems specifically configured for GH2 production, storage, and distribution processes.

ii. Upgrading Existing VET qualifications:

A practical and scalable approach involves integrating GH2 awareness modules, basic hydrogen properties, specific safety precautions, and an overview of the GH2 value chain into relevant existing trade qualifications (e.g., General Electrician, Fitter and Turner, Plumber, Automotive Mechanic). This strategy would rapidly disseminate foundational GH2 knowledge and safety awareness across a broad base of technicians in traditional trades, many of whom will work in or around GH2 facilities without needing to be fully specialised hydrogen technicians. This approach accelerates the "hydrogen readiness" of the wider technical workforce, leveraging existing training infrastructure and instructor cohorts for cost-effective widespread basic competency.

B. Higher Education Level (NUST, UNAM and Others)

NUST and UNAM, alongside other higher education institutions, should develop new programs or enhance existing ones to cultivate the advanced engineering, scientific, and research expertise needed for the GH2 sector.

i. New or Enhanced Bachelor's Specialisations/Streams

- **B.Eng. Chemical Engineering with Green Hydrogen Processes Specialisation:** Curriculum to include advanced thermodynamics, kinetics, reactor design, separation processes, and process simulation, all applied to electrolysis, green ammonia synthesis (Haber-Bosch), synthetic fuel production (e.g., Fischer-Tropsch), and other PtX technologies.
- **B.Eng. Electrical Engineering with Renewable Energy Systems & GH2 Integration Specialisation:** Focus on the design and operation of large-scale solar PV and wind farms for dedicated GH2 production, advanced power electronics for electrolyser systems, grid stability and control for hybrid RE-H2 systems, and the design of microgrids for off-grid GH2 facilities.
- **B.Eng. Mechanical Engineering with Hydrogen Systems & Storage Specialisation:** Coursework to cover fluid mechanics and thermodynamics of compressible gases, design of high-pressure hydrogen systems (compressors, storage vessels), principles of cryogenics for liquid hydrogen (LH2) storage and transport, pipeline design and integrity for hydrogen, and the application of hydrogen in fuel cells and combustion turbines.
- **B.Sc. Materials Science/Engineering with focus on Hydrogen Technologies:** Specialisation in the selection, characterisation, and development of materials for electrolyser components (electrodes, membranes, bipolar plates), fuel cells, hydrogen storage tanks (addressing issues like hydrogen embrittlement in metals and permeability in polymers), and catalysts for H2 production and conversion.

ii. New or Enhanced Master's Programmes

- **M.Sc/M.Eng. in Green Hydrogen Technologies:** A dedicated, interdisciplinary postgraduate program covering the full GH2 value chain, including advanced production technologies, storage and distribution systems, end-use applications, GH2 economics and market development, policy and regulatory frameworks, project finance, and comprehensive safety engineering for hydrogen facilities.
- **M.Sc. in Renewable Energy Engineering with Advanced GH2 Systems Module:** Building on existing Master's programs in renewable energy (like NUST's Sustainable Energy Systems), this would incorporate in-depth modules on GH2 production from renewables, system integration challenges, and the techno-economics of RE-H2 projects.
- **M.Sc. in Process Safety Engineering for Hydrogen Facilities:** A specialised program focusing on advanced hazard identification (HAZID), hazard and operability studies (HAZOP), quantitative risk assessment (QRA), consequence modelling, design of safety-instrumented systems (SIS), and emergency preparedness specifically for facilities handling large quantities of hydrogen.

iii. PhD Research Opportunities:

- These should be closely aligned with the research agendas of NGHRI and NEI. Potential research areas include: development of more efficient and durable electrolyser catalysts and membranes, innovative solid-state or liquid organic hydrogen carriers for storage, advanced sensors for H2 leak detection, socio-economic impact assessments of GH2 development in Namibia, and policy studies to optimise the regulatory environment for GH2.

C. Professional Development and Certifications

Encouraging and facilitating access to internationally recognised professional certifications will be crucial for ensuring a competent workforce that meets global standards, particularly for an export-oriented industry.

i. Internationally Recognised Certifications⁴⁴³

- **Safety:**
 - Global Wind Organisation (GWO) Basic Safety Training (BST) and Basic Technical Training (BTT) for personnel working on or near wind turbines supplying power to GH2 plants. Modules include Working at Height, First Aid, Fire Awareness, Manual Handling, and Sea Survival (for offshore).
 - Hydrogen-Specific Safety Certifications: Credentials such as those offered by City & Guilds (e.g., in energy efficiency systems with a focus on safe handling of explosive gases), IOSH (Certificate in Environmental Management with relevance to chemical hazards), or NEBOSH (Certificate in Environmental Management) can provide foundational knowledge. As the industry matures, dedicated hydrogen safety practitioner certifications should be pursued.
- **Renewable Energy Operations:**
 - North American Board of Certified Energy Practitioners (NABCEP) certifications for solar PV professionals (e.g., PV Installation Professional (PVIP), PV Design Specialist (PVDS), PV Commissioning & Maintenance Specialist (PVCMS)) involved in the RE plants supplying GH2 facilities.
 - Association of Energy Engineers (AEE) Certified Renewable Energy Professional (REP™) for individuals involved in the specification, application, and assessment of renewable energy projects.
- **Technical Operations (Hydrogen Specific):**
 - Certifications for handling and transporting compressed and liquefied gases.
 - Certifications for pressure vessel design, inspection, and maintenance (e.g., aligned with ASME BPVC or relevant DOT standards for mobile vessels).
- **Hydrogen Transportation and Export Compliance:**
 - Certifications related to Renewable Fuels of Non-Biological Origin (RFNBO) to demonstrate compliance with criteria such as those in the EU's Renewable Energy Directive (RED III) for hydrogen and its carriers (e.g., ammonia, methanol) intended for export.
 - Type-approval certifications for hydrogen-powered motor vehicles and their components (e.g., UN ECE R134, GTR No. 13, EC 79/2009) and fuelling infrastructure (e.g., SAE J2601) if Namibia develops a domestic H2 mobility market.

Footnotes

⁴⁴³ https://www.airswift.com/blog/hydrogen-certificates#:~:text=The%20GWO%20Basic%20Safety%20Training,including%20hydrogen%20production%20and%20storage.https://www.airswift.com/blog/hydrogen-certificateshttps://maersktraining.com/industries/renewables-industry/career-guides/gwo-training-explainedhttps://newcollegeinstitute.org/workforce-training/gwo-renewable-energy-industry-training-certifications/https://rejobs.org/en/renewable-energy-blog/career-opportunities-in-solar-energyhttps://www.nabcep.org/certifications/nabcep-board-certifications/https://www.solarenergy.org/nabcep/https://www.aeecenter.org/certified-renewable-energy-professional/https://cogentskills.com/wp-content/uploads/2025/04/HSA_Hyd_skills_framework_v3.pdfhttps://h2tools.org/bestpractices/maintenance-and-inspection/maintenance-requirements-for-vesselshttps://cryospain.com/compressed-hydrogenhttps://english.rvo.nl/topics/hydrogen/certificate-green-hydrogenhttps://www.tuvsud.com/en-us/industries/mobility-and-automotive/automotive-and-oem/automotive-testing-solutions/hydrogen-fuelhttps://www.energydegrees.org/resources/energy-certifications/https://www.anavo.com/learn/most-in-demand-transferable-skills-for-a-career-in-the-renewable-energy-industry/https://www.legal500.com/developments/thought-leadership/financing-renewable-energy-projects-and-acquisitions-key-considerations-for-investors-and-lenders/https://www.sperton.com/all/human-resources-and-effective-management-in-renewable-energy-engineering-companies/

ii. Project Management & Business

- Project Management Professional (PMP)® from the Project Management Institute (PMI) is highly recommended for individuals managing large-scale, complex GH2 projects, as identified as a priority need.
- Certified Energy Manager (CEM)® from AEE for professionals responsible for optimising energy performance in GH2 production and associated facilities.

iii. Specialised Engineering Licensures:

- Encouraging engineers in relevant disciplines (chemical, electrical, mechanical, civil) to attain professional engineer (PE) status through the Engineering Council of Namibia will be important for accountability and maintaining high professional standards.

The emphasis on professional certifications like PMP and CEM, alongside technical GH2 credentials and engineering licensures, addresses the critical need for high-level management expertise, operational excellence, and stringent regulatory compliance. These are indispensable for the successful execution of capital-intensive and technologically complex GH2 projects. Such a holistic skill set, combining technical depth with robust management capabilities, is key not only for project delivery but also for attracting international investment and ensuring the long-term operational sustainability and competitiveness of Namibia's GH2 sector.

D. Cross-cutting Skills Development⁴³⁴

Alongside specialised technical and professional qualifications, a range of cross-cutting skills are essential for a well-rounded GH2 workforce.

- **Digital Literacy and Data Analytics:** Short courses and integrated modules in SCADA systems, Internet of Things (IoT) applications in energy management, data analytics for process optimisation and predictive maintenance in RE and GH2 plants, and cybersecurity for industrial control systems.
- **Circular Economy Principles and Practices:** Dedicated short courses or modules focusing on life-cycle assessment (LCA), sustainable design, and the practical aspects of decommissioning, dismantling, and recycling/repurposing of renewable energy (solar PV, wind turbines) and GH2 components (electrolysers, fuel cells).
- **Policy, Economics, and Regulatory Aspects of GH2:** Workshops, executive education programs, and short courses for professionals covering GH2 policy development, international market dynamics, project financing mechanisms for GH2, specific legal frameworks (including land use, environmental permits, offtake agreements), and negotiation of Power Purchase Agreements (PPAs).
- **Entrepreneurship and Innovation for GH2:** Development of modules within technical programs or specialised incubator/accelerator programs, possibly linked with NGHRI and NEI, to foster local innovation, start-up creation, and business development within the domestic GH2 value chain.
- **Communication, Teamwork, and Leadership:** Integration of soft skills development across all technical and academic programs to enhance collaboration, problem-solving, and leadership capabilities within the workforce.

Footnotes

⁴³⁴ <https://rejobs.org/en/renewable-energy-blog/career-opportunities-in-solar-energy>
<https://www.centuracollege.edu/blogs/trades-industry/trades-industry-wind-farm-technician-courses/>
<https://www.libertyspecialtymarkets.com/article/green-hydrogen-designing-for-reliability-and-maintainability>
<https://engineuity.org/tools-and-resources/tech-explained/future-skills-hub/demystifying-hydrogen/what-skills-might-you-need>
<https://www.anavo.com/learn/most-in-demand-transferable-skills-for-a-career-in-the-renewable-energy-industry/>
<https://www.acre.com/Circular-Economy-jobs>
<https://www.ziprecruiter.com/Jobs/Decommissioning/-in-Pennsylvania>
<https://www.greenlancer.com/post/decommissioning-solar-panels>
<https://insideclimatenews.org/news/25012024/inside-clean-energy-decommissioning-solar-plants/>
<https://www.futurelearn.com/info/courses/the-role-of-hydrogen-in-the-clean-energy-transition/0/steps/371394>
<https://www.legal500.com/developments/thought-leadership/financing-renewable-energy-projects-and-acquisitions-key-considerations-for-investors-and-lenders/>
<https://www.unam.edu.na/nghri>

Table 44: Recommended New/ Enhanced Qualifications for GH2 – Vocational and Higher Education

Recommended New/ Enhanced Qualifications for GH2 – Vocational and Higher Education			
Recommended Qualification/ Specialization Title ⁴³⁵	Key Competencies/Skills to be Developed	Primary GH2 Value Chain Stage Addressed	Link to Identified Gap
Electrolyser Operations & Maintenance Technician	Electrolyser tech (PEM, Alkaline), process control, water quality management, maintenance, troubleshooting, safety	GH2 production	Addresses finding need for electrolysis technicians
Hydrogen Systems Installation & Commissioning Technician	Installation & commissioning of H2 production, storage, distribution components; safety systems	GH2 production, storage, distribution	Fills gap for specialised H2 system installers beyond general trades
GH2 Plant Safety Technician/Officer	H2-specific hazards, risk assessment, safety protocols (NFPA 2, ATEX), emergency response, gas detection	GH2 production, storage, distribution, end-use	Critical need for specialised H2 safety expertise
Water Treatment Technician for Electrolysis	Industrial water purification (RO, DI), water quality monitoring, maintenance of treatment plants	GH2 production (feedstock)	Ensures high-purity water for electrolyzers
RE (Solar/Wind) Technician with GH2 Interface	RE system O&M, specifics of powering electrolyzers, grid stability for GH2 plants	RE generation for H2	Adapts existing RE skills for GH2 context
Pipefitter/Welder with H2 Systems Specialisation	H2-suitable materials, high-pressure welding, H2 embrittlement mitigation, NDT	GH2 storage, distribution	Specialised skills beyond general welding for H2 integrity
Instrumentation & Control Technician for GH2 Processes	Calibration, maintenance, troubleshooting of sensors, control systems (PLC/SCADA) for H2 plants	GH2 production, storage, distribution	Addresses need for specialised I&C skills in automated H2 facilities
B.Eng. Chemical Eng. with GH2 Processes Specialisation	Electrolysis, ammonia/synfuel synthesis, reactor design, PtX process optimization	GH2 production, end-use (derivatives)	Deepens chemical engineering for core GH2 processes
B.Eng. Electrical Eng. with RE Systems & GH2 Integration Specialisation	Large-scale RE for H2, power electronics for electrolyzers, grid stability, H2 microgrids	RE generation, GH2 production	Focuses electrical engineering on RE-H2 nexus
B.Eng. Mechanical Eng. with H2 Systems & Storage Specialisation	High-pressure H2 systems, cryogenics (LH2), H2 compression, pipeline design, fuel cells	GH2 storage, distribution, end-Use (mobility, power)	Addresses mechanical aspects of H2 handling and use
B.Sc. Materials Science/ Eng. with H2 Technologies Focus	Materials for electrolyzers, fuel cells, H2 storage; H2 embrittlement studies	Component manufacturing, R&D	Critical for local component development and durability
M.Sc./M.Eng. in Green Hydrogen Technologies	Full GH2 value chain, advanced tech, policy, economics, safety engineering	Entire GH2 value chain	Comprehensive high-level expertise for leadership roles
M.Sc. in Process Safety Engineering for H2 Facilities	Advanced hazard ID, QRA, SIS design, emergency preparedness for H2	GH2 production, storage, distribution, end-use	Addresses critical need for high-level safety engineering
PhD Research in GH2 areas (aligned with NGHRI/NEI)	Specialised knowledge in advanced electrolyzers, H2 storage, safety, socio-economics	R&D, policy	Drives innovation and local knowledge creation

Footnotes

⁴³⁵ <https://restservice.epri.com/publicdownload/000000003002031505/0/Product>
<https://www.libertyspecialtymarkets.com/article/green-hydrogen-designing-for-reliability-and-maintainability>
<https://kresogroup.com/job-description-templates/electrolyser-engineer/>
https://cogentskills.com/wp-content/uploads/2025/04/HSA_Hyd_skills_framework_v3.pdf

Table 45: Key Recommended Professional Certifications for the GH2 Sector in Namibia

Key Recommended Professional Certifications for the GH2 Sector in Namibia				
Certification Name/Type ⁴³⁶	Issuing Body (or type)	Target Professionals	Key GH2 Value Chain Relevance	Rationale for Namibia
GWO Basic Safety Training (BST) / Basic Technical Training (BTT)	Global Wind Organisation	Technicians, engineers working on wind farms for H2	RE generation (wind)	Ensures safety standards for wind energy workforce supplying GH2 plants.
Hydrogen Safety Practitioner (emerging/specialized)	Specialised Safety Bodies / City & Guilds / IOSH / NEBOSH (adapted)	Safety officers, engineers, plant operators, technicians	Plant safety, H2 handling & storage	Critical for managing specific H2 hazards; enhances operational safety and compliance.
NABCEP PV Installation Professional (PVIP) / Design Specialist (PVDS) / Commissioning & Maintenance Specialist (PVCMS)	North American Board of Certified Energy Practitioners	Solar PV installers, designers, O&M technicians	RE generation (solar)	Validates competence in solar PV for GH2 feedstock; ensures quality of RE supply.
AEE Certified Renewable Energy Professional (REP™)	Association of Energy Engineers	Energy managers, engineers, consultants	RE generation, project development	Demonstrates expertise in RE project application and assessment.
Certified Pressure Vessel Inspector (e.g., API 510 or equivalent)	Relevant industry bodies (e.g., API)	Inspectors, maintenance engineers/technicians	H2 storage	Ensures integrity and safety of high-pressure H2 storage vessels.
RFNBO Hydrogen/Carrier Certification (compliant with RED III)	Approved voluntary schemes (EU context)	Producers, exporters, logistics personnel	H2 Export (ammonia, methanol)	Essential for accessing EU export markets; demonstrates sustainability.
Project Management Professional (PMP)®	Project Management Institute (PMI)	Project managers, program managers	Project development & execution (entire value chain)	Manages complexity of large GH2 projects; identified as high-demand skill.5
Certified Energy Manager (CEM)®	Association of Energy Engineers	Energy managers, facility managers, consultants	GH2 production, industrial end-use	Optimises energy performance of GH2 plants and related facilities.
Professional Engineer (PE) License	Engineering Council of Namibia	Engineers (chemical, electrical, mechanical, civil etc.)	Design, construction, operation (entire value chain)	Ensures professional accountability and adherence to engineering standards.

Footnotes

⁴³⁶ <https://www.airswift.com/blog/hydrogen-certificates#:~:text=The%20GWO%20Basic%20Safety%20Training,including%20hydrogen%20production%20and%20storage.>
<https://www.airswift.com/blog/hydrogen-certificates>
<https://maersktraining.com/industries/renewables-industry/career-guides/gwo-training-explained>
<https://newcollegeinstitute.org/workforce-training/gwo-renewable-energy-industry-training-certifications/>
<https://rejobs.org/en/renewable-energy-blog/career-opportunities-in-solar-energy>
<https://www.nabcep.org/certifications/nabcep-board-certifications/>
<https://www.solarenergy.org/nabcep/>
<https://www.aeecenter.org/certified-renewable-energy-professional/>
https://cogentskills.com/wp-content/uploads/2025/04/HSA_Hyd_skills_framework_v3.pdf
<https://h2tools.org/bestpractices/maintenance-and-inspection/maintenance-requirements-for-vessels>
<https://cryospain.com/compressed-hydrogen>
<https://english.rvo.nl/topics/hydrogen/certificate-green-hydrogen>
<https://www.tuvsud.com/en-us/industries/mobility-and-automotive/automotive-and-oem/automotive-testing-solutions/hydrogen-fuel>
<https://www.energydegrees.org/resources/energy-certifications/>

6.4.6 Strategic Recommendations for Bridging the Gaps in the Green Hydrogen Sub-Sector

Realising Namibia's green hydrogen (GH2) ambitions necessitates a robust and agile strategic framework for skills development. This framework must address curriculum design, institutional capacity, stakeholder collaboration, quality assurance, and pathways for continuous learning.

A. Enhance Governance and Coordination	• Streamline Governance and Coordination through the establishment of a high-level National PtX Skills Task Force (such as the National Task Force on Education, Training and Research for Green Hydrogen and its Derivatives) comprising representatives from relevant government ministries (energy, education, labour, finance), industry associations, project developers, academic institutions (UNAM, NUST), and TVET authorities (NTA, NQA). This body would oversee the development, implementation, and monitoring of the national skills strategy, including all research initiatives in the country related to GH2 and its derivatives.
B. Enhance Curricula in Educational and Vocational Institutions	• Modernise VTC Curricula for core trades with GH2-specific modules covering the full lifecycle: safety, materials, equipment for RE, H2 plants, ammonia, fuel cells, turbines, and specific modules on construction techniques, safe decommissioning, dismantling, and material handling for recycling. International standards and best practices, such as those derived from UNIDO's skills mapping methodology or lessons from countries with established hydrogen strategies like Germany or Australia, should inform curriculum content. • Develop Specialised "Hydrogen Plant Construction Supervisor," "Hydrogen Technician," "Fuel Cell Technician," and "Renewable Energy Decommissioning & Recycling Technician" programs. • Strengthen University Programs with Specialisations in GH2 technologies, H2 power generation, materials science (including for recyclability and recovery), circular economy engineering, and construction management for energy projects.
C. Institutional Capacity Building	The capacity of Namibia's educational and vocational institutions needs significant strengthening to deliver the required volume and quality of GH2-related training. This involves: • Targeted Investment in NUST, UNAM (particularly NGHRI), NTA, and key VTCs: This includes upgrading and modernising training equipment and workshop facilities to reflect industry standards, a direct recommendation from the Sectoral Review Study. • Comprehensive Technical "Train the Trainer" programs: Developing a pool of qualified local instructors and assessors is paramount. This may initially involve partnerships with international institutions or experts to transfer knowledge and pedagogical skills related to GH2 technologies and safety. This addresses the need to internalise expertise currently sought from international partners. • Support for NGHRI, NEI and Any Other Entities Involved in Research to expand their research capabilities and their role in postgraduate training and specialised short courses. These institutes are pivotal for developing cutting-edge curricula and training the trainers and advanced specialists who will underpin the skills ecosystem. Their success in R&D and advanced training directly influences Namibia's ability to develop an indigenous and innovative GH2 skills base. • Expanding Access to Training, Particularly in Rural Areas: This could involve establishing decentralised VTC campuses or specialised training wings in regions earmarked for GH2 development, and leveraging blended learning or online platforms to reach a wider audience, as recommended by the Sectoral Review Study.

D. Fostering Collaboration (Tripartite Plus)

A collaborative approach is fundamental to the success of the GH2 skills development strategy. This involves:

- **Strengthening partnerships** between government ministries (MEIYSAC, MIME), industry stakeholders (GH2 project developers, renewable energy companies, technology providers, future off-takers), and academic/VET institutions (NUST, UNAM, NTA, VTCs).
- **Developing National Occupational Standards (NOS) for Green Hydrogen roles** with industry experts and international standards bodies to define clear, competency-based National Occupational Standards for key roles within the green hydrogen storage and transportation value chain. These NOS will serve as benchmarks for curriculum design, training delivery, assessment, and certification, ensuring a consistent quality of skills across the sector.
- **Leveraging and potentially expanding the role of a GH2-specific skills committee** to specifically address the needs of the GH2 sector. A dedicated GH2 Skills Council, or a prominent GH2-focused committee, with strong representation from all key stakeholders, could be crucial for coordinating the diverse range of recommended actions, ensuring alignment, avoiding duplication, and driving the national GH2 skills agenda forward. Such a body would ensure sustained effort beyond initial strategy development. The NGHP is in the process of establishing a national task force on skills, which could very well fit this role.
- **Promoting Public-Private Partnerships (PPPs)** for funding training initiatives, developing industry-relevant curricula, offering apprenticeships and internships, and providing access to specialised equipment and facilities.
- **Engaging Civil Society Organisations and Local Communities** to ensure that skills development initiatives contribute to a just transition, address local employment needs, and foster community buy-in and participation in the GH2 economy.

E. Quality Assurance and Accreditation

Maintaining high standards in training delivery and qualification outcomes is essential for the credibility of the Namibian workforce and the competitiveness of its GH2 industry.

- All new GH2-related qualifications, whether vocational or academic, must be aligned with the National Qualifications Framework (NQF) and formally accredited by the Namibia Qualifications Authority (NQA). This ensures national consistency and recognition.
- Efforts should be made to benchmark key Namibian GH2 qualifications against international standards and seek international recognition or articulation where appropriate. This is particularly important for an export-oriented industry and aligns with Phase 3 of Namibia's skills development strategy, which aims for international standards and certification. This can facilitate labour mobility and enhance the global competitiveness of Namibian professionals.

F. Quality Assurance and Accreditation

The GH2 industry will be dynamic, with evolving technologies and job roles. A framework for lifelong learning is therefore crucial.

- **Development of flexible learning pathways**, including short courses, modular programs, and micro-credentials, to facilitate the upskilling of the existing energy sector workforce and the reskilling of individuals transitioning from other sectors.
- **Establishment of robust Recognition of Prior Learning (RPL) mechanisms** to allow experienced workers to gain formal qualifications based on their existing skills and knowledge, reducing the need for redundant training.
- **Promotion of Continuous Professional Development (CPD)** programs for engineers, technicians, and managers already working in the energy and GH2 sectors to keep them abreast of the latest technological advancements, safety protocols, and regulatory changes.

	• Fostering international collaboration for skills development with countries and institutions that have established expertise in hydrogen technologies, vocational training, and safety standards (e.g., Germany, the Netherlands, Japan, Australia, EU bodies). This can involve faculty exchange programs, joint research initiatives, sharing of best practices in curriculum design, and access to specialised training resources. • Promotion of Work-Based Learning (WBL) and apprenticeships, internships, and structured on-the-job training programs within green hydrogen projects. Work-based learning is critical for developing practical skills and ensuring a smooth transition from education to employment, especially in a nascent sector where practical experience is limited.
G. Attract, Develop, and Retain Skilled Talent	• Promote GH2 career pathways nationally, highlighting opportunities across the entire lifecycle, including roles in engineering, design, construction, innovative recycling, and refurbishment. • Streamline strategic talent acquisition for Highly Specialised Expatriate Skills (e.g., in complex plant design, specialised construction, PGM recovery, complex plant decommissioning) with mandatory knowledge transfer components. • Incentivise Local Skill Retention in all segments of the GH2 value chain.
H. Prioritise Safety Training and Certification Regimes	• Adopt and enforce robust international safety standards for H2 and derivatives for all lifecycle stages, including design safety (HAZOP, LOPA), construction safety, operational safety, decommissioning, and waste handling (e.g., ISO, IEC, NFPA, OSHA, RINA guidelines for decommissioning). • Develop local capacity for accredited safety training (H2 handling, PSM, emergency response, construction safety, safe dismantling, hazardous waste management) and personnel certification. • Mandate Comprehensive Safety Management Systems (PSM-based) and Environmental Management Plans for all GH2 projects, covering design, construction, operations through to decommissioning and site restoration.

The successful implementation of this comprehensive skills strategy will be contingent upon securing sustainable and adequate funding. The Sectoral Review Study identified insufficient funding for skills development generally, including a lack of modern equipment and resources for instructor development, as a key weakness. Given that GH2 technologies are capital-intensive, training equipment and specialised facilities will also be costly. Therefore, exploring blended finance models, potential industry levies (if deemed feasible and equitable), and continued engagement with international development partners for financial and technical support will be essential to translate these strategic skills development goals into tangible outcomes.

6.5 High-Level Consolidated Implementation Plan

The "Namibia Energy Sector Skills Strategy" provides a critical roadmap for aligning human capital development with the nation's transformative economic ambitions. The success of this strategy hinges not on the recommendations themselves, but on a dynamic, well-coordinated, and urgent implementation plan, contextualising it within the latest developments in Namibia's policy, industry, and education ecosystems, while drawing more detailed lessons from international models.

The overarching challenge identified in the report is a systemic mismatch between the foundational skills produced by local institutions and the highly specialised, internationally certified competencies demanded by the advanced energy sectors. This is not a future problem; it is a present-day bottleneck. With TotalEnergies and Shell targeting a Final Investment Decision (FID) on their multi-billion-dollar oil and gas projects around 2026 for first oil production by 2029-2030, and Hyphen's US\$10 billion green hydrogen project moving through development phases, the window to build a competitive local workforce is closing rapidly.

The implementation plan is therefore structured around four critical thematic pillars that cut across all energy sub-sectors:

1. **Governance & Institutional Frameworks:** Creating the leadership and structures to guide the national effort.
2. **Higher Education Enhancement:** Cultivating high-level engineers, scientists, and researchers.
3. **Technical & Vocational (TVET) Capacity Building:** Forging the skilled technicians and artisans who form the operational backbone.

This matrix synthesises the recommendations for the Oil & Gas, Biomass, and Green Hydrogen sub-sectors, grouping them into overarching strategic themes to provide a unified action plan for Namibia's energy sector.

Thematic Area	Specific Recommendation	Relevant Sub-Sector(s)	Process Owners & Role	Proposed Timeline	Complementary Initiatives (Synergies within Namibia)	International Best Practices & Considerations
Governance & Institutional Frameworks	Establish a National Oil and Gas Institute	Oil & Gas	Lead: Ministry of Mines and Energy (MME), NAMCOR. Partners: Petrofund, NIPDB, Industry Operators, NUST, UNAM. Role: Create a central hub for specialised O&G training, certification, and research	Short-term (1-2 Years): Finalise feasibility and governance. Medium-term (2-4 Years): Launch initial programs.	The MME has already proposed this institute. It will centralize the efforts of Petrofund scholarships and NAMCOR's partnerships	Norway Model: Establish a centre of excellence with strong industry governance and funding, ensuring training is directly aligned with the needs of operators in the Orange Basin.
	Establish a National PtX Skills Task Force	Green Hydrogen	Lead: NGH2P. Members: MME, Ministry of Education, NTA, NQA, NUST, UNAM, Industry. Role: Provide high-level coordination for the national GH₂ skills strategy	Short-term (Immediate - 1 Year): Formal establishment and action planning. Ongoing: Monitor and adapt strategy.	The Namibia Green Hydrogen Programme (NGHP) is already establishing this task force. The STED methodology provides an analytical foundation	Australian Model: A national task force coordinates actions across government, industry, and research to build a coherent "hydrogen-ready" workforce.
	Establish a National Biomass Skills Development Task Force	Biomass	Lead: N-BiG. Members: MME, MEFT, Ministry of Education, NTA, NQA, NUST, UNAM, NamPower. Role: Guide biomass skills forecasting, curriculum review, and quality assurance	Short-term (1-2 Years): Formal establishment and development of a charter. Ongoing: Provide continuous guidance to align training with industry needs	This formalises existing collaborations between N-BiG, NTA, and educational institutions, creating a single point of coordination.	Cluster Model: Create an industry-led skills council that brings all public and private stakeholders together to ensure training is demand-driven and responsive to technological changes in the bio-economy.
	Mandate & Enforce Skills Transfer Mechanisms	Oil & Gas	Lead: Ministry of Home Affairs, Ministry of Labour. Partners: MME, Industry Operators. Role: Implement clear, enforceable policies requiring structured skills transfer plans from expatriates to Namibians as a condition for work permits	Short-term (1-2 Years): Policy formulation and gazettement. Ongoing: Implementation and monitoring.	This formalises and scales existing operator initiatives focused on training Namibians abroad and nationalization plans.	Levy-Grant System: Implement a model where companies contribute to a national training fund (like Petrofund) but can claim back funds by demonstrating certified training and skills transfer to local staff, incentivising genuine development.

Thematic Area	Specific Recommendation	Relevant Sub-Sector(s)	Process Owners & Role	Proposed Timeline	Complementary Initiatives (Synergies within Namibia)	International Best Practices & Considerations
Higher Education Enhancement	Enhance University Programs for Oil & Gas	Oil & Gas	Lead: NUST, UNAM. Partners: NCHE, Petrofund. Role: Develop specialized undergraduate and postgraduate programs in Petroleum Engineering, Geophysics, and Subsea Engineering to fill a complete absence of such degrees.	Short-term (1-2 Years): Develop specialized modules. Medium-term (3-5 Years): Launch full degree programs.	Builds on existing support to UNAM's Geology Dept by Petrofund and NUST's plans to introduce optional O&G programs.	Center of Excellence Model: Government and industry co-fund specialized postgraduate programs at existing universities, attracting international academics to seed local faculty development.
	Introduce GH ₂ University Specialisations	Green Hydrogen	Lead: NUST, UNAM. Partners: NGHRI. Role: Launch specialized streams or dedicated degrees in Green Hydrogen Technologies, focusing on process engineering, materials science, and renewable energy systems integration.	Short-term (1-2 Years): Introduce GH ₂ -focused elective modules. Medium-term (3-5 Years): Launch MSc programs and specialization streams.	The Y4GH2 Scholarship Programme and the establishment of NGHRI at UNAM create both the demand for and the institutional foundation to support these new specializations.	UK Model (Centres for Doctoral Training): Establish government-industry funded centers to support clusters of PhD and Master's students working on specific GH ₂ challenges, building high-level expertise.
	Strengthen University Curricula for Biomass	Biomass	Lead: NUST, UNAM. Partners: N-BiG, NCHE. Role: Enhance engineering and agriculture programs with in-depth modules on advanced biomass conversion technologies, biorefining, and circular economy principles	Short-term (1-2 Years): Review curricula and develop new elective modules. Medium-term (2-4 Years): Integrate new modules.	NUST's ButoVal research project and UNAM's existing programs in Rangeland Management and bioenergy modules provide a strong basis for curriculum enhancement	Finnish Model (Bioeconomy): Foster inter-faculty programs combining engineering, natural sciences, and business economics to cultivate graduates who understand the entire bio-economy value chain.
	Foster Industry-Academia Research & Development	Biomass, GH ₂	Lead: NUST, UNAM, PRI. Partners: N-BiG, Industry. Role: Strengthen applied R&D collaborations to adapt technology, develop new value-added products, and feed innovations back into curriculum development	Ongoing: A continuous process of building trust and joint projects.	This recommendation seeks to scale successful models like NUST's ButoVal project and the research being conducted at NGHRI.	Wageningen Model (Netherlands): Create "Innovation Clusters" that co-locate researchers, students, and industry R&D departments to accelerate the cycle of innovation from lab-scale research to commercial application.

Thematic Area	Specific Recommendation	Relevant Sub-Sector(s)	Process Owners & Role	Proposed Timeline	Complementary Initiatives (Synergies within Namibia)	International Best Practices & Considerations
Technical & Vocational (TVET) Capacity Building	Upgrade TVET Capacity for O&G	Oil & Gas	Lead: NTA. Implementers: NIMT, VTCs. Partners: Petrofund. Role: Invest in industry-standard simulators and equipment and align curricula with international standards (e.g., OPITO, API) to produce certified technicians	Short-term (1-2 Years): Curricula alignment. Medium-term (2-5 Years): Phased investment in equipment.	Petrofund is already targeting TVET programs at NIMT, creating a direct synergy for focused investment.	International Accreditation: Partner with an established international training body (e.g., OPITO) to fast-track curriculum development, quality assurance, and instructor training, ensuring graduates meet global standards.
	Formalize & Scale Biomass TVET Qualifications	Biomass	Lead: N-BiG, NTA. Implementers: VTCs. Role: Prioritise the registration and national rollout of the N-BiG-developed National Vocational Certificates in Bush Control, Biomass Utilisation, and SME Management	Short-term (1-2 Years): Finalise NTA registration and launch pilot programs. Medium-term (2-4 Years): National rollout.	These qualifications are already developed by industry (N-BiG), ensuring relevance and addressing a key gap in formalized training.	German Model (Dual VET System): Integrate these new qualifications into an apprenticeship model where trainees spend significant time in industry, ensuring practical skills are developed alongside theoretical knowledge.
	Develop Specialised TVET Programs for Biomass & GH₂	Biomass, GH ₂	Lead: NTA. Partners: N-BiG, NamPower, GH ₂ Project Developers. Role: Create new qualifications for "Biomass Power Plant Technician," "Biochar Production Technician," "Hydrogen Technician," and "GH ₂ Plant Safety Officer"	Short-term (1-2 Years): Needs analysis and curriculum design. Medium-term (3-5 Years): Launch and accredit new programs.	Demand is being created by projects like the Otjikoto Biomass Power Station and the Hyphen GH ₂ project. NIT's existing Renewable Energy diplomas offer a foundational platform.	Modular VET Programs: Develop a core curriculum in industrial safety and operations, supplemented by specialised modules (e.g., electrolysis, combustion, cryogenics), allowing for a more flexible and adaptable technical workforce.
	Build Institutional Trainer & Equipment Capacity	All Sectors	Lead: Ministry of Education, NTA. Partners: NUST, UNAM, VTCs, International Partners. Role: Invest in upgrading training equipment and facilities and implement comprehensive "Train-the-Trainer" programs to build a sustainable local instructor base.	Short-term (1-2 Years): Launch "Train-the-Trainer" programs. Medium-term (2-5 Years): Phased investment in equipment.	The Green Hydrogen Skills Study Tour to the Netherlands is a key example of international collaboration that must be scaled to build lasting local training capacity.	Demand-Led Investment: Utilise Sector Skills Committees to get direct industry input on equipment needs, ensuring that capital investment in education is effective and aligned with technology used in the field.

6.5.1 The Critical Need for Data

Whereas this report encapsulates a lot of important information, the report also notes a significant lack of readily available and credible data, particularly from a labour dynamics point. The report hints at this challenge, particularly in the annexures where skills quantification tables for the biomass and green hydrogen sectors are left blank. An effective skills strategy is impossible without a clear, evidence-based understanding of the current and future labour market.

Addressing this data deficit is not just a preliminary step; it must be a core, ongoing function of the national energy strategy. Here are specific recommendations for Namibia to build a robust data and intelligence ecosystem for its energy sector.

A. Establish a Centralised National Energy Sector Labour Market Observatory (NES-LMO)

The most critical step is to create a single, authoritative body responsible for gathering, analysing, and disseminating energy sector data. A fragmented approach will only perpetuate data silos and inconsistencies.

- **Mandate and Ownership:** This should be a formal, government-mandated entity, ideally established as a public-private partnership. A potential structure could be a joint initiative led by the Namibia Statistics Agency (NSA) (for methodological rigour and legal authority to survey), the Ministry of Justice and Labour Relations (for labour market expertise), and the NIPDB (for industry and investment linkage).
- **Core Functions:**
 - **Data Collection & Aggregation:** Implement standardised surveys and integrate data from various sources.
 - **Analysis & Forecasting:** Employ labour economists and data analysts to model skills gaps, forecast demand based on project pipelines, and track wage trends.
 - **Dissemination:** Produce an annual "State of Energy Skills in Namibia" report, maintain a public-facing data dashboard for high-level indicators, and provide detailed datasets to policymakers, educational institutions, and researchers.
- **International Model (Canada):** Canada's PetroLMI (Petroleum Labour Market Information) division of Energy Safety Canada is an excellent model. It is industry-funded and provides detailed labour market data, forecasts, and occupational profiles specifically for the energy sector, which helps both companies and training providers make informed decisions. Namibia could create a similar dedicated entity under the Observatory.

B. Implement Dynamic and Mandatory Data Collection Mechanisms

The Observatory cannot function without reliable data streams. This requires moving beyond one-off studies to a system of continuous data collection.

- **Annual Energy Sector Skills Survey:**
 - What it is- A mandatory annual survey for all registered companies in the energy sector (operators, major contractors, etc.) above a certain size threshold.
- **What it collects:**
 - **Current Workforce:** Number of employees by occupation, skill level, qualification, and demographic (gender, age, region).
 - **Skills Gaps:** Current hard-to-fill vacancies and the specific skills lacking.
 - **Future Demand:** A 2- and 5-year forecast of hiring needs by occupation.
 - **Training:** Data on in-house training programs and expenditure.
 - **Compensation:** Anonymised wage and salary data to benchmark compensation.
- The existing skills quantification for the Oil & Gas sector in the report's annexures provides an excellent template for the types of roles to survey. The blank tables for Biomass and GH₂ highlight precisely where this new survey needs to focus.
- **Integrate with National Surveys:** The NSA should incorporate a specific "Energy Sector" module into its regular Labour Force Surveys. This would capture data from smaller enterprises and provide a nationally consistent baseline.
- **Leverage Administrative Data:** The Observatory must have formal data-sharing agreements to access and analyse anonymised data from:
 - **Ministry of Home Affairs:** Data on work permits issued to expatriates, providing a real-time indicator of which specific, high-level skills are being imported.
 - **Namibia Training Authority (NTA):** Data on enrolments and graduates from all VTCs by trade.
 - **Higher Education Institutions:** Graduate tracer studies from higher education institutions to track the employment outcomes of engineering and science graduates.

C. Foster a Collaborative Data-Sharing Ecosystem

Industry stakeholders often guard data for competitive reasons. Overcoming this requires building trust and demonstrating a clear value proposition.

- **Establish a "Data Sharing Compact":** The PtX Skills Task Force, along with industry bodies like the Namibia Petroleum Operators Association (NAMPOA) and the Namibia Biomass Industry Group (N-BiG), should champion a formal compact. This agreement would outline the terms of data submission, with strong guarantees of confidentiality and data anonymisation.
- **Show the Value Proposition:** The value for the industry is significant. In return for contributing data, companies gain access to:
 - **Reliable Salary Benchmarks:** Helping them design competitive compensation packages.
 - **Skills Supply Insights:** Understanding the pipeline of graduates from VTCs and universities, enabling better recruitment planning.
 - **Aggregate Labour Market Forecasts:** Allowing them to anticipate future skills shortages or surpluses and adjust their own training and recruitment strategies accordingly.
- **International Model (UK Energy Skills Alliance):** The UK's Energy Skills Alliance is a partnership between industry, government, and trade unions that works to identify and address skills issues. A key function is collaborative workforce planning, which is only possible through a culture of shared intelligence.

D. Utilise Policy Levers to Ensure Compliance

While collaboration is preferred, policy and regulatory levers can ensure comprehensive data collection.

- **Make Data Submission a Condition of Operation:** Make participation in the Annual Energy Sector Skills Survey a mandatory requirement for:
 - Maintaining licenses to operate (e.g., for major project developers).
 - Qualifying for government incentives or contracts.
 - Being listed as a registered supplier for national content purposes.
 - **Data-Informed Work Permits:** The Ministry of Home Affairs and Security should use the Observatory's data as a primary reference when adjudicating work permit applications for expatriates. A company applying for a permit should be required to demonstrate, with reference to the Observatory's data, that a specific skill set is genuinely unavailable in the Namibian labour market. This creates a direct, data-driven link between the skills development strategy and immigration policy
-

07

Energy Sector Skills Strategy - Namibia

ANNEXURES

7. ANNEXURES

Annexure 1: Examples of Oil & Gas Demand-Industry Skills Quantification

Oil & Gas Exploration and Appraisal- Quantification of skills ⁴³⁷			
Function/Role	No of individuals required	Function/Role	No of individuals required
Occupation/ Skill area		Based onshore Namibia during well preparations, drilling and post campaign	
General Manager	1	Drilling Manager	1
Deputy General Manager	1	Senior Drilling Engineer	1
Finance Manager	1	Drilling Engineer	2
Cost Control Senior	1	Fluids Superintendent	2
Cost Control Junior	1	Drilling Superintendent	2
Accountant Senior	1	DST Engineer	2
Accountant Junior	1	Subsurface Manager	1
Admin Manager	1	Subsurface Ops Manager	1
Commercial Manager	1	Maritime Superintendent	1
JV Coordinator	1	Aeronautic Superintendent	1
Logistics Manager	1	ROV Specialist	3
Operations Manager	1	Contract Engineer	1
Contract & Procurement Manager	1	Surveys Superintendent	1
Procurement Engineer	1		
Human Resources Manager	1	Based offshore Namibia during drilling	
HSE Manager	1	Day Drilling Supervisor	1
Safety Officer	2	Night Drilling Supervisor	1
Environmental Officer	1	HSE Supervisor	1
IT Engineer	1	Night Well Site Geologist	1
Supply Base Superintendent	1	Day Wellsite Geologist	1
Legal Support	1	Drilling Engineer	1
		Fluids Supervisor	1
		DST Supervisor	1

Footnotes

⁴³⁷ Sourced from NAMPOA

Annexure 2: Examples of Oil & Gas Engineering, Construction and Production-Quantification of skills⁴³⁸

- Starting construction indicates post-Financial Investment Decisions and assumes that the engineering and construction phase will take five years.
- First oil denotes the start of production
- Information sourced from NAMPOA, specific to Namibia's envisioned needs
- The green-highlighted section indicates the total number of individuals needed for a project, per annum. After year six, the numbers are expected to remain the same until the Cessation of Production (CoP).

			Start Construction 1	2	3	4	5	First Oil 6	7	8
BY JOB TITLE	Domain	Skill level	1,242	1,506	2,105	1,785	1,170	1,162	1,162	1,162
2nd Officer	Vessel crew	Semi-skilled	10	12	16	14	10	10	10	10
Able seaman	Vessel crew	Low skilled	104	132	160	104	76	76	76	76
Architect	Construction	Skilled	0	0	0	0	0	0	0	0
Assistant driller	Drilling	Low skilled	16	16	16	0	0	0	0	0
Bosun	Vessel crew	Low skilled	20	32	40	28	20	20	20	20
Building / Structural control engineer	Construction	Skilled	0	0	0	0	0	0	0	0
Cargo care coordinator	Logistics	Skilled	6	6	6	6	6	6	6	6
Carpenter	Construction	Semi-skilled	0	0	0	0	0	0	0	0
CCR Operator	Operations	Semi-skilled	0	6	6	2	2	2	2	2
Cement engineer	Construction	Skilled	8	8	8	0	0	0	0	0
Cementing technician	Construction	Semi-skilled	16	16	16	0	0	0	0	0
Chief Officer	Vessel crew	Semi-skilled	16	22	26	20	16	16	16	16
Civil control engineer	Construction	Skilled	0	0	0	0	0	0	0	0
Coiled tubing engineer	Drilling	Skilled	0	0	0	2	2	2	2	2
Coiled tubing technician	Drilling	Semi-skilled	0	0	0	4	4	4	4	4
Commissioning engineer	Operations	Skilled	6	2	14	12	0	0	0	0
Commissioning technician	Operations	Semi-skilled	0	0	36	36	0	0	0	0
Company man	Drilling	Skilled	8	10	14	8	4	4	4	4
Completion engineer	Drilling	Skilled	13	13	13	3	3	3	3	3
Construction manager	Construction	Skilled	0	0	0	0	0	0	0	0
Control engineer	Quality	Skilled	0	0	4	9	5	5	5	5
Control room operator	Operations	Skilled	0	0	0	12	12	12	12	12
Cook	Catering & facility management	Semi-skilled	56	62	74	60	48	48	48	48
Coring & cutting technician	Drilling	Semi-skilled	16	16	16	0	0	0	0	0

Footnotes

⁴³⁷ Sourced from NAMPOA

			Start Construction 1	2	3	4	5	First Oil 6	7	9
BY JOB TITLE	Domain	Skill level	1,242	1,506	2,105	1,785	1,170	1,162	1,162	1,162
Crane operator	Transportation	Semi-skilled	25	35	43	31	23	23	23	23
Deck Cadet	Vessel crew	Low skilled	28	40	48	28	20	20	20	20
Derrickman	Drilling	Unskilled	8	8	8	0	0	0	0	0
Dive supervisor	Diving	Low skilled	0	2	2	0	0	0	0	0
Dive technician	Diving	Semi-skilled	0	4	4	0	0	0	0	0
Divers	Diving	Low skilled	0	12	12	0	0	0	0	0
Document controller	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Drill Stem Service coordinator	Drilling	Skilled	8	8	8	0	0	0	0	0
Driller	Drilling	Low skilled	8	8	8	0	0	0	0	0
Drilling engineer	Drilling	Skilled	4	4	4	5	3	3	3	3
Drilling fluids supervisor	Drilling	Skilled	8	8	8	0	0	0	0	0
Drilling waste engineer	Drilling	Skilled	8	8	8	0	0	0	0	0
Drilling/ Completion equipment superintendent	Drilling	Skilled	1	1	1	1	1	1	1	1
Drilling/ Completion manager	Drilling	Skilled	1	1	1	0	0	0	0	0
Electrical control engineer	Electrical	Skilled	0	0	12	14	2	2	2	2
Electrical engineer	Electrical	Skilled	8	10	22	16	4	4	4	4
Electrician	Electrical	Semi-skilled	0	0	36	42	6	6	6	6
Electrician foreman	Electrical	Semi-skilled	0	0	12	14	2	2	2	2
Engine Cadet	Vessel crew	Low skilled	28	40	48	28	20	20	20	20
Engineering superintendent	Operations	Skilled	1	1	1	1	1	1	1	1
Equipment control engineer	Quality	Skilled	0	2	6	8	4	4	4	4
Field Asset Manager	Operations	Skilled	1	1	1	2	2	2	2	2
Fluid engineer	Mechanical	Skilled	8	8	16	11	3	3	3	3
Foremen (construction)	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Forklift driver	Transportation	Low skilled	13	13	13	15	15	15	15	15
Freight forwarder	Logistics	Low skilled	13	13	13	13	13	13	13	13
General foreman	Construction	Semi-skilled	0	0	0	2	2	2	2	2
General warehouse operative	Logistics	Unskilled	30	30	30	33	33	33	33	33
Geologist	Geotechnical	Skilled	6	6	6	19	17	17	17	17
Geophysicist	Geotechnical	Skilled	2	0	0	0	0	0	0	0
Geoscience data management	Geotechnical	Skilled	2	2	2	36	36	36	36	36
Geoscience director	Geotechnical	Skilled	1	1	1	1	1	1	1	1
Geotechnical engineer	Geotechnical	Skilled	4	4	4	4	2	2	2	2
Gypsum foreman	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Gypsum technicians	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Helper	Operations	Unskilled	68	84	144	120	60	60	60	60
Catering supervisor	Catering & facility management	Semi-skilled	10	16	20	14	10	10	10	10
HSE specialist	HSE	Semi-skilled	8	10	16	12	6	6	6	6

			Start Construction 1	2	3	4	5	First Oil 6	7	9
BY JOB TITLE	Domain	Skill level	1,242	1,506	2,105	1,785	1,170	1,162	1,162	1,162
Inspection methods engineer	Quality	Skilled	8	8	8	4	4	4	4	4
Inspector	Quality	Skilled	0	0	8	11	3	3	3	3
Instrumentation engineer	Instrumentation	Skilled	0	2	4	2	0	0	0	0
Instrumentation foreman	Instrumentation	Semi-skilled	0	2	4	2	0	0	0	0
Instrumentation technician	Instrumentation	Semi-skilled	0	10	18	8	0	0	0	0
Instrumentation technician	Instrumentation	Semi-skilled	0	10	18	8	0	0	0	0
Insulation engineer	Construction	Skilled	0	0	0	0	0	0	0	0
Insulation technician	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Lab technician	Drilling	Semi-skilled	16	16	28	25	13	13	13	13
Labourer	Construction	Unskilled	0	0	0	0	0	0	0	0
Safety worker	HSE	Low skilled	0	0	0	0	0	0	0	0
Logistics manager	Logistics	Skilled	6	6	6	7	7	7	7	7
Maintenance superintendent	Maintenance	Skilled	0	0	1	1	1	1	1	1
Maintenance supervisor	Maintenance	Semi-skilled	0	4	4	5	5	5	5	5
Maintenance technician	Maintenance	Semi-skilled	17	21	21	54	54	54	54	54
Mechanical engineer	Mechanical	Skilled	16	18	30	26	14	10	10	10
Mechanical technician	Mechanical	Semi-skilled	24	32	50	40	22	22	22	22
Mechanician foreman	Mechanical	Semi-skilled	0	0	12	14	2	2	2	2
Medic	Medical	Semi-skilled	14	16	24	21	13	13	13	13
Mud engineer	Drilling	Skilled	8	8	8	0	0	0	0	0
Mud logging engineer	Drilling	Skilled	8	8	8	14	14	14	14	14
O&G electrical foreman	Electrical	Semi-skilled	8	10	10	2	2	2	2	2
O&G electrical technician	Electrical	Semi-skilled	24	32	32	16	16	16	16	16
O&G mechanical foreman	Mechanical	Semi-skilled	8	10	10	4	4	4	4	4
O&G mechanical technician	Mechanical	Semi-skilled	0	0	18	18	0	0	0	0
Office boy	Construction	Unskilled	0	0	0	0	0	0	0	0
Operations manager	Operations	Skilled	7	7	7	17	17	17	17	17
Operations manager	Operations	Skilled	7	7	7	17	17	17	17	17
Painter	Painting	Low skilled	0	0	0	0	0	0	0	0
Passenger's vehicle driver	Transportation	Low skilled	0	0	0	0	0	0	0	0
Petrophysicist	Operations	Skilled	7	7	7	7	4	4	4	4
Piping control engineer	Piping	Skilled	0	2	14	14	2	2	2	2
Piping control engineer	Piping	Skilled	0	2	14	14	2	2	2	2
Piping foreman	Piping	Semi-skilled	0	2	14	14	2	2	2	2
Piping technician	Piping	Semi-skilled	0	8	44	42	6	6	6	6
Planner	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Plasterer/Mason	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Port agent	Logistics	Low skilled	15	15	15	15	15	15	15	15
Port and harbour engineer	Logistics	Skilled	6	6	6	6	6	6	6	6

			Start Construction 1	2	3	4	5	First Oil 6	7	9
BY JOB TITLE	Domain	Skill level	1,242	1,506	2,105	1,785	1,170	1,162	1,162	1,162
Port drayage dispatcher	Logistics	Low skilled	15	15	15	15	15	15	15	15
Port operations logistic specialist	Logistics	Skilled	6	6	6	6	6	6	6	6
Port operations logistics coordinator	Logistics	Semi-skilled	13	13	13	13	13	13	13	13
Process engineer	Operations	Skilled	8	8	16	18	10	6	6	6
Production chemist	Operations	Skilled	0	0	0	2	2	2	2	2
Production technician	Operations	Semi-skilled	0	0	0	13	13	13	13	13
Production technologist	Operations	Skilled	4	4	4	4	3	3	3	3
Project engineer	Construction	Skilled	0	0	0	4	4	4	4	4
Project manager	Construction	Skilled	0	0	0	6	6	6	6	6
QA/QC manager	Quality	Skilled	0	0	0	2	2	2	2	2
QA/QC engineer	Quality	Skilled	0	0	8	11	3	3	3	3
QA/QC technician	Quality	Semi-skilled	0	0	0	1	1	1	1	1
QS engineer	Quality	Skilled	0	0	0	0	0	0	0	0
Radio operator	Operations	Low skilled	10	16	20	14	10	10	10	10
Reservoir engineer	Operations	Skilled	8	8	8	8	2	2	2	2
Roughneck	Operations	Unskilled	64	64	64	0	0	0	0	0
Roustabout	Operations	Unskilled	80	80	80	0	0	0	0	0
ROV electrical technician	Electrical	Semi-skilled	0	2	2	0	0	0	0	0
ROV mechanical technician	Mechanical	Semi-skilled	0	2	2	0	0	0	0	0
ROV pilot technician	Maintenance	Semi-skilled	0	2	2	0	0	0	0	0
ROV supervisor	Operations	Skilled	0	2	2	0	0	0	0	0
Safety manager	Security	Skilled	4	4	4	4	4	4	4	4
Sample catcher	Drilling	Unskilled	8	8	12	6	2	2	2	2
Scaffolder	Construction	Low skilled	0	0	0	20	20	20	20	20
Security officer	Security	Skilled	0	0	0	0	0	0	0	0
Security personnel	Security	Unskilled	0	0	16	16	0	0	0	0
Seismic specialist	Seismic	Skilled	0	0	0	0	0	0	0	0
Service personnel	Catering & facility management	Unskilled	76	98	126	96	68	68	68	68
Slickline engineer	Operations	Skilled	0	0	0	2	2	2	2	2
Slickline technician	Operations	Semi-skilled	0	0	0	5	5	5	5	5
Snubbing engineer	Operations	Skilled	8	8	8	0	0	0	0	0
Steward	Vessel crew	Low skilled	34	46	54	34	26	26	26	26
Store keeper	Construction	Low skilled	0	0	0	4	4	4	4	4
Subsea engineer	Operations	Skilled	4	4	12	18	8	8	8	8
Subsea technician	Operations	Semi-skilled	0	0	24	32	8	8	8	8
Subsurface manager	Operations	Skilled	1	1	1	1	1	1	1	1
Surveyor	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Surveyor engineer	Construction	Skilled	0	2	2	0	0	0	0	0
Tiling Team	Construction	Semi-skilled	0	0	0	0	0	0	0	0

			Start Construction 1	2	3	4	5	First Oil 6	7	9
BY JOB TITLE	Domain	Skill level	1,242	1,506	2,105	1,785	1,170	1,162	1,162	1,162
Tool pusher	Drilling	Skilled	8	8	8	0	0	0	0	0
Transport & lifting engineer	Logistics	Skilled	6	6	6	7	7	7	7	7
Transport/Logistics supervisor	Transportation	Skilled	17	17	17	19	19	19	19	19
Transportation engineer	Transportation	Skilled	0	0	0	0	0	0	0	0
Truck driver	Transportation	Unskilled	0	0	0	3	3	3	3	3
Vendor expert (custom interface)	IT	Skilled	0	0	0	1	1	1	1	1
Piping welder	Welding	Semi-skilled	0	0	0	1	1	1	1	1
Welder / fitter	Construction	Semi-skilled	0	0	0	0	0	0	0	0
Well testing specialist	Drilling	Skilled	8	8	16	17	9	9	9	9
Wellhead/ Xmas tree specialist	Operations	Skilled	8	8	16	16	8	8	8	8
Wireline engineer	Drilling	Skilled	10	10	10	10	10	10	10	10
Wireline technician	Drilling	Semi-skilled	4	4	4	19	19	19	19	19
Workover engineer	Drilling	Skilled	0	0	0	8	8	8	8	8
Workover superintendent	Operations	Skilled	0	0	0	0	1	1	1	1
Civil engineer	Construction	Skilled	0	0	0	0	0	0	0	0
Corrosion inspection engineer	Maintenance	Skilled	0	0	0	2	2	2	2	2
Forklift mechanic	Transportation	Semi-skilled	4	4	4	4	4	4	4	4
Gun technicians	Seismic	Semi-skilled	0	0	0	0	0	0	0	0
Life support technician	HSE	Semi-skilled	0	4	4	0	0	0	0	0
Materials controller	Operations	Semi-skilled	9	9	9	9	9	9	9	9
Navigators	Seismic	Skilled	0	0	0	0	0	0	0	0
Observers	Seismic	Semi-skilled	0	0	0	0	0	0	0	0
Operations engineer	Operations	Skilled	0	0	0	13	13	13	13	13
Operations technician	Operations	Semi-skilled	0	0	0	18	18	18	18	18
Party chief	Seismic	Skilled	0	0	0	0	0	0	0	0
Planner/Scheduler	Operations	Skilled	15	15	15	15	15	15	15	15
Production supervisor	Operations	Skilled	0	0	0	2	2	2	2	2
QA/QC technician	Quality	Semi-skilled	0	0	0	1	1	1	1	1
Transportation manager	Transportation	Skilled	4	4	4	4	4	4	4	4
Business administration technicians	Business administration	Semi-skilled	0	0	0	3	3	3	3	3
Computer and Information Systems manager	IT	Skilled	0	0	0	1	1	1	1	1
Lawyers and Judicial Law Clerks	Legal	Skilled	0	0	0	1	1	1	1	1
Marketing and sales manager	Sales	Skilled	0	0	0	22	22	22	22	22
Sales representatives, Wholesale and manufacturing	Sales	Semi-skilled	0	0	0	3	3	3	3	3
SG&A Clerks and workers	Business administration	Low skilled	0	0	0	3	3	3	3	3

Notes

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Notes

[illegible]

Notes

[illegible]



International
Labour
Organization



NIPDB

Namibia Investment Promotion
& Development Board



www.nipdb.com.na