NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

NEI NAMIBIA ENERGY INSTITUTE

Ministry of Industries, Mines and Energy

HYDROSYNERGY: AN INTEGRATED PTX-WEF NEXUS FRAMEWORK

Prof Samuel John (PhD) & Dr Andréas Elombo (PhD)

2026 Learning Visit on Green Hydrogen Production and Fuel Cell

14–16 July 2026, Seoul and Daejeon, Republic of Korea

Agenda

1. Introduction of Namibia Energy Institute (NEI)
2. Introduction to the WEF Concept
3. The Blueprint - Namibia's Green Hydrogen Industrialisation Strategy
4. The Competitive Advantage - Why Namibia is the Ideal Partner
5. The Opportunities - Partnering to Overcome Challenges

ABOUT THE NAMIBIA ENERGY INSTITUTE

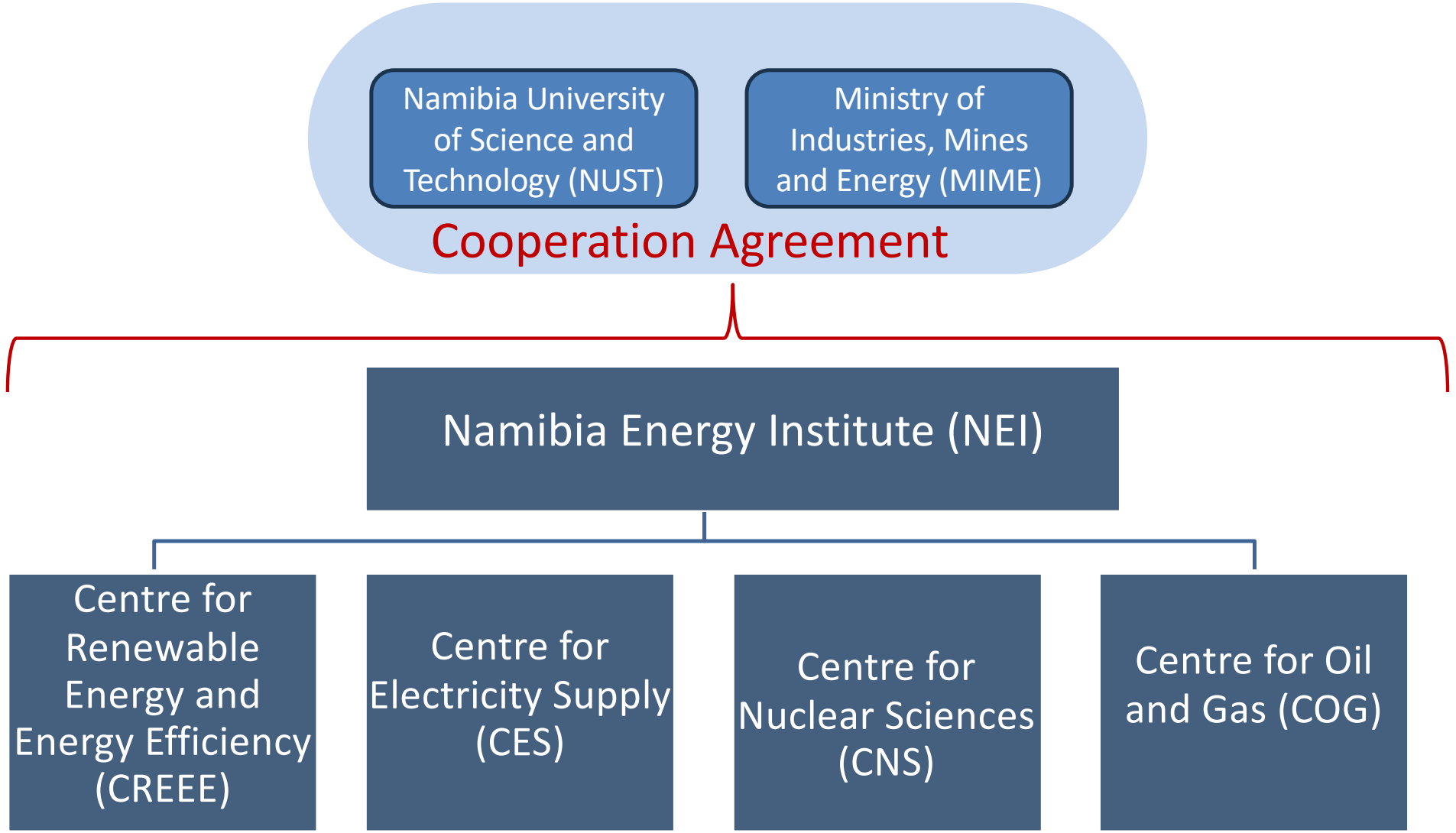
Vision

To be a leading institute for energy research and development in Namibia and beyond.

Mission

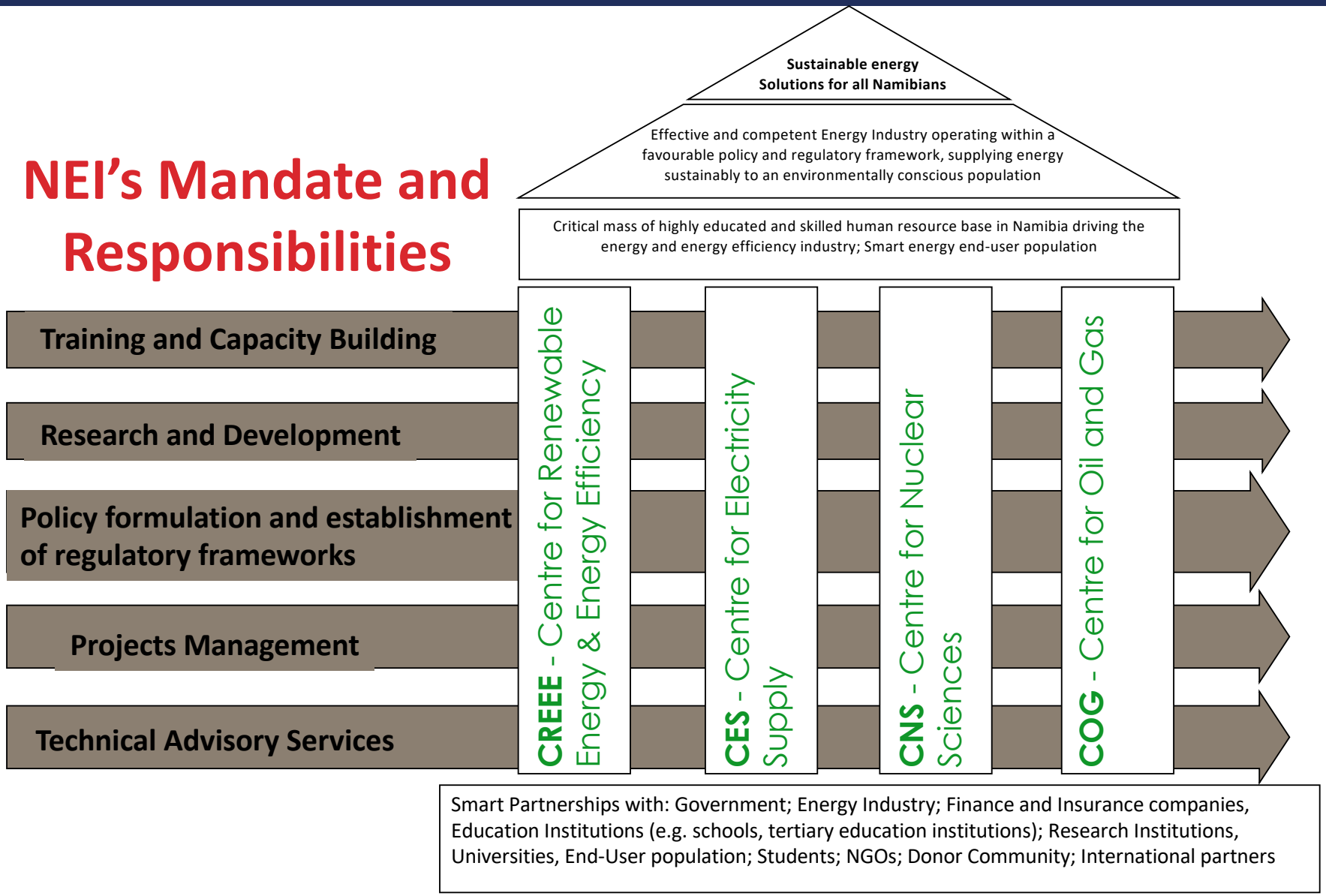
To contribute to Namibia's industrialisation by linking energy research, technology, policy, and education to the needs of industry, and to national socio-economic development imperatives, initiatives and programmes.

NEI STRUCTURE



NEI MANDATE

NEI's Mandate and Responsibilities



NAMIBIA'S ENERGY CONTEXT

59.5%
Electricity Access
(46.9% grid+12.4% solar)

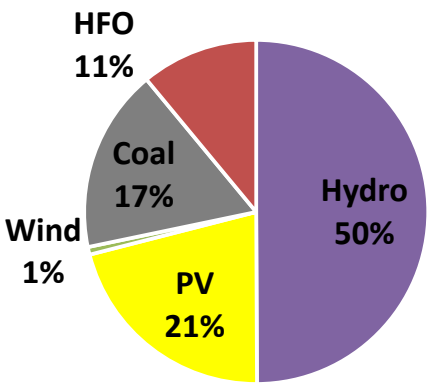
48.5%
Access to Clean cooking

695 MW
Generation Capacity
***563.5** MW NamPower*
***131.5** MW IPPs*
Peak demand projected to rise from 673 MW to 1,243 MW by 2040.

60%
Import Dependency
***45-73%** electricity imports over the past five years*

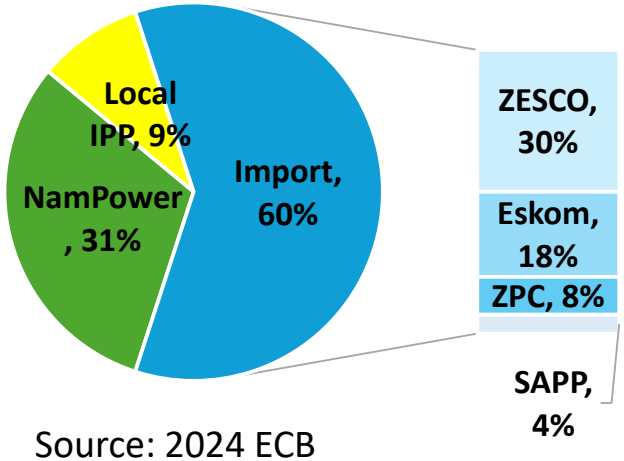
15US¢/kWh
Electricity Tariff
N$2.78/kWh (reviewed annually)
Among highest tariffs in Sub-Saharan Africa due to its cost-reflective tariff structure

Generation Capacity



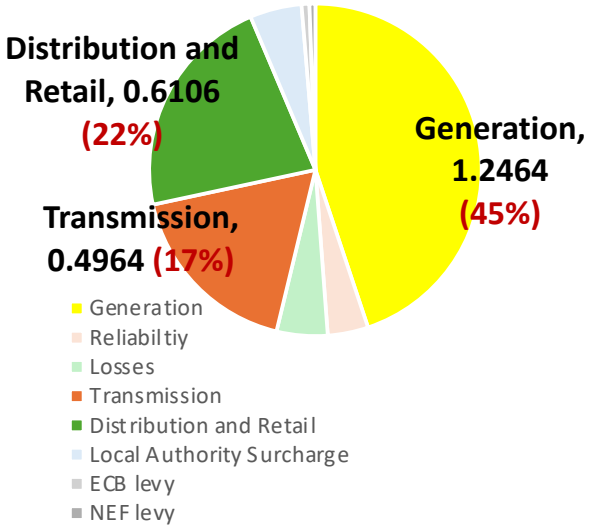
Source: 2024 NamPower Integrated Annual Report

Energy Mix



Source: 2024 ECB annual report

Total End-User Tariff Components



Total End-user tariff: N$2.78 kWh

NAMIBIA CENTRE OF GREEN ENERGY AND INOVATION (N-CEGEI)

The **primary objective** of the N-CEGEI is to accelerate inclusive and sustainable economic transformation by fostering innovation, building green energy skills, empowering entrepreneurs, and advancing industrialisation through integrated academic-industry collaboration and ecosystem development. The initiative is structured around five key pillars (Outputs):

- **Academia-Industry Partnership:** Developing a strong partnership to expand energy and minerals' value chains, drive regional collaboration, and build youth capacity.

- **Outreach and Engagement:** Improving accessibility and promoting the **utilisation** of knowledge among diverse stakeholders.

- **Curriculum Development:** Designing and delivering innovation-focused training **programmes** and capacity-building initiatives through the Centre of Excellence and regional "pods".

- **Innovation Pipeline:** Creating a robust system for ideation, start-ups, and business development to move concepts to market-ready solutions.

- **Private Sector Investment:** Establishing partnerships and securing financing from the private sector

THE GREEN ENERGY LABORATORY AT NEI

Supporting the N-CEGEI

For:

- Technicians
- Artisans
- Engineers
- Students & Professionals

Supported by:

From the People of Japan

HYDROSYNERGY: AN INTEGRATED PTX-WEF NEXUS FRAMEWORK

Transforming PtX from a Water Competitor into a Catalyst for Holistic Resource Security

Introduction- WEF Concept

At its core, the **Water-Energy-Food** (WEF) Nexus highlights that:

- **Water** is needed for energy production (e.g., hydropower, cooling in thermal plants, hydrogen electrolysis) and food production (irrigation, livestock, processing).
- **Energy** is required to pump, treat, and distribute water, and to produce, process, and transport food.
- **Food production** depends on both water and energy, and in turn, affects their demand (e.g., agricultural runoff affects water quality, bioenergy crops compete for land and water).

The **goal** of the WEF Nexus is to promote **resource efficiency**, **sustainability**, and **resilience** by understanding and managing these interlinkages rather than treating each sector in isolation.

Introduction- PtX-WEF Concept

It moves beyond traditional "siloed" management by asking:

How can we achieve water, energy, and food security simultaneously while minimising trade-offs and maximising synergies?

THE PTX DILEMMA: BALANCING GLOBAL DECARBONIZATION WITH LOCAL WATER SCARCITY

Insight: Arid nations face a fundamental conflict between energy exports and water security

THE WATER CONSTRAINT

Electrolysis is water-intensive, requiring **9–10 liters of high-purity water** per kilogram of hydrogen. In arid regions like Namibia, this creates direct competition with municipal and agricultural needs.

THE ENERGY OPPORTUNITY

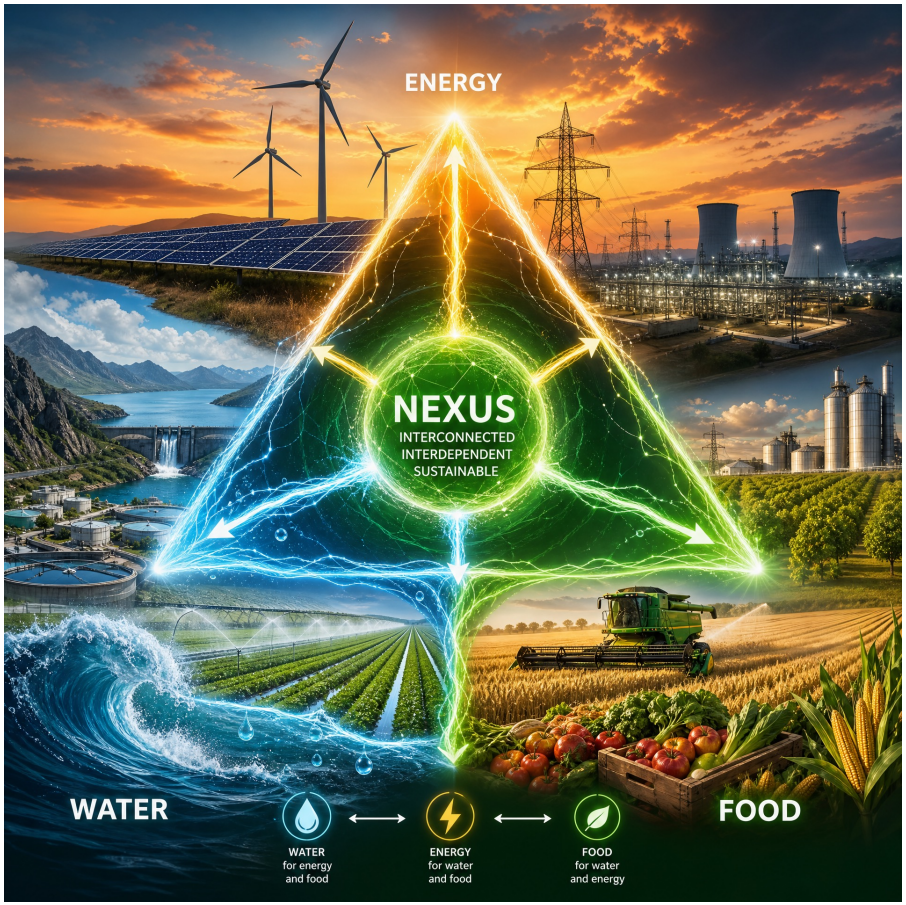
Power-to-X (PtX) converts renewable electricity into **hydrogen, ammonia, and synthetic fuels**. This presents a monumental opportunity for economic diversification and decarbonizing hard-to-abate sectors like shipping and aviation.

THE NEXUS SOLUTION

Resource security requires an **integrated management approach**. Siloed strategies inevitably create trade-offs and inefficiencies, making the Water-Energy-Food (WEF) Nexus essential for sustainable growth.

Classic Water–Energy–Food (WEF) Nexus Concept

- Emphasises interdependence between resource systems:
  - Water for energy and food production.
  - Energy for water treatment and agriculture.
  - Food systems influencing water and energy use.
- Goal: Balance trade-offs and maximise co-benefits for sustainability.



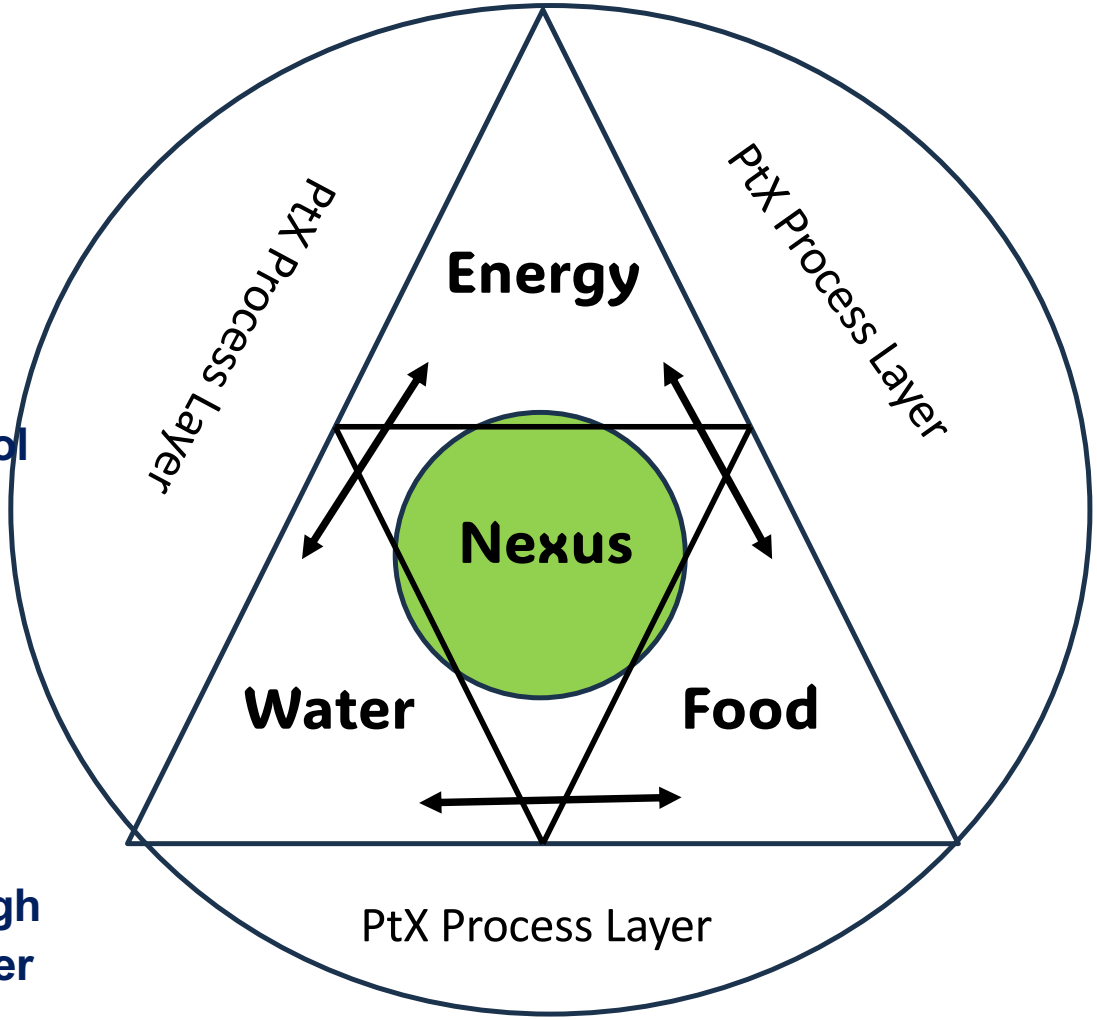
Classic Water–Energy–Food (WEF) Nexus Concept

COMPARATIVE POSITIONING

Framework	Strength	PtX-WEF Extension
Bonn 2011	Governance & Policy	Adds industrial decarbonisation & export modules
FAO WEF	Implementation Cycle	Incorporates industrial stakeholders & monitoring
EU WEFE	Environment & Circularity	Integrates LCA, heat/water reuse across sites
SEI (WEAP)	Quantitative Scenarios	Introduces PtX process blocks & data schemas

Extending the WEF Nexus through Power-to-X

- PtX introduces industrial conversion processes into the resource nexus.
- Hydrogen, ammonia, and methanol link energy to agriculture and exports.
- Water use in electrolysis ties energy to water systems.
- Enables circular feedbacks through oxygen reuse, heat and wastewater recoveries.



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Power-to-X Integrated within the Water-Energy-Food Nexus:
A Paradigm for Circular Sustainability

WEF FRAMEWORK AT THE CORE:
Interdependencies between water, energy, and food

LAYER 1 (RESOURCES):
Renewable energy, desalination, and land inputs

LAYER 2 (PtX CONVERSIONS):
Electrolysis, green hydrogen, ammonia, and e-fuels

LAYER 3 (CIRCULAR FEEDBACK):
O_2 reuse, wastewater recycling, and heat recovery

LAYER 4 (OUTCOMES):
Job creation, security, emission reductions, and resilience

THE HYDROSYNERGY FRAMEWORK: A MULTI-OUTPUT ENGINE

Insight: The PtX plant serves as a central hub in a circular, synergistic resource loop


ELECTROLYSIS
H_2
HYDROGEN
GREEN FUEL
POWER-TO-X
FUEL CELL
H_2
STORAGE
PtX PLANT –
Central Processing Hub

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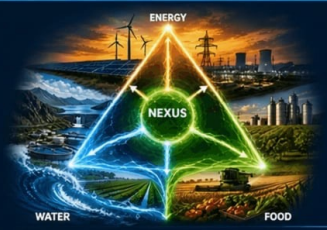
Evolution: From Classical WEF to the PtX-WEF Paradigm



CLASSICAL WEF NEXUS

Managing Scarcity & Trade-offs

FOCUS: Focuses on interdependencies (how one sector impacts another).

APPROACH: Primarily a defensive framework (preventing resource depletion).

MODEL: Linear consumption model (extract, use, dispose).

EXTRACT → USE → DISPOSE

GOAL: System stability and basic security.

VS

PtX-WEF NEXUS

Driving Circular Value Creation

FOCUS: Focuses on technological transformation (PtX conversions).

APPROACH: Proactive framework (generating green fuels and new economic value).

MODEL: Circular feedback loops (O_2 reuse, heat recovery, wastewater treatment).

O_2 REUSE → WASTEWATER TREATMENT → HEAT RECOVERY

GOAL: Decarbonization, resilience, and sustainable growth.

The PtX-WEF framework transforms the nexus from a model of resource constraints into an engine for the green energy transition.

PtX-WEF- Nexus Applied to Namibia

Power to X

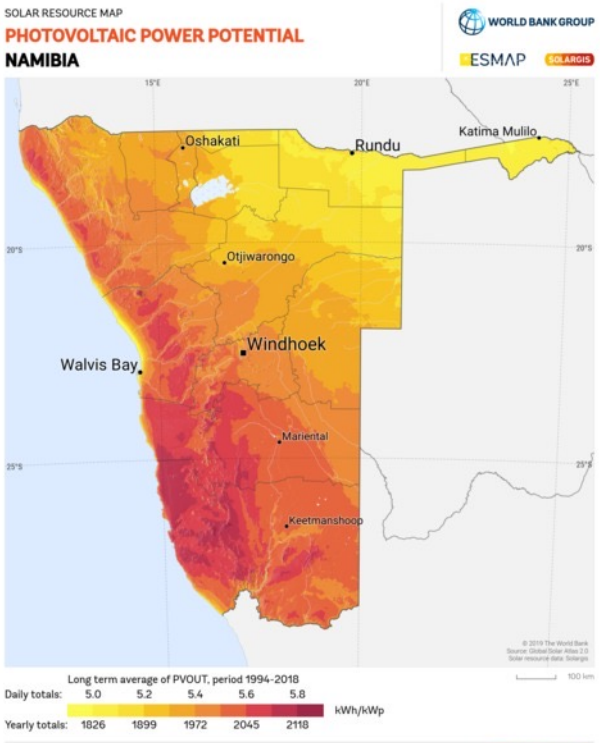
Towards Sustainable Green Industrialisation

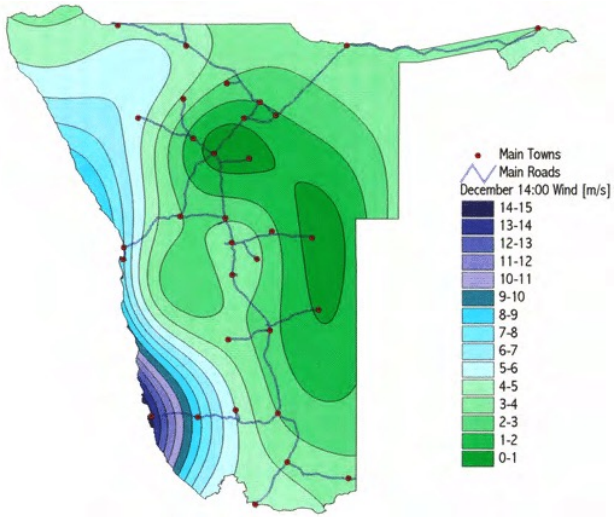
Renewable Energy

Solar

Wind

Namibia's Context: Resource Endowment and Opportunity



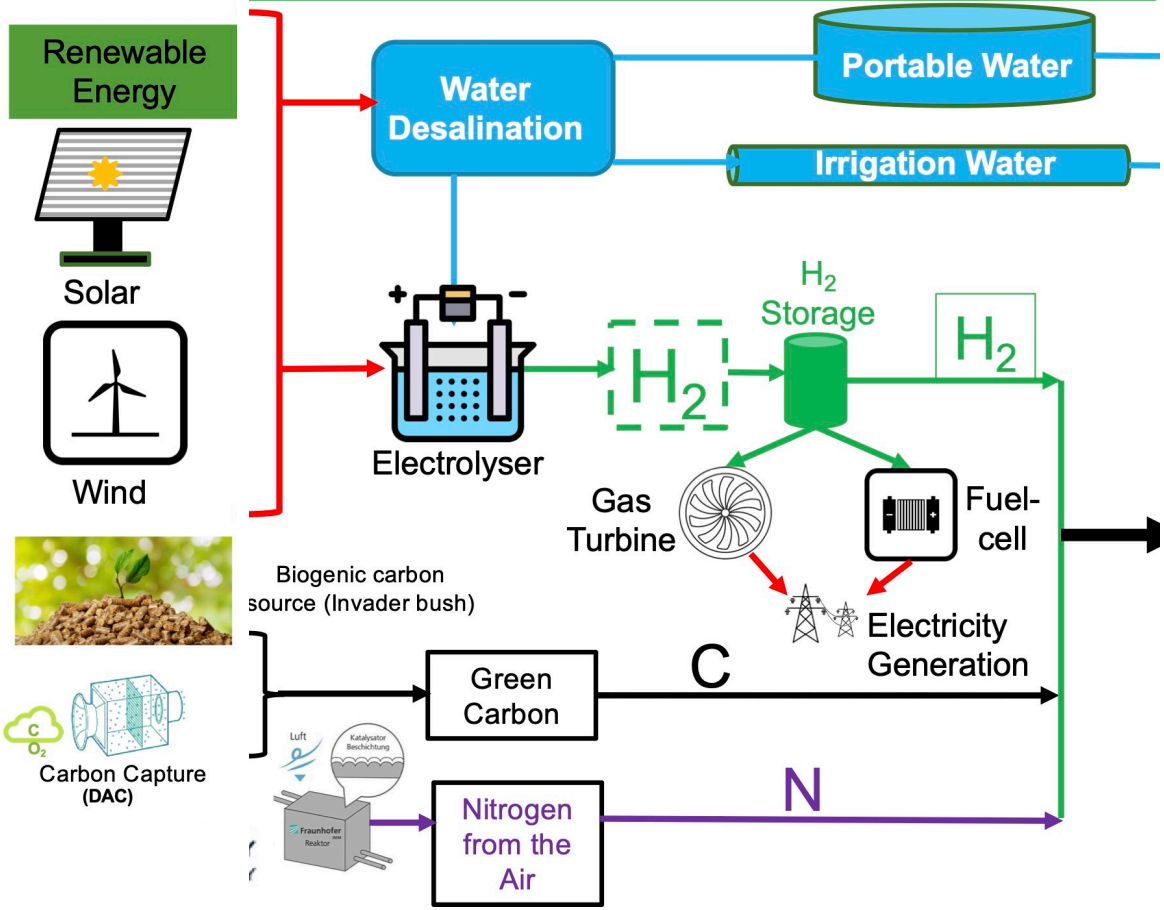


- Solar: up to 2,200 kWh/m²/yr
- Wind: Good to excellent coastal wind speeds ≅7 m/s
- About 45 million hectares of gracing land is encroached by unwanted bush, giving great biomass sources
- Vast land, low population density for scaling renewables
- Ports: Walvis Bay & Lüderitz connect SADC to EU/Asia

Power to X

Towards Sustainable Green Industrialisation

A NUST Green H_2 Energy–Water–Food Nexus Framework



Power to X

A NUST Green H_2 Energy–Water–Food Nexus Framework

Towards Sustainable Green Industrialisation

Renewable Energy

Solar

Wind

Water Desalination

Portable Water

Irrigation Water

Green schemes

Electrolyser

H_2

H_2 Storage

H_2

Gas Turbine

Fuel-cell

Electricity Generation

Biogenic carbon source (Invader bush)

Carbon Capture (DAC)

Green Carbon

C

Nitrogen from the Air

N

Cooling

Synthetic fuel

Chemicals

Liquid Fuel

Ammonia

Fertiliser Production

Industrial and Local Applications

Fuel-cell initial use will be for Energy Storage

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Southern Corridor Development Initiative

Namibia's Green Hydrogen Industrialisation Strategy

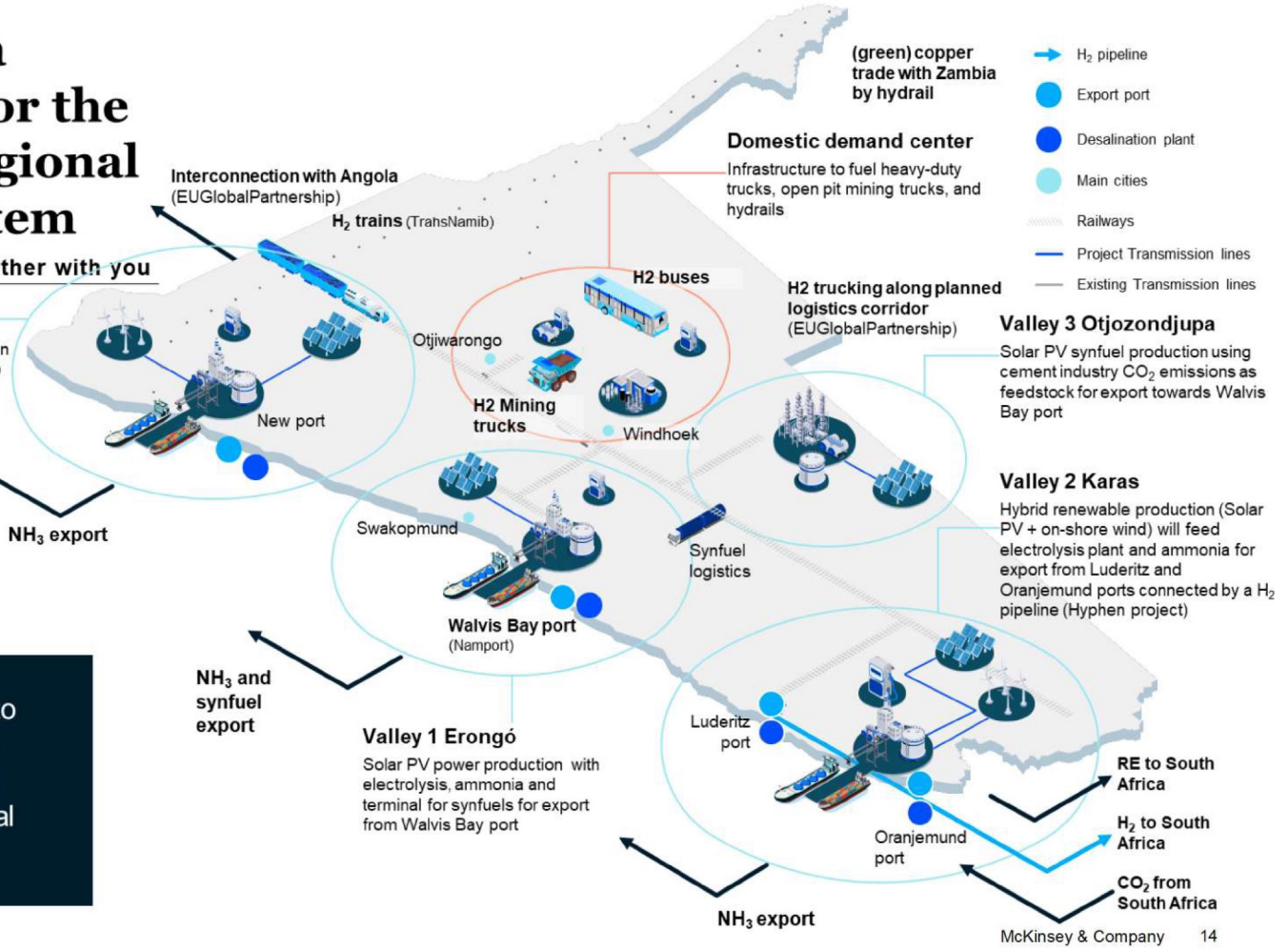
We aspire to create a green fuels industry with a production target of 10-15 Mtpa hydrogen equivalent by 2050."

Southern Corridor Development Initiative

Namibia's green hydrogen industrialisation strategy

We will develop a granular vision for the Namibian and regional hydrogen ecosystem

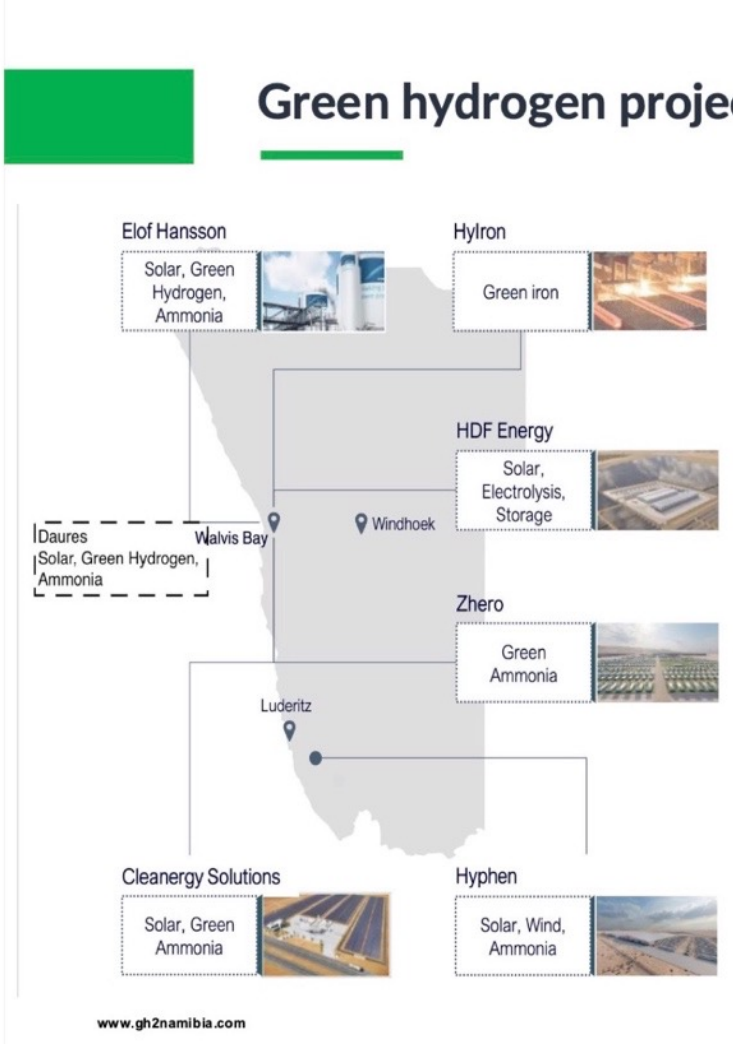
Initial thinking - to be developed further with you



We will build on existing plans to further refine and detail out the concept for ecosystem clusters within Namibia, reflecting natural synergies and existing assets

Current Green Hydrogen Projects

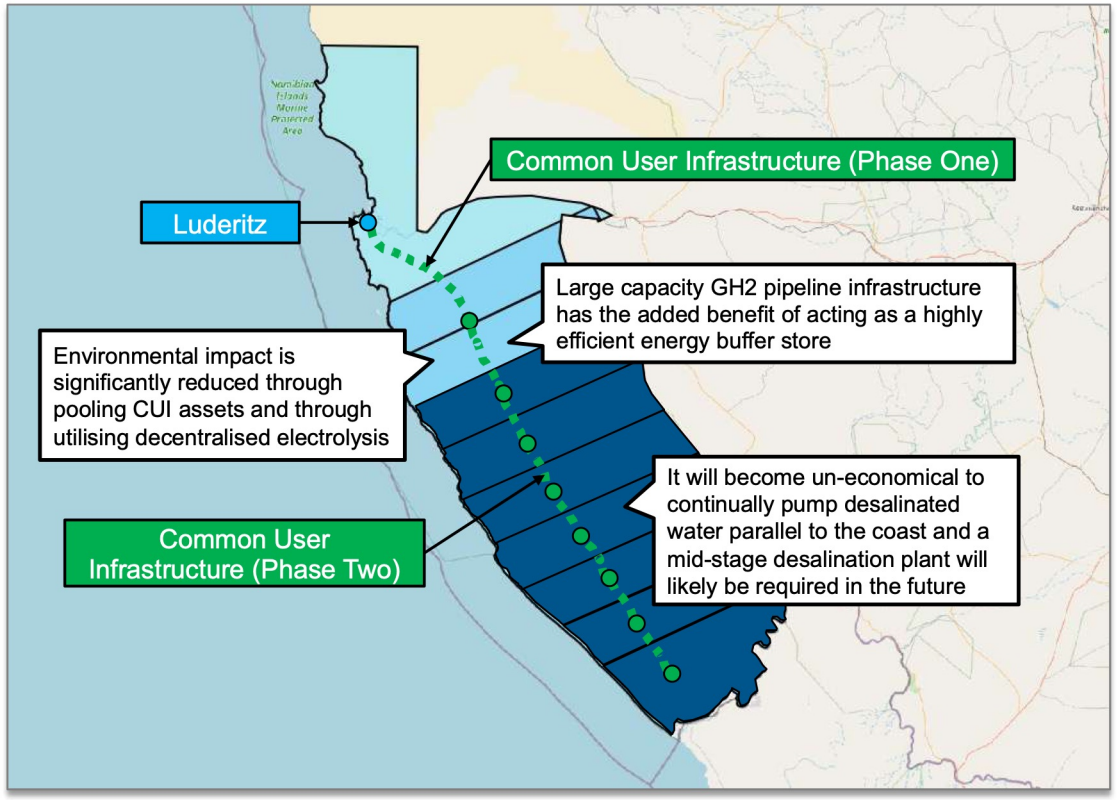
- Hyphen (Karas): $9.4bn, 370ktpa H_2, 2mtpa ammonia
- Daures GH2 Village: pilot green ammonia + agriculture
- HyIron Oshivela: Africa's first green iron project
- Cleanergy Namibia: Hydrogen Academy, refuelling stations



Project	Phase of development
Hyphen	Feasibility
Elof Hansson	Development/planning phase
HDF	Development/planning phase
HyIron	Phase 1 - Production in 2024/5
Zhero	Development/planning phase
Cleanergy Solutions	Pilot/Phase 1 - Production in 2024/5
Daures Hydrogen Village	Pilot/Phase 1 - Production in 2024/25

Southern Corridor Development Initiative (SCDI)

Namibia's first GH2 mega-project will unlock 'CUI' for future projects



SCDI Common User Infrastructure ("CUI") Approximate Cost

Green Hydrogen Gas Pipeline
- *Length: ~400km*
- *Diameter: 1,400mm*
- *Peak flow: 3m GH2 tons p.a.*
- *Cost: EUR 3,500m*

Water Pipeline
- *Length: ~400km*
- *Diameter: 1,200mm*
- *Peak flow: 200 ML p.d.*
- *Cost: EUR 1,200m*

Transmission Lines
- *Length: ~400km*
- *Size: 2x 400kv*
- *Cost: EUR 600m*

Challenges = Opportunities

- Skills gap → training & education partnerships
- Infrastructure → PPPs for ports, rail, power
- Technology → need for electrolysers, turbines, SAF, desalination
- Water stress → smart desalination & circular water systems

Pathways for Partnership

- Bilateral agreements: Germany, South Korea, Netherlands, Japan
- Joint ventures in investable industries (electrolysers, steel, SAF)
- Knowledge exchange: scholarships, research hubs, dual-study training
- Finance partnerships: syndication of $55bn FDI needed

The blueprint for green industrialisation

The new agenda brings together a series of prioritised and integrated public and private investments.

INVESTABLE INDUSTRIES

Renewable energy hardware

1. **Solar panel manufacturing, p36**
   Capex (by 2050): $170m
   Location: Walvis Bay/Lüderitz
2. **Electrolyser manufacturing, p38**
   Capex (by 2050): $250m
   Location: Lüderitz (or Walvis Bay)
3. **Wind turbine manufacturing, p40**
   Capex (by 2050): $200m
   Location: Lüderitz & Kunene

Mineral refining

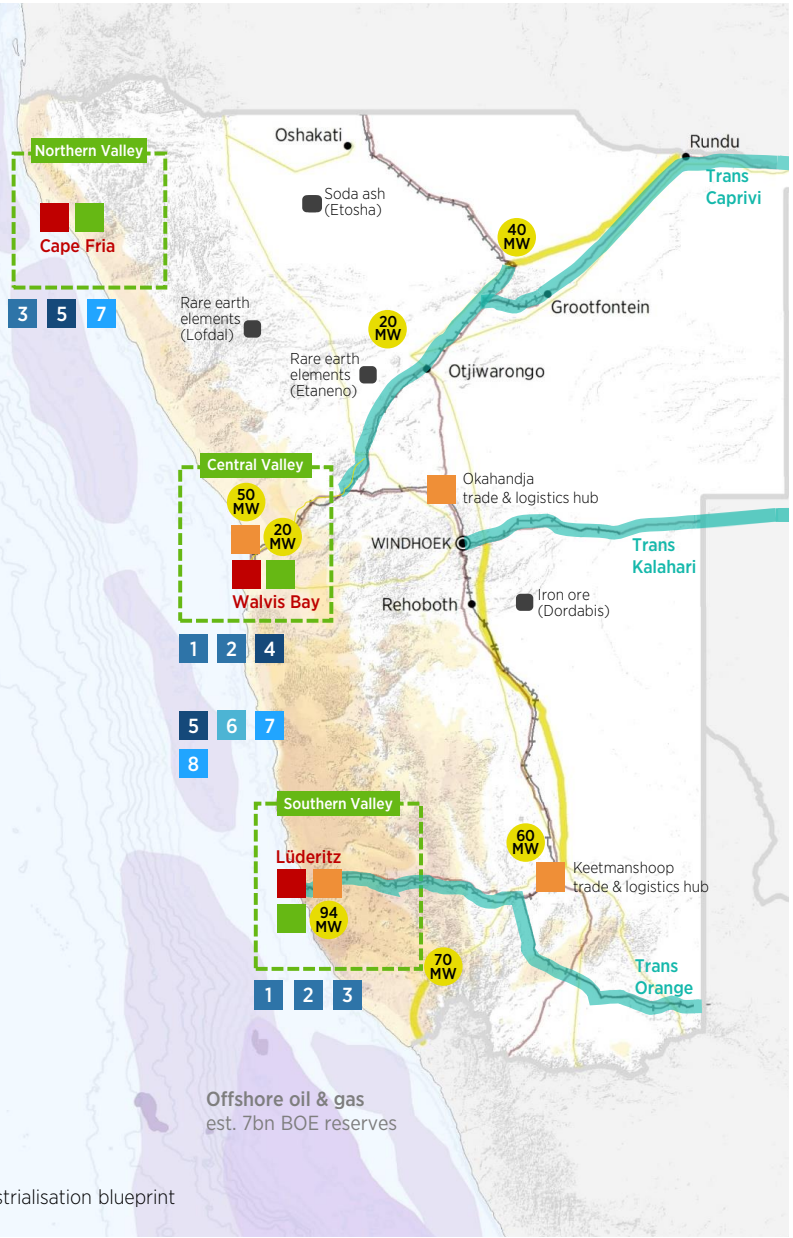
4. **Lithium refinery, p42**
   Capex (by 2050): $900m
   Location: Walvis Bay
5. **Rare earth elements refinery, p44**
   Capex (by 2050): $300m
   Location: Walvis Bay (or Kunene)

Low CO_2

6. **Flat glass production, p46**
   Capex (by 2050): $1.5bn
   Location: Walvis Bay

gH_2 derivatives

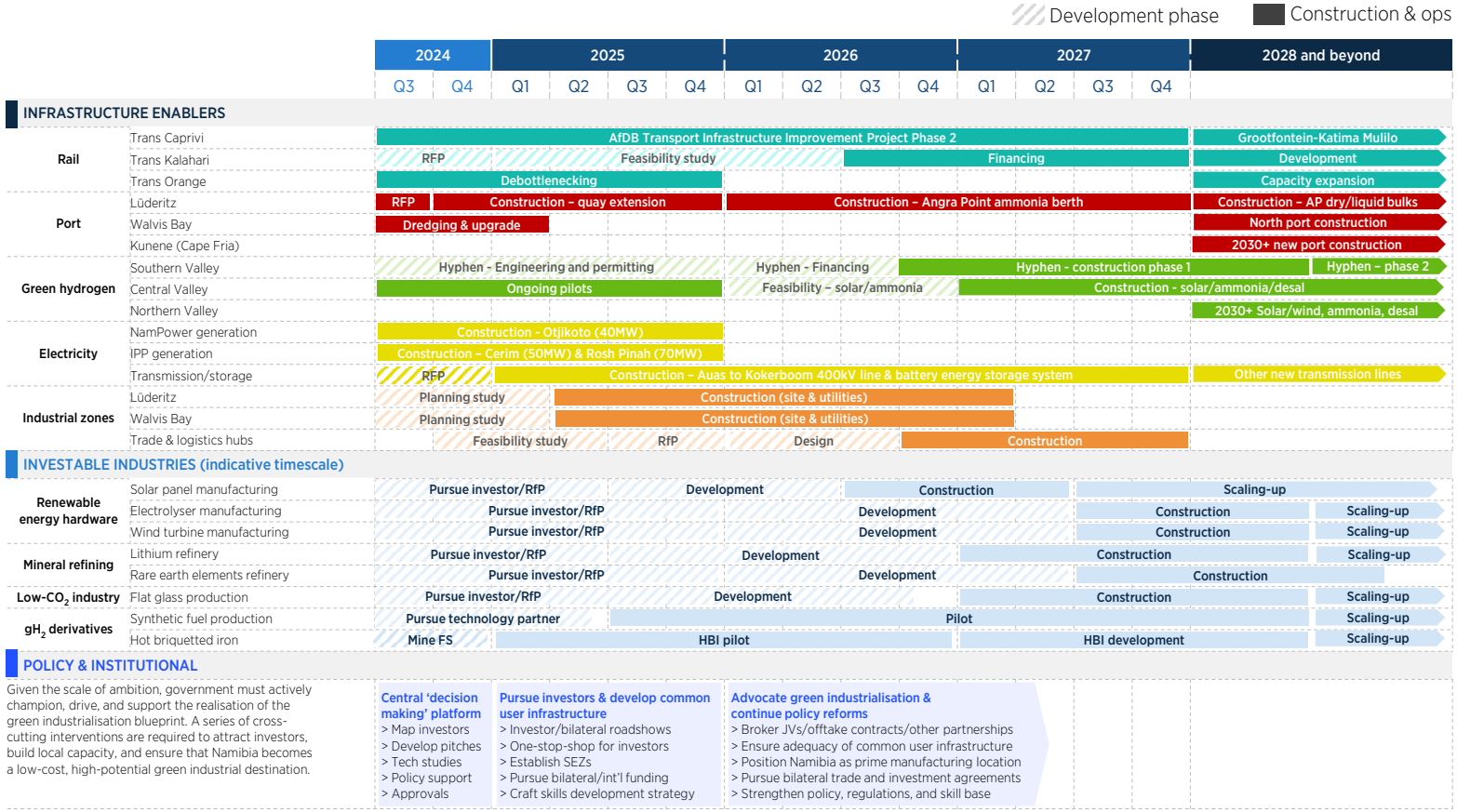
7. **Synthetic fuel production, p48**
   Capex (by 2050): $20bn
   Location: Walvis Bay & Kunene
8. **Hot briquetted iron production, p50**
   Capex (by 2050): $6bn
   Location: Walvis Bay



DELIVERING THE BLUEPRINT

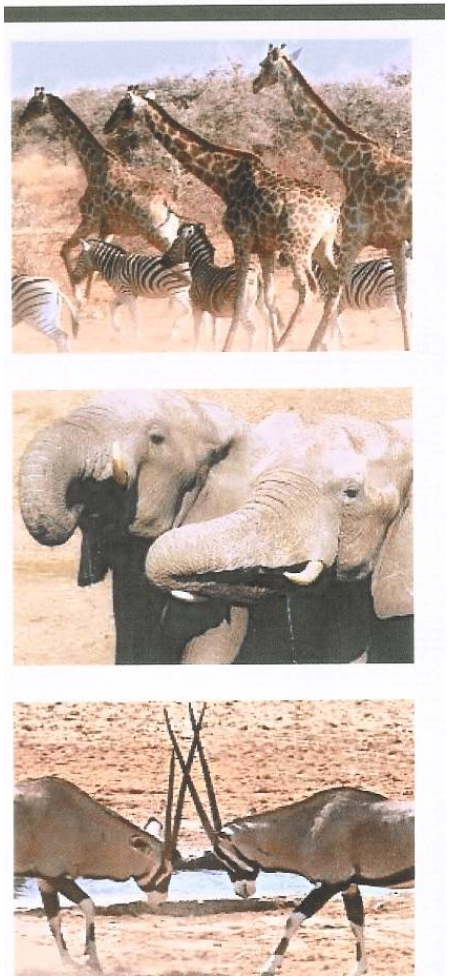
Roadmap

Realising the blueprint requires parallel delivery of three distinct workstreams. Government must act quickly and decisively to streamline policy, attract investors, and deliver enabling infrastructure.



Key Resources

- Namibia Green Hydrogen Programme (GH2 Namibia): https://gh2namibia.com
- Hyphen Hydrogen Energy: https://www.hyphenafrica.com
- Hylron Oshivela Project: https://hyiron.com
- Cleanergy Solutions Namibia: https://www.cleanergynamibia.com/
- Daures Green Hydrogen Village:https://daures.green
- Namibia Investment Promotion and Development Board (NIPDB): https://nipdb.com
- Namibia University of Science and Technology (NUST): https://www.nust.na
- Green Hydrogen Atlas Africa: https://africa.h2atlas.de/africa



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Thank You


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