| | | | |
|---|---|---|---|
| Partners: | DAURES GREEN HYDROGEN VILLAGE | NGHRI<br>UNAM UNIVERSITY OF NAMIBIA | Universität Stuttgart<br>University of Stuttgart<br>IER Institut für Energiewirtschaft und Rationelle Energieanwendung<br>Institute of Energy Economics and Rational Energy Use |
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**Namibia - Germany Green Hydrogen Research and Development Conference - 2025**

# PROCEEDINGS OF THE
# NAMIBIA - GERMANY GREEN HYDROGEN RESEARCH AND DEVELOPMENT CONFERENCE - 2025


Editors:

Dr. Zivayi Chiguvare – University of Namibia

Dr. Ludger Eltrop - University of Stuttgart

Dr Alina Uusiku - University of Namibia



Windhoek, Namibia 04 - 05 June 2025

# PROCEEDINGS OF THE NAMIBIA - GERMANY GREEN HYDROGEN RESEARCH AND DEVELOPMENT CONFERENCE 2025

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| Dr Alina Uusiku | - | University of Namibia |


Namibia Green Hydrogen Research Institute,

University of Namibia,

340 Mandume Ndemufayo Ave,

Pionierspark, Windhoek, NAMIBIA

June 04 – 05, 2025

Namibia - Germany Green Hydrogen Research and Development Conference 2025
ORGANISING COMMITTEE

- Dr. Zivayi Chiguvare – Acting Director – Namibia Green Hydrogen Research Institute (NGHRI) – University of Namibia (UNAM) – Chairperson
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- Ms. Fenni Shidhika – SASSCAL
- Ms. Rejoyce Hamukoshi – NGHRI UNAM

# FOREWORD

The Namibia - German Green Hydrogen Research and Development Conference was organised and hosted by the Namibia Green Hydrogen Research Institute of the University of Namibia. The conference was in collaboration with Institute of Economics and Rational Use of Energy (IER) -University of Stuttgart, Germany, and Daures Green Hydrogen - internationally recognized for their leading roles and pioneering actions in the development of the Green Hydrogen Economy in Namibia. The aim was to present and inform stakeholders of progress made since the award of the Joint Communique' of Intent (JCOI) funds by Southern African Science Services Centre for Climate Change and Adaptation Land Management (SASSCAL), the Fund Administrator of the funds availed by then German Federal Ministry of Education and Research (BMBF), now Federal Ministry of Research, Technology, and Space (BMFTR). The Conference took place from 04 to 05 June 2025, in Windhoek, Namibia. It consisted of an Opening Session and a Plenary Session where 15 research presentations were given on the Daures Green Hydrogen Village, and related research findings. We sincerely thank the presenters, session chairpersons, moderators, and the students who greatly contributed to the success of the conference. We are grateful to the presenters and the participants for their engaging contributions.

Zivayi Chiguvare, Ph.D. On behalf of the Organizing Committee

# Contents

# University of Namibia 's Role in Namibia's Green Hydrogen Development

UNIVERSITY OF NAMIBIA VICE CHANCELLOR'S REMARKS ON THE OCCASION OF THE NAMIBIA - GERMANY GREEN HYDROGEN RESEARCH AND DEVELOPMENT CONFERENCE, 2025

PRESENTED BY PROF GIDEON, PVC: ACADEMIC AFFAIRS, UNAM

I am delighted this morning to express few remarks before experts in the areas of Green-hydrogen.

- I should mention from the onset that modern energy transforms difficult tasks into manageable ones, even to the extent that human beings would never manage with their physical power. When used for the good of mankind it is the best invention ever.
- However, the exploitation of energy resources stored over millions of years within a short time brings about challenges such as global warming due to greenhouse gas emissions, exceeding natural sequestration through photosynthesis.
- Such emissions, especially from the use of fossil fuels increase the levels of Carbon dioxide and other gases in the atmosphere, leading to global warming, with global consequences, usually negative, for all.
- Conversion of energy sources to electricity has revolutionized economies by making it possible to transmit and distribute energy over long distances in a fast and efficient manner.

Director of Proceedings, exploitation of renewable energy sources such as solar, wind and biomass, and geothermal, is an alternative, environmentally friendly, and sustainable initiative, which has brought us all together here.

- Green Hydrogen is produced by using solar and wind energy resources to break water molecules into Hydrogen and Oxygen.
- Hydrogen is an energy carrier, which when recombined with Oxygen, releases a lot of energy. This way we can export our sun and wind to Germany and other countries with less opportunity to have the sun we enjoy here in Namibia, and this can be a source of economic growth for our country.
- Global partnerships, such as the collaboration between Germany and Namibia, enables the exploitation of these resources for the greater good.
- The global push toward renewable energy sources have seen Namibia position itself as a key player in green hydrogen development, largely due to its abundant natural resources and strategic location.

Dear Participants, central to this emerging industry is the University of Namibia (UNAM), which has made significant contributions to green hydrogen development, ensuring the country remains at the forefront of this global energy transition.

- As alluded to earlier, one of UNAM's contributions is the establishment of the Namibia Green Hydrogen Research Institute (NGHRI), as a hub for research, innovation, and development in green hydrogen technologies.
- The creation of the Institute underscores the university's commitment to contributing to sustainable energy solutions not only for Namibia but also for the global community.
- The institute plays a pivotal role in advancing knowledge, fostering innovation, and developing technologies related to green hydrogen, a clean and renewable energy source that holds immense potential for reducing carbon emissions.
- The NGHRI focusses on different aspects of green hydrogen value chain, including Clean Hydrogen Production, Hydrogen Storage and Distribution, New Materials and Delivery, Hydrogen Use and Fuel Cell Technology for Mobility Applications, Hydrogen Capacity Building Competence and Standards, and Hydrogen Digital and Emerging Technologies.
- We have no doubt that research in these areas will help in addressing the technical, economic, and environmental challenges associated with green hydrogen production, storage, and utilization.
- The institute is geared to support interdisciplinary research, bringing together experts in engineering and natural sciences like physics, chemistry, environmental science, and economics, to drive Namibia's green hydrogen agenda forward.

Director of proceedings, by investing in education and capacity building, UNAM ensures that Namibia has a pool of highly trained professionals who can lead the development and implementation of green hydrogen projects.

- Youth for Green Hydrogen scholarships awarded through SASSCAL, and PhD scholarship at BAM is point of reference in building capacity.
- I should point out that we are thankful to the German Government for facilitating such initiatives, which not only strengthens Namibia's human resource base but also fosters international collaboration and knowledge exchange, crucial for the success of green hydrogen initiatives.

Dear participants, the University of Namibia (UNAM) has taken a proactive role in advancing green hydrogen development through its participation in key pilot projects such as the Daures Green Hydrogen Village Pilot Project in the Erongo Region of Namibia.

- Such projects are critical for demonstrating the viability of green hydrogen technologies and for positioning Namibia as a leader in the global green hydrogen market.
    - I wish to mention that the Daures Green Hydrogen Village is a landmark project that aims to create a sustainable community powered entirely by green hydrogen. Located in the Daures Constituency of the Erongo Region,

this project is a collaborative effort involving the government, private sector, and academia, where the University of Namibia and the University of Stuttgart play a critical role in research and development.

- As I conclude I wish to stress that one of the unique aspects of the Daures Green Hydrogen Village is the production of green ammonia, using green hydrogen.
- UNAM's involvement includes research on optimal methods for green ammonia production, and its application in fertilizers for hydroponic systems, ensuring efficient and sustainable agricultural practices.
- The university's involvement therefore ensures that the solutions developed are not only technologically sound but also economically viable and environmentally sustainable for the local context.

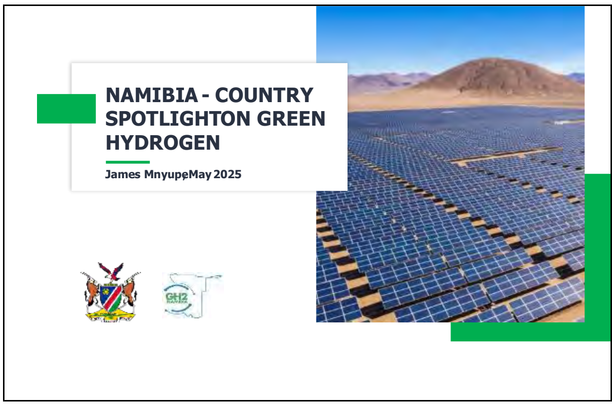
Dear Participants, with these few remarks, I wish you all, fruitful deliberations during this Conference.

Thank you!

# Green Hydrogen Initiatives and Progress in Namibia

Mr. James Mnyupe

Head of the Green Hydrogen Programme – Namibia





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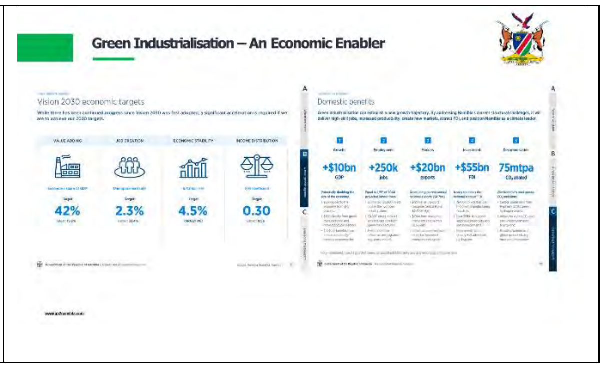


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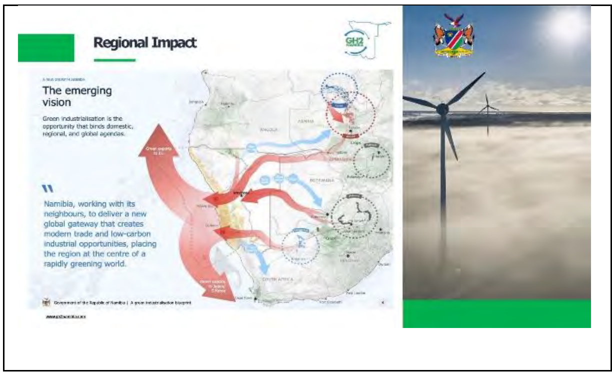



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VisionMeetsReality– CMB.TECH
NH3
REPORT:
FINAL SCOPING REPORT FOR THE CONSTRUCTION OF AN AMMONIA TERMINAL AT THE WALVIS BAY PORT AREA, ERONGO REGION, NAMIBIA
ECC


VisionMeetsReality- DauresGreenHydrogenVillage
TB
Daures Green Hydrogen Village to benefit from UK-funded A2D Facility

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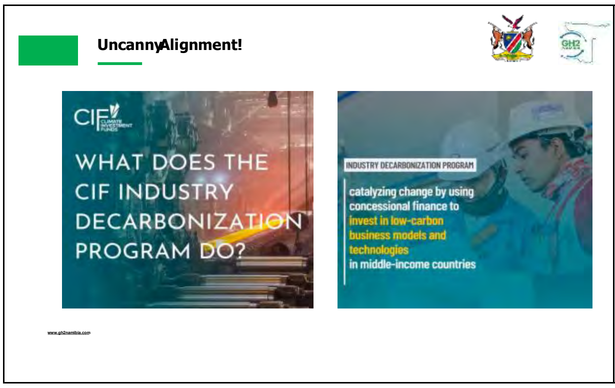
UncannyAlignment!
CIF
WHAT DOES THE CIF INDUSTRY DECARBONIZATION PROGRAM DO?
INDUSTRY DECARBONIZATION PROGRAM
catalyzing change by using concessional finance to invest in low-carbon business models and technologies in middle-income countries


Thankyou

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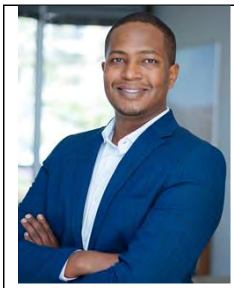
# Daures Green Hydrogen Village Pilot Project - Status of Completion

Jerome Namaseb

Daures Green Hydrogen Village

E-mail: jerome@Daures.green

The Daures Green Hydrogen Village initiative represents a pioneering approach to sustainable energy production, community empowerment and participation through the integration of renewable resources. The presentation will outline the innovative framework of the Daures project, which harnesses the abundant solar and wind energy in the Namibian landscape to produce green hydrogen and ammonia. The project is a crucial element in the transition to a low-carbon economy. The project, which partnered with the University of Namibia and University of Stuttgart, is multifaceted in nature and includes the establishment of a self-sustaining energy ecosystem, the production of agriculture products, training facility in the hydrogen and agricultural space and enablement of research activities related to the green hydrogen and ammonia industries. The presentation will highlight project milestones and implementation processes. Furthermore, we will discuss the scaling of the project for industrial production.



Mr. Jerome Namaseb is the Chief Executive Officer of the Daures Green Hydrogen Village (www.daures.green). The Daures Green Hydrogen Village is a ground-breaking initiative that has established a green hydrogen and green ammonia production project. The project leverages the country's abundant renewable resources in a sustainable manner demonstrating a green circular economy that includes participation by local community groups.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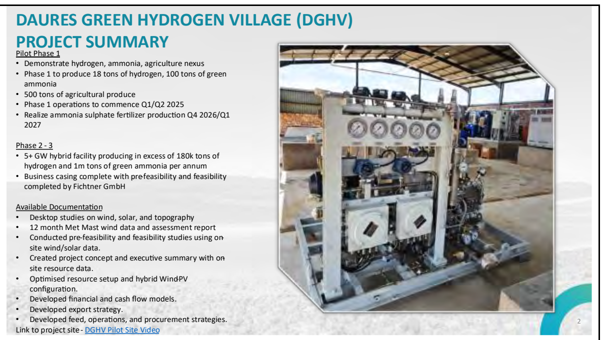


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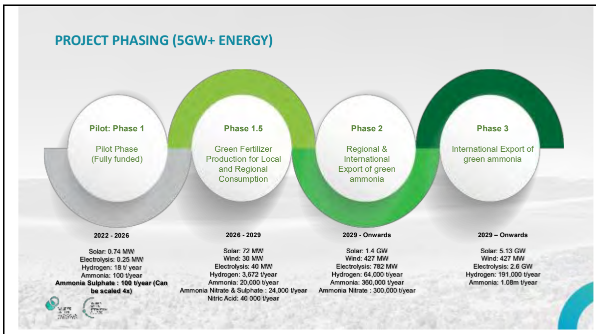


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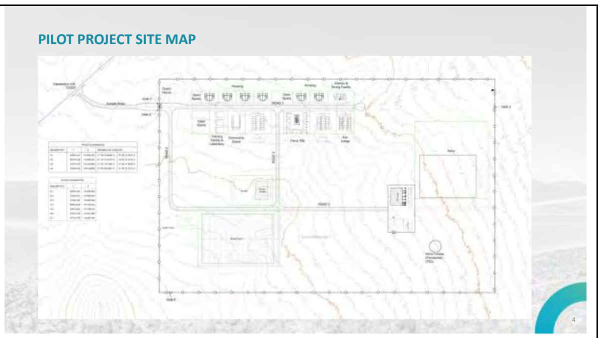


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| # | KPI | BASELINE | Actual |
|---|---|---|---|
| 1 | Number of jobs created throughout the project | 150 | 375 |
| 2 | Percentage of Namibians employed and/or trained | 80% | 99% |
| 3 | Number of foreigners employed | 10% | 1% |
| 4 | Percentage of persons employed from the community | 30% | 30% |
| 5 | Percentage of youths employed | 20% | 77% |
| 6 | Percentage of SME's & local companies employed | 20% | 92% |
| 7 | Project Percentage local spent in Namibia | 5% | 70% |
| 8 | Number of unique local firms employed | 3% | 87% |
| 9 | Number of foreign firms utilized | 5% | 8% |

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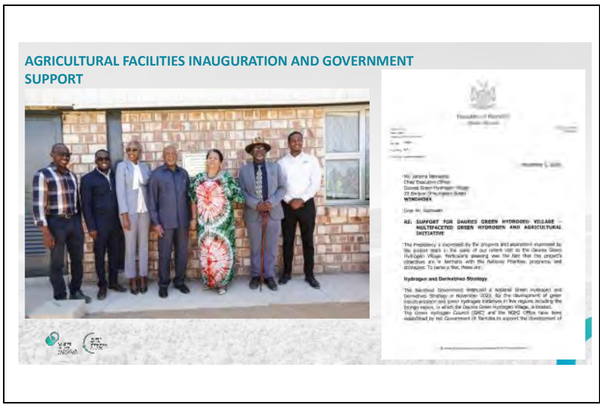
AGRICULTURAL FACILITIES INAUGURATION AND GOVERNMENT SUPPORT

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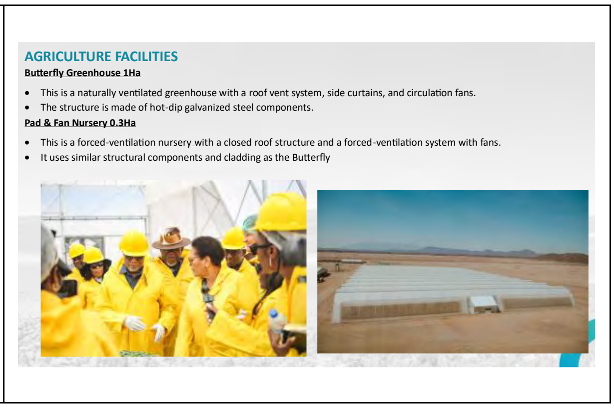
AGRICULTURE FACILITIES
Butterfly Greenhouse 1Ha
This is a naturally ventilated greenhouse with a roof vent system, side curtains, and circulation fans.
The structure is made of hot-dip galvanized steel components.
Pad & Fan Nursery 0.3Ha
This is a forced-ventilation nursery with a closed roof structure and a forced-ventilation system with fans.
It uses similar structural components and cladding as the Butterfly

8


CUCUMBER, TOMATOES AND PEPPERS HARVESTED
Products available in Woermann Brock, Spar Walvis, and Metro, in Erongo Region of Namibia

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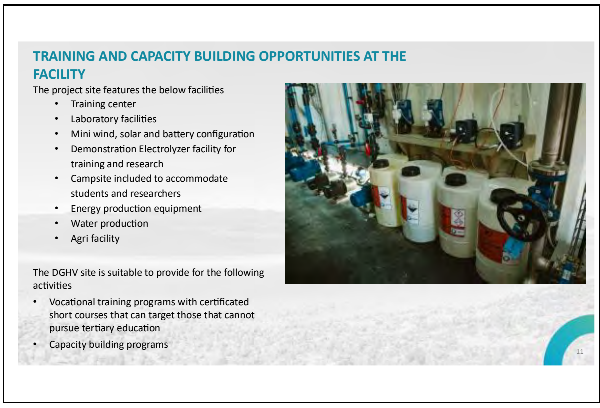
SEEDLING PRODUCTION PROCESS

10


TRAINING AND CAPACITY BUILDING OPPORTUNITIES AT THE FACILITY
The project site features the below facilities
Training center
Laboratory facilities
Mini wind, solar and battery configuration
Demonstration Electrolyzer facility for training and research
Campsite included to accommodate students and researchers
Energy production equipment
Water production
Agri facility
The DGHV site is suitable to provide for the following activities
Vocational training programs with certificated short courses that can target those that cannot pursue tertiary education
Capacity building programs

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A2D FACILITY

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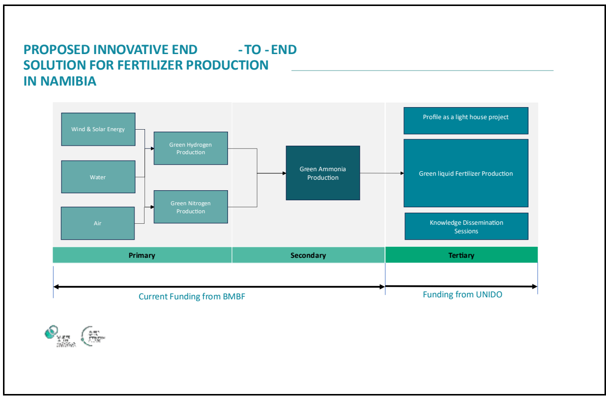


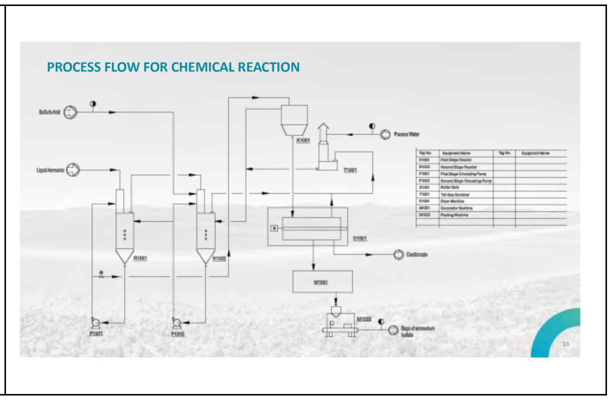


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# Overview of Research Undertaken by IER- University of Stuttgart on Daures GH2 Village

Dr. Ludger Eltrop

Institute of Energy Economics and Rational Energy Use – University of Stuttgart, Heßbrühlstr. 49 a, D-70569 Stuttgart, Germany


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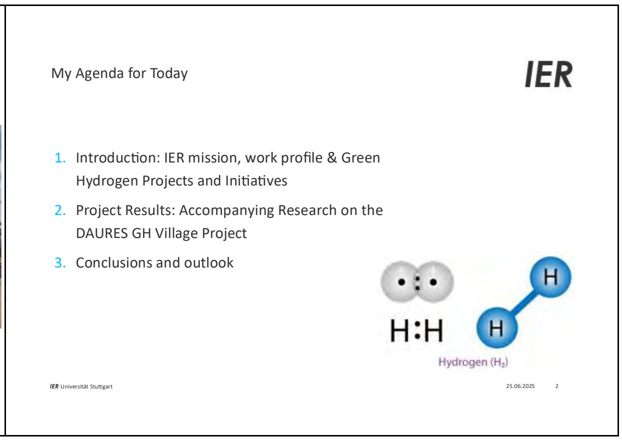


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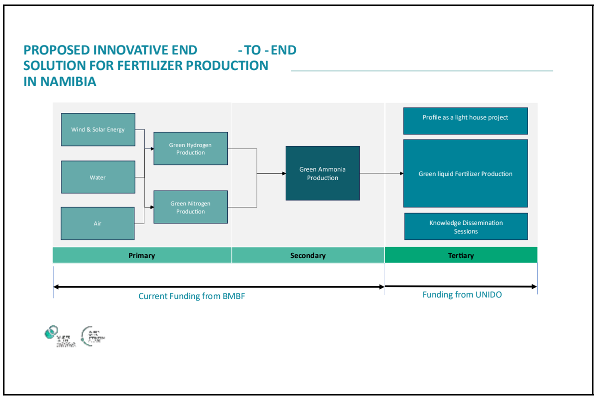


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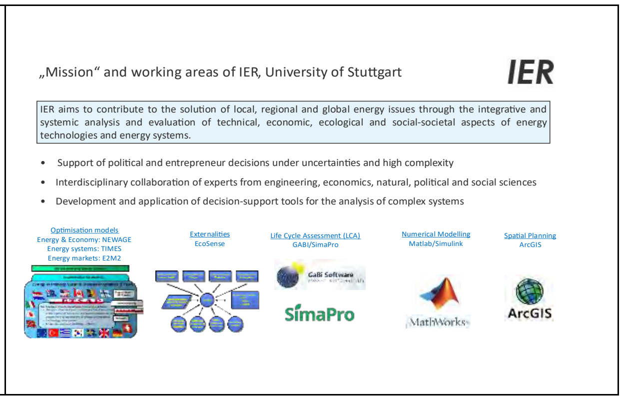


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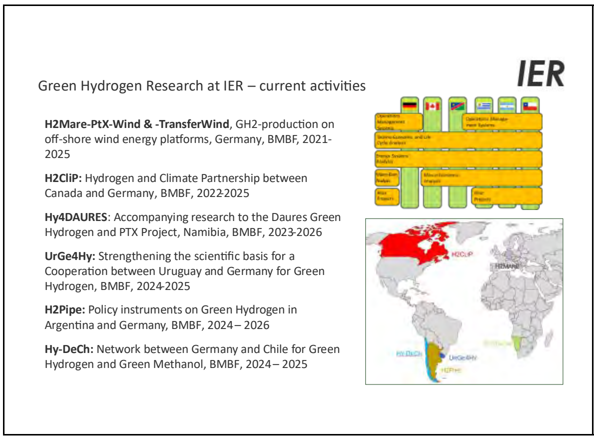


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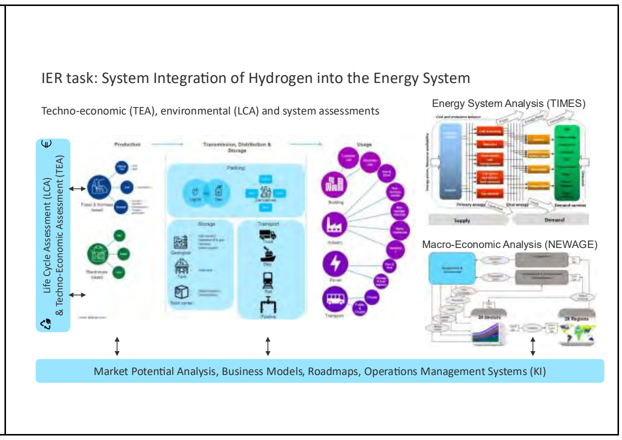


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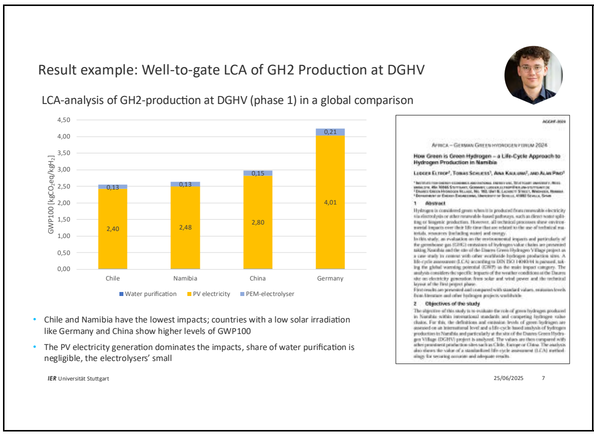
Result example: Well-to-gate LCA of GH2 Production at DGHV
LCA-analysis of GH2-production at DGHV (phase 1) in a global comparison
GWP100 [kgCO2eq/kgH2]
Chile
Namibia
China
Germany
2,40
2,48
2,80
4,01
0,13
0,13
0,15
0,21
Water purification
PV electricity
PEM-electrolyser
Chile and Namibia have the lowest impacts; countries with a low solar irradiation like Germany and China show higher levels of GWP100
The PV electricity generation dominates the impacts, share of water purification is negligible, the electrolysers' small
IER Universität Stuttgart
25/06/2025
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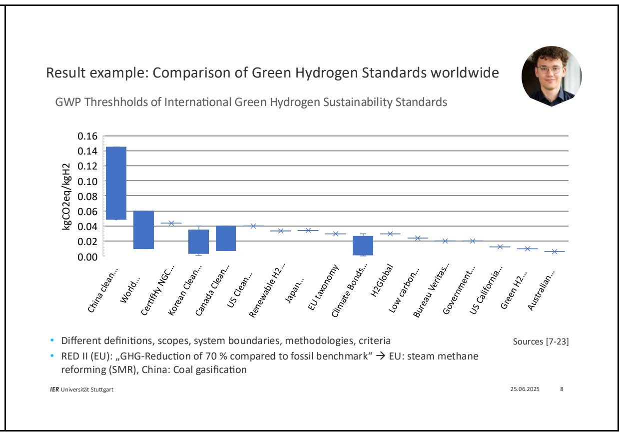
Result example: Comparison of Green Hydrogen Standards worldwide
GWP Thresholds of International Green Hydrogen Sustainability Standards
kgCO2eq/kgH2
China clean...
World...
Certifiy NGC...
Korean Clean...
Canada Clean...
US Clean...
Renewable H2...
Japan...
EU taxonomy
Climate Bonds...
H2Global
Low carbon...
Bureau Veritas...
Government...
US California...
Green H2...
Australian...
Different definitions, scopes, system boundaries, methodologies, criteria
Sources [7-23]
RED II (EU): „GHG-Reduction of 70 % compared to fossil benchmark" → EU: steam methane reforming (SMR), China: Coal gasification
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25.06.2025
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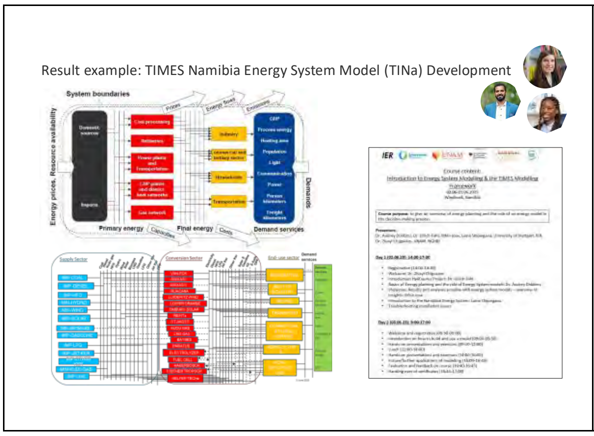
Result example: TIMES Namibia Energy System Model (TINa) Development
System boundaries
Primary energy
Final energy
Demand services
Energy prices, Resource availability
Demands

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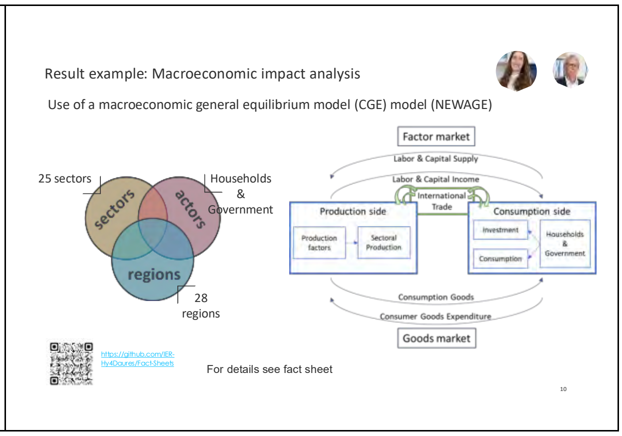
Result example: Macroeconomic impact analysis
Use of a macroeconomic general equilibrium model (CGE) model (NEWAGE)
25 sectors
Households & Government
sectors
actors
regions
28 regions
Factor market
Labor & Capital Supply
Labor & Capital Income
International Trade
Production side
Production factors
Sectoral Production
Consumption side
Investment
Consumption
Households & Government
Consumption Goods
Consumer Goods Expenditure
Goods market
https://github.com/IER-Hy4Douros/Fact-Sheets
For details see fact sheet
10

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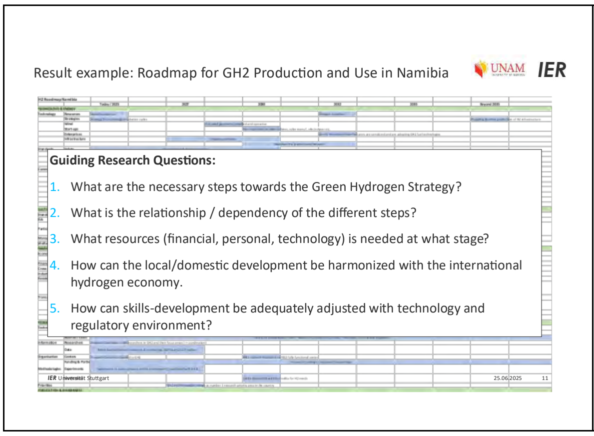
Result example: Roadmap for GH2 Production and Use in Namibia
UNAM
IER
Guiding Research Questions:
1. What are the necessary steps towards the Green Hydrogen Strategy?
2. What is the relationship / dependency of the different steps?
3. What resources (financial, personal, technology) is needed at what stage?
4. How can the local/domestic development be harmonized with the international hydrogen economy.
5. How can skills-development be adequately adjusted with technology and regulatory environment?
IER Universität Stuttgart
25.06.2025
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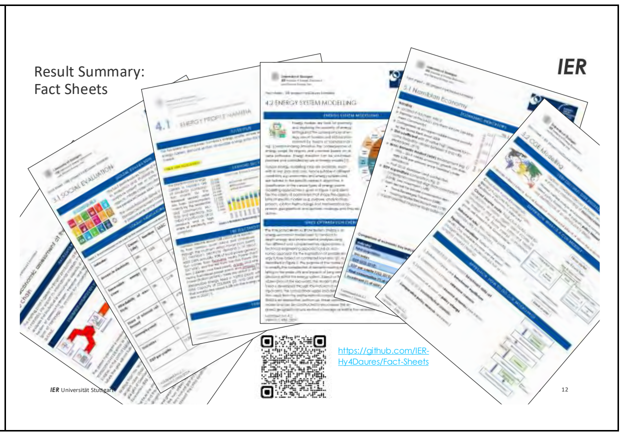
Result Summary:
Fact Sheets
IER
https://github.com/IER-Hy4Douros/Fact-Sheets
IER Universität Stuttgart
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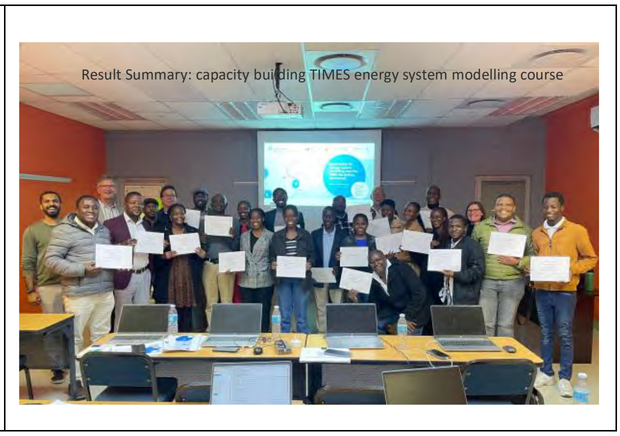
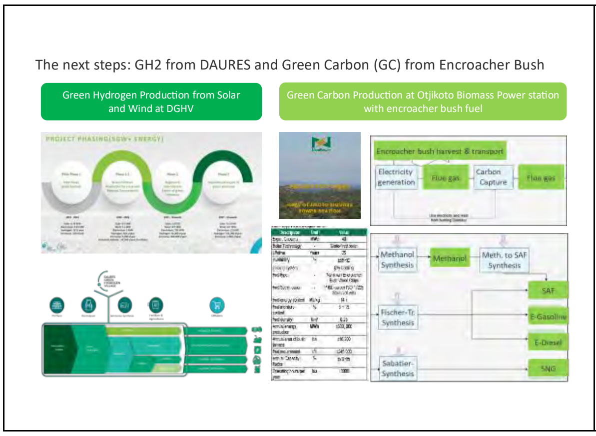
Result Summary: capacity building with our scholar and partner network
UNAM
Enersense
SASSCAL
Dr. Alan Pino
University of Seville
Aina Kauluma
Daures Green
Hydrogen Village
ESSLINGEN
hsrm
DECHEMA
giz
25.06.2025
13
13


Result Summary: capacity building TIMES energy system modelling course
14


The next steps: GH2 from DAURES and Green Carbon (GC) from Encroacher Bush
Green Hydrogen Production from Solar and Wind at DGHV
Green Carbon Production at Otjikoto Biomass Power station with encroacher bush fuel
Encroacher bush harvest & transport
Electricity generation
Flue gas
Carbon Capture
Flue gas
Methanol Synthesis
Methanol
Meth. to SAF Synthesis
SAF
Fischer-Tr. Synthesis
E-Gasoline
E-Diesel
Sabatier-Synthesis
SNG
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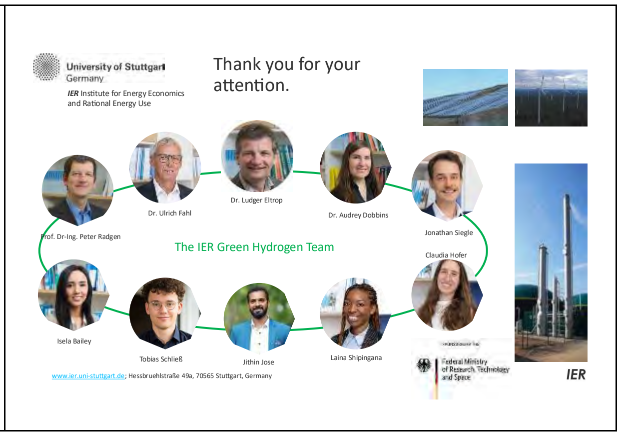
University of Stuttgart
Germany
IER Institute for Energy Economics and Rational Energy Use
Thank you for your attention.
Prof. Dr-Ing. Peter Radgen
Dr. Ulrich Fahl
Dr. Ludger Eltrop
Dr. Audrey Dobbins
Jonathan Siegle
Claudia Hofer
The IER Green Hydrogen Team
Isela Bailey
Tobias Schließ
Jithin Jose
Laina Shipingana
www.ier.uni-stuttgart.de; Hessbruehlstraße 49a, 70565 Stuttgart, Germany
Federal Ministry of Research, Technology and Space
IER
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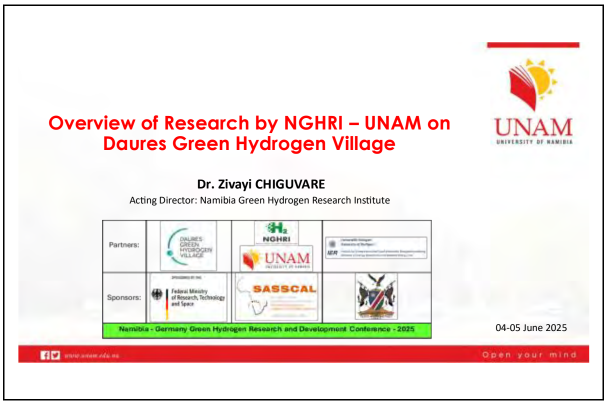
# Overview of Research undertaken by NGHRI – University of Namibia on Daures GH2 Village

Dr. Zivayi Chiguvare

Namibia Green Hydrogen Research Institute, University of Namibia

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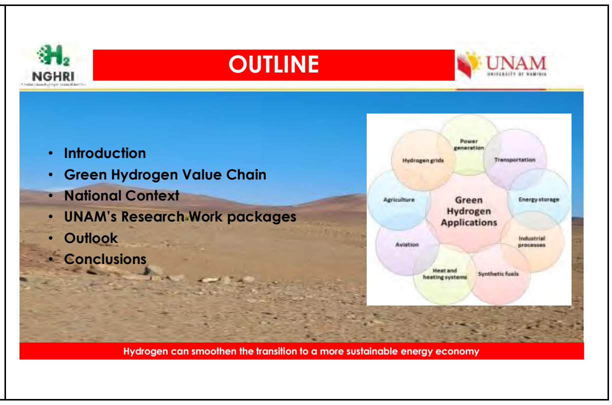


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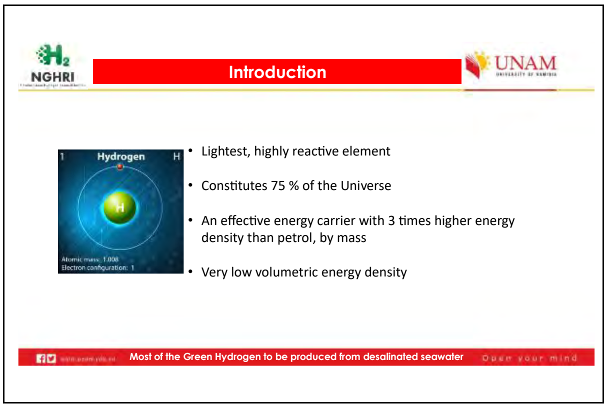


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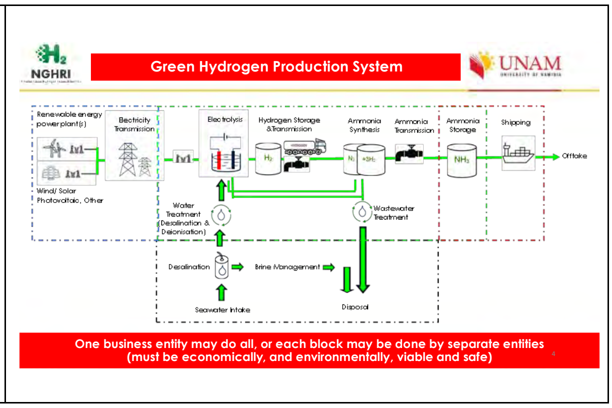


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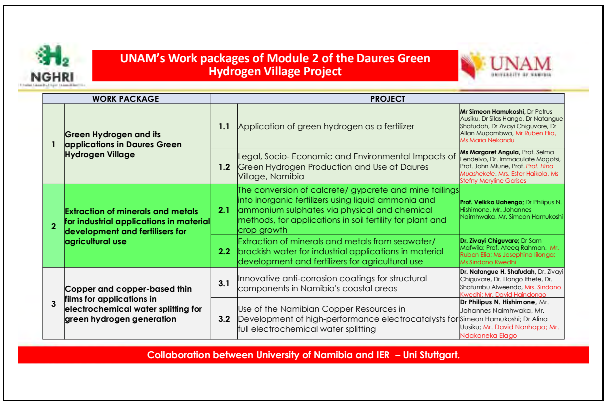


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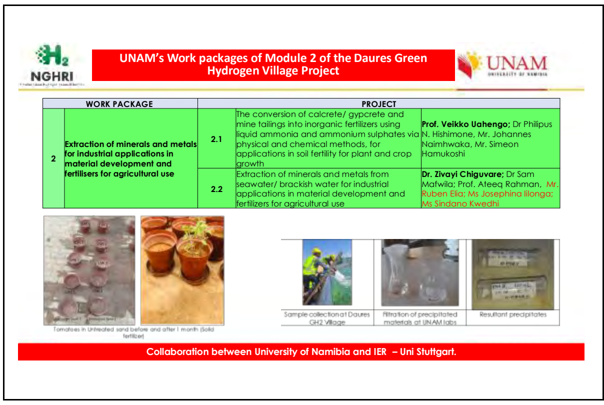
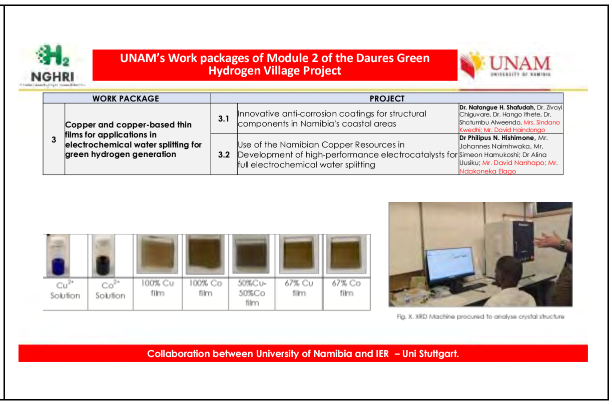
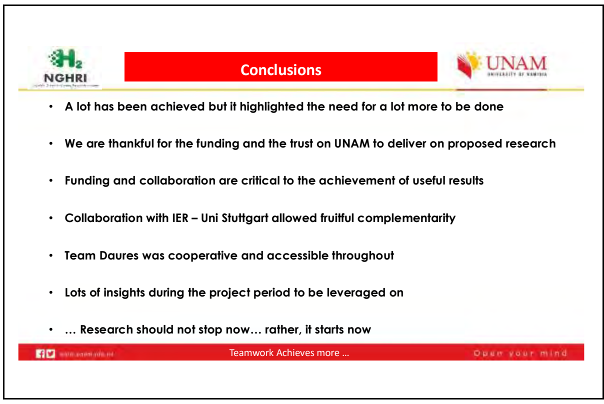

NGHRI
UNAM's Work packages of Module 2 of the Daures Green Hydrogen Village Project
UNAM
UNIVERSITY OF NAMIBIA
WORK PACKAGE
PROJECT
2
Extraction of minerals and metals for industrial applications in material development and fertilisers for agricultural use
2.1
The conversion of calcrete/ gypcrete and mine tailings into inorganic fertilizers using liquid ammonia and ammonium sulphates via physical and chemical methods, for applications in soil fertility for plant and crop growth
Prof. Veikko Uahengo; Dr Philipus N. Hishimone, Mr. Johannes Naimhwaka, Mr. Simeon Hamukoshi
2.2
Extraction of minerals and metals from seawater/ brackish water for industrial applications in material development and fertilizers for agricultural use
Dr. Zivayi Chiguvare; Dr Sam Mafwila; Prof. Ateeq Rahman, Mr. Ruben Elia; Ms Josephina Iilonga; Ms Sindano Kwedhi
Tomatoes in Untreated sand before and after 1 month (Solid fertilizer)
Sample collection at Daures GH2 Village
Filtration of precipitated materials at UNAM labs
Resultant precipitates
Collaboration between University of Namibia and IER – Uni Stuttgart.

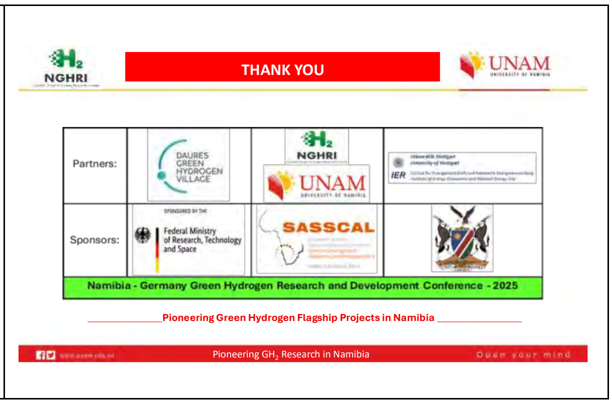
7


NGHRI
UNAM's Work packages of Module 2 of the Daures Green Hydrogen Village Project
UNAM
UNIVERSITY OF NAMIBIA
WORK PACKAGE
PROJECT
3
Copper and copper-based thin films for applications in electrochemical water splitting for green hydrogen generation
3.1
Innovative anti-corrosion coatings for structural components in Namibia's coastal areas
Dr. Natangue H. Shafudah, Dr. Zivayi Chiguvare, Dr. Hango Ithete, Dr. Shatumbu Alweendo, Mrs. Sindano Kwedhi; Mr. David Haindongo
3.2
Use of the Namibian Copper Resources in Development of high-performance electrocatalysts for full electrochemical water splitting
Dr Philipus N. Hishimone, Mr. Johannes Naimhwaka, Mr. Simeon Hamukoshi; Dr Alina Uusiku; Mr. David Nanhapo; Mr. Ndakoneka Elago
$Cu^{2+}$ Solution
$Co^{2+}$ Solution
100% Cu film
100% Co film
50%Cu-50%Co film
67% Cu film
67% Co film
Fig. X. XRD Machine procured to analyse crystal structure
Collaboration between University of Namibia and IER – Uni Stuttgart.

8


NGHRI
Conclusions
UNAM
UNIVERSITY OF NAMIBIA
• A lot has been achieved but it highlighted the need for a lot more to be done
• We are thankful for the funding and the trust on UNAM to deliver on proposed research
• Funding and collaboration are critical to the achievement of useful results
• Collaboration with IER – Uni Stuttgart allowed fruitful complementarity
• Team Daures was cooperative and accessible throughout
• Lots of insights during the project period to be leveraged on
• … Research should not stop now… rather, it starts now
Teamwork Achieves more …
Open your mind

9


NGHRI
THANK YOU
UNAM
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Partners:
DAURES GREEN HYDROGEN VILLAGE
NGHRI
UNAM
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Sponsors:
SPONSORED BY THE
Federal Ministry of Research, Technology and Space
SASSCAL
Namibia - Germany Green Hydrogen Research and Development Conference - 2025
Pioneering Green Hydrogen Flagship Projects in Namibia
Pioneering $GH_2$ Research in Namibia
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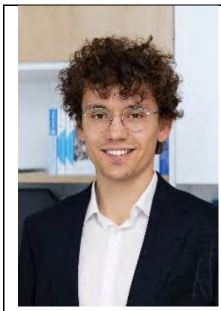
10

# How Green is Green Hydrogen – A Life Cycle Approach to Hydrogen Production in Namibia

Tobias Schliess and Ludger Eltrop

Institute of Energy Economics and Rational Energy Use – University of Stuttgart, Heßbrühlstr. 49 a, D-70569 Stuttgart, Germany

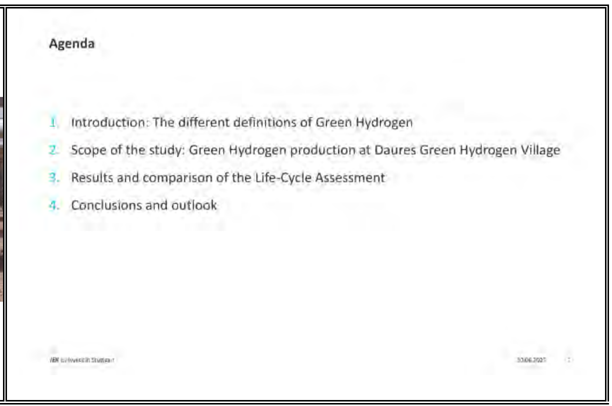
This study evaluates the environmental impacts of green hydrogen production at the Daures Green Hydrogen Village in Namibia. Setting the system boundaries at cradle-to-gate, we found that hydrogen produced from electrolysis using solar electricity here has a remarkably low carbon footprint (1.8 $kgCO_2eq/kgH_2$), compared to other production sites in Germany and China (2.1 – 3.3 $kgCO_2eq/kgH_2$). Thereby it adheres to most sustainability standards for green hydrogen. Future improvements in electrolyser efficiency and the decarbonisation of supply chains could further reduce emissions. Issues like freshwater usage in water scarce regions like Namibia, on the other hand, show a low impact on the carbon footprint, indicating that categories like water use should be included in such assessments. Future studies should include conversion and transport of the hydrogen produced to give a more holistic estimation of the sustainability of green hydrogen production.



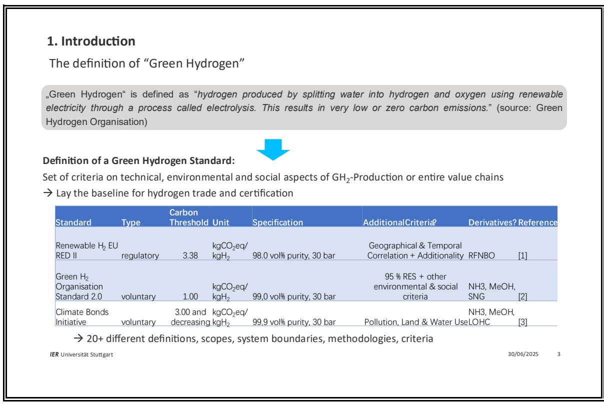
Mr. Tobias Schliess holds a master's degree in Distributed Energy Systems and Energy Efficiency. As a research associate at the Institute of Energy Economics and Rational Energy Use, he works in the field of system analysis. His background in mechanical engineering lays the basis for understanding the technical aspects of renewable energy technologies, while drawing conclusions on a broader systems level. Within the Daures Green Hydrogen Research team he coordinates the team and conducts techno-economic analysis and prospective life-cycle assessments. His research revolves around the environmental and economic impacts of emerging international green hydrogen value chains considering policy and sustainability standards.


University of Stuttgart
IER Institute of Energy Economics and Rational Energy Use
How Green is Green Hydrogen?
A Life-Cycle Approach to Green Hydrogen Production in Namibia
Tobias Schliess
IER
Enersense. Namibia
UNAM
SASSCAL

1


Agenda
1. Introduction: The different definitions of Green Hydrogen
2. Scope of the study: Green Hydrogen production at Daures Green Hydrogen Village
3. Results and comparison of the Life-Cycle Assessment
4. Conclusions and outlook

2


1. Introduction
The definition of "Green Hydrogen"
„Green Hydrogen" is defined as "hydrogen produced by splitting water into hydrogen and oxygen using renewable electricity through a process called electrolysis. This results in very low or zero carbon emissions." (source: Green Hydrogen Organisation)
Definition of a Green Hydrogen Standard:
Set of criteria on technical, environmental and social aspects of $GH_2$-Production or entire value chains
→ Lay the baseline for hydrogen trade and certification
Standard | Type | Carbon Threshold | Unit | Specification | Additional Criteria? | Derivatives? | Reference
Renewable $H_2$ EU RED II | regulatory | 3.38 | $kgCO_2eq/kgH_2$ | 98.0 vol% purity, 30 bar | Geographical & Temporal Correlation + Additionality | RFNBO | [1]
Green $H_2$ Organisation Standard 2.0 | voluntary | 1.00 | $kgCO_2eq/kgH_2$ | 99,0 vol% purity, 30 bar | 95 % RES + other environmental & social criteria | NH3, MeOH, SNG | [2]
Climate Bonds Initiative | voluntary | 3.00 and decreasing | $kgCO_2eq/kgH_2$ | 99,9 vol% purity, 30 bar | Pollution, Land & Water Use | NH3, MeOH, LOHC | [3]
→ 20+ different definitions, scopes, system boundaries, methodologies, criteria
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3

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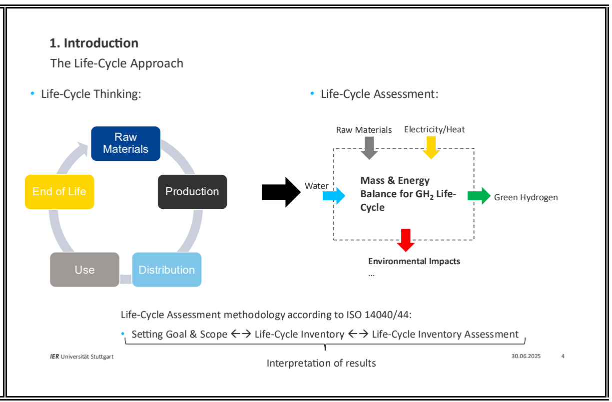
1. Introduction
The Life-Cycle Approach
Life-Cycle Thinking:
Raw Materials
Production
Distribution
Use
End of Life
Life-Cycle Assessment:
Raw Materials
Electricity/Heat
Water
Mass & Energy Balance for $GH_2$ Life-Cycle
Green Hydrogen
Environmental Impacts
...
Life-Cycle Assessment methodology according to ISO 14040/44:
Setting Goal & Scope ←→ Life-Cycle Inventory ←→ Life-Cycle Inventory Assessment
Interpretation of results
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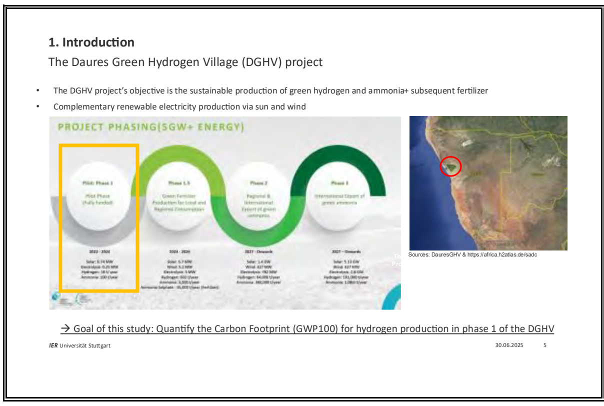
4


1. Introduction
The Daures Green Hydrogen Village (DGHV) project
The DGHV project's objective is the sustainable production of green hydrogen and ammonia+ subsequent fertilizer
Complementary renewable electricity production via sun and wind
PROJECT PHASING(5GW+ ENERGY)
Sources: DauresGHV & https://africa.h2atlas.de/sadc
→ Goal of this study: Quantify the Carbon Footprint (GWP100) for hydrogen production in phase 1 of the DGHV
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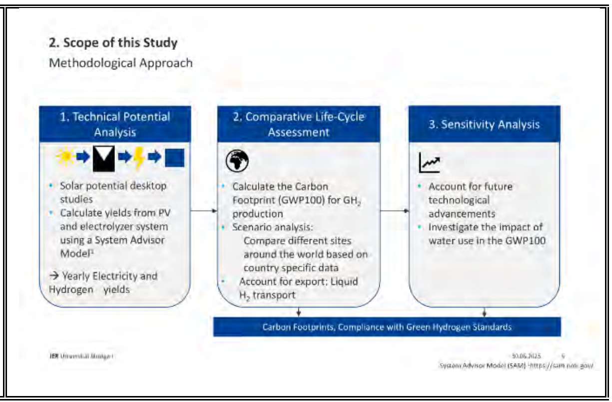
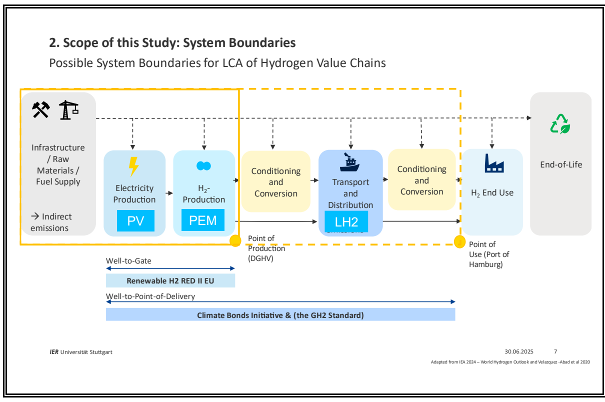

2. Scope of this Study
Methodological Approach
1. Technical Potential Analysis
Solar potential desktop studies
Calculate yields from PV and electrolyzer system using a System Advisor Model[1]
→ Yearly Electricity and Hydrogen yields
2. Comparative Life-Cycle Assessment
Calculate the Carbon Footprint (GWP100) for $GH_2$ production
Scenario analysis:
Compare different sites around the world based on country specific data
Account for export: Liquid $H_2$ transport
3. Sensitivity Analysis
Account for future technological advancements
Investigate the impact of water use in the GWP100
Carbon Footprints, Compliance with Green Hydrogen Standards
30.06.2025
6
System Advisor Model (SAM) https://sam.nrel.gov/

6


2. Scope of this Study: System Boundaries
Possible System Boundaries for LCA of Hydrogen Value Chains
Infrastructure / Raw Materials / Fuel Supply
→ Indirect emissions
Electricity Production
PV
H2-Production
PEM
Conditioning and Conversion
Transport and Distribution
LH2
Conditioning and Conversion
H2 End Use
End-of-Life
Point of Production (DGHV)
Point of Use (Port of Hamburg)
Well-to-Gate
Renewable H2 RED II EU
Well-to-Point-of-Delivery
Climate Bonds Initiative & (the GH2 Standard)
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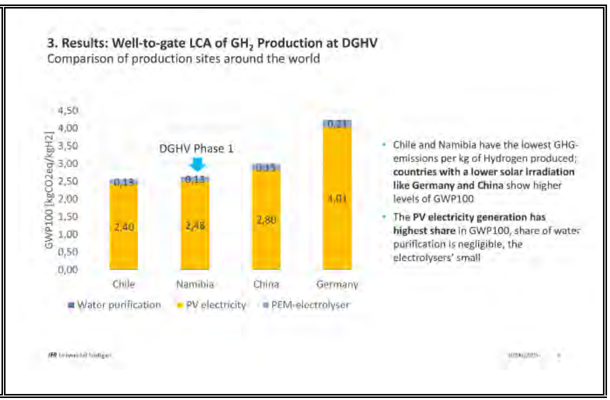
3. Results: Well-to-gate LCA of GH2 Production at DGHV
Comparison of production sites around the world
GWP100 [kgCO2eq/kgH2]
4,50
4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
DGHV Phase 1
0,13
2,40
0,13
2,48
0,15
2,80
0,21
4,01
Chile
Namibia
China
Germany
Water purification
PV electricity
PEM-electrolyser
Chile and Namibia have the lowest GHG-emissions per kg of Hydrogen produced; countries with a lower solar irradiation like Germany and China show higher levels of GWP100
The PV electricity generation has highest share in GWP100, share of water purification is negligible, the electrolysers' small
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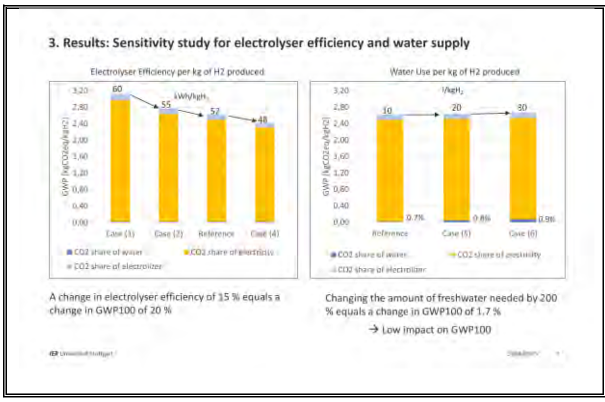
3. Results: Sensitivity study for electrolyser efficiency and water supply
Electrolyser Efficiency per kg of H2 produced
kWh/kgH2
60
55
52
48
Case (1)
Case (2)
Reference
Case (4)
CO2 share of water
CO2 share of electricity
CO2 share of electrolizer
Water Use per kg of H2 produced
l/kgH2
10
20
30
0.7%
0.8%
0.9%
Reference
Case (5)
Case (6)
CO2 share of water
CO2 share of electricity
CO2 share of electrolizer
A change in electrolyser efficiency of 15 % equals a change in GWP100 of 20 %
Changing the amount of freshwater needed by 200 % equals a change in GWP100 of 1.7 %
→ Low impact on GWP100
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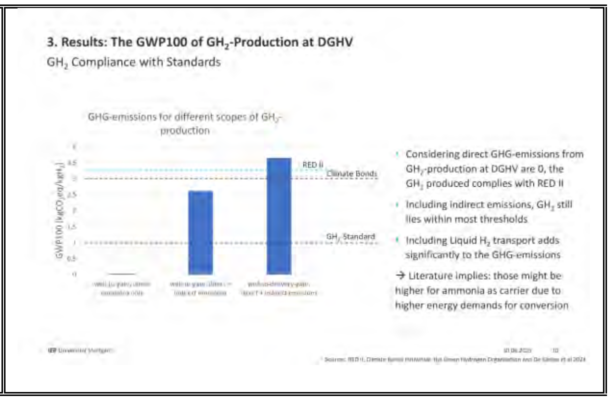
3. Results: The GWP100 of GH2-Production at DGHV
GH2 Compliance with Standards
GHG-emissions for different scopes of GH2-production
RED II
Climate Bonds
GH2 Standard
Considering direct GHG-emissions from GH2-production at DGHV are 0, the GH2 produced complies with RED II
Including indirect emissions, GH2 still lies within most thresholds
Including Liquid H2 transport adds significantly to the GHG-emissions
→ Literature implies: those might be higher for ammonia as carrier due to higher energy demands for conversion
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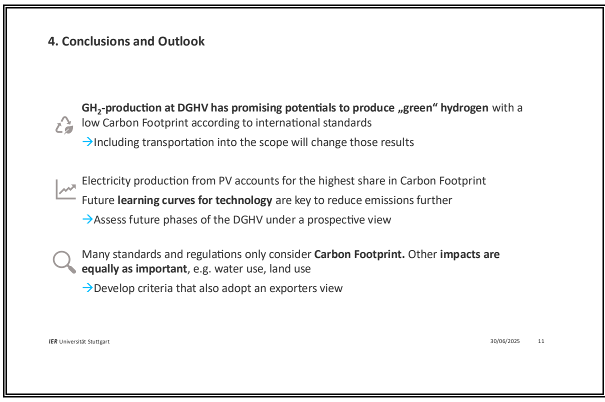
4. Conclusions and Outlook
GH2-production at DGHV has promising potentials to produce „green" hydrogen with a low Carbon Footprint according to international standards
→Including transportation into the scope will change those results
Electricity production from PV accounts for the highest share in Carbon Footprint
Future learning curves for technology are key to reduce emissions further
→Assess future phases of the DGHV under a prospective view
Many standards and regulations only consider Carbon Footprint. Other impacts are equally as important, e.g. water use, land use
→Develop criteria that also adopt an exporters view
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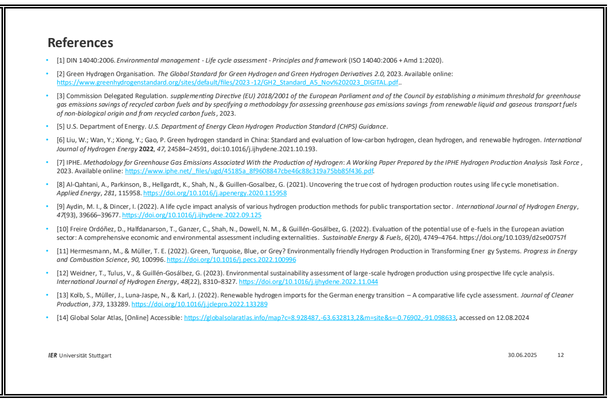
References
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[2] Green Hydrogen Organisation. The Global Standard for Green Hydrogen and Green Hydrogen Derivatives 2.0, 2023. Available online: https://www.greenhydrogenstandard.org/sites/default/files/2023-12/GH2_Standard_A5_Nov%202023_DIGITAL.pdf..
[3] Commission Delegated Regulation. supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels, 2023.
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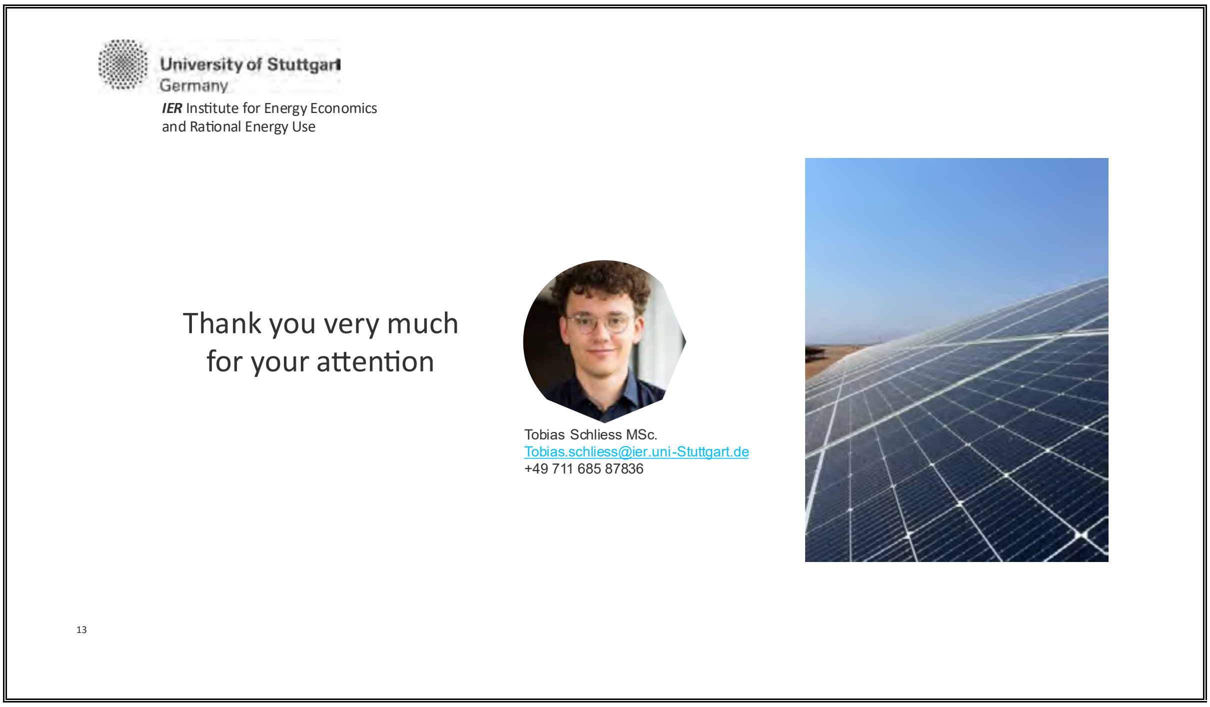
University of Stuttgart
Germany
IER Institute for Energy Economics
and Rational Energy Use
Thank you very much
for your attention
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13

13

# Community Participation and Perceptions Regarding Dâures Green Hydrogen Initiative

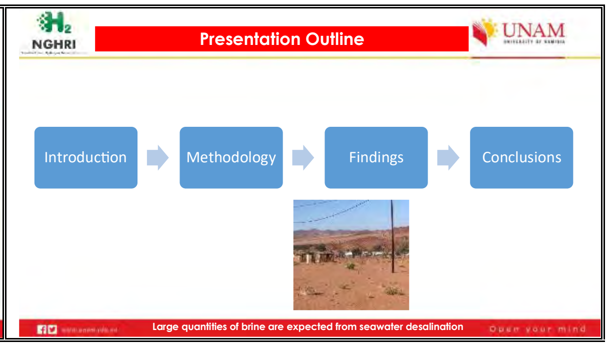
Margaret Angula, Ester Haikola, Stephanie Gougoros & Immaculate Mogotsi

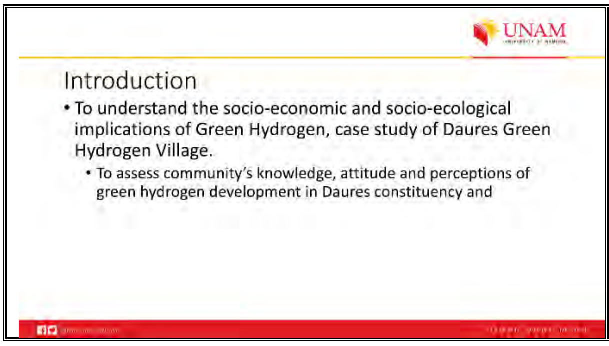
NGHRI University of Namibia

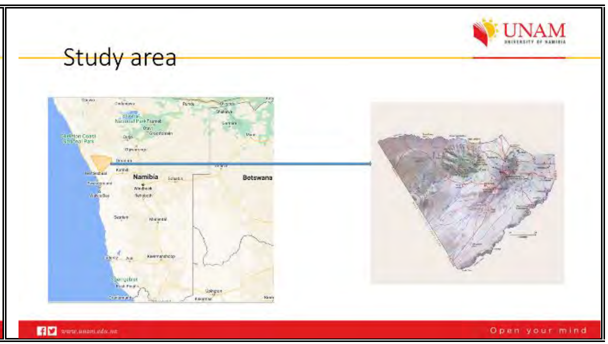
Namibia's pursuit of sustainable development through green hydrogen (GH) production is challenged by the absence of a robust framework for inclusive stakeholder engagement and a clear understanding of the legal, social, and economic benefits for local communities. This study examines community and stakeholder perceptions of GH initiatives in the Daures Constituency. Employing a quantitative survey on Knowledge, Attitude, and Perception (KAP) alongside key informant interviews, the research gathered insights from men, women, and youth across neighbouring local authorities - Henties Bay and Okombahe - and conservancies adjacent to Daures Village, including ǂGaingu/Spitzekoppe, Tsiseb, and Sorris-Sorris. The findings reveal that stakeholder awareness of green hydrogen is limited, with significant knowledge gaps and mixed attitudes about its potential impacts. While some optimism exists regarding economic opportunities, many stakeholders expressed concerns over environmental degradation and the inequitable distribution of benefits. Moreover, a gender analysis highlighted that women and vulnerable groups are largely underrepresented in decision-making processes. The study concludes that without a clear legal and regulatory structure for stakeholder engagement; GH projects may fall short of harmonizing with conservation objectives and fostering societal resilience. It proposes an inclusive framework with gender-responsive strategies to inform a national policy that drives equitable participation and sustainable green hydrogen development.

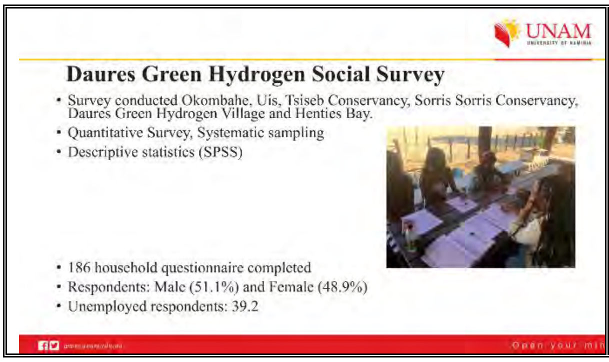
| | |
|---|---|
|  | Ms. Margaret Ndapewa Angula is a distinguished academic and climate change adaptation expert renowned for her gender-responsive approach to environmental challenges. She has dedicated her career to understanding and addressing the complex interplay between climate change, gender, and governance. Starting her academic journey in 1997 as a junior researcher, Margaret quickly emerged as a leader in community-based natural resource management and poverty research. Over the years, her work has evolved to focus on how climate change impacts vulnerable communities, making her a respected figure both in Africa and Asia. Her contributions extend beyond the classroom, serving as the Namibia country lead for initiatives that drive climate-resilient development and human dimensions of Green Hydrogen thereby inspiring a new generation of environmental advocates. In addition to her tireless teaching and research efforts, Margaret has played a pivotal role in shaping policy and building capacity for effective climate adaptation. Her expertise in designing methodologies for gender and intersectional analysis, along with vulnerability assessments, positions her at the forefront of integrating climate responses into development planning an expertise she is now applying to Green Hydrogen research. |

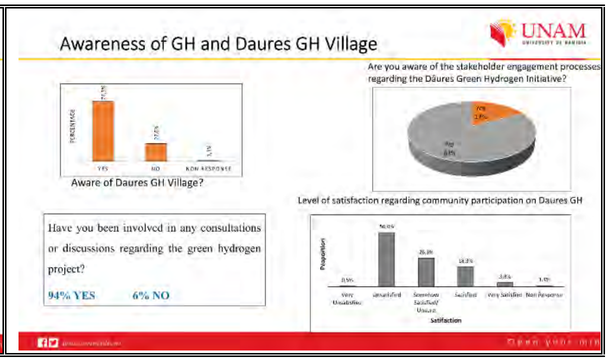

COMMUNITY PARTICIPATION AND PERCEPTIONS REGARDING DÂURES GREEN HYDROGEN INITIATIVE
UNAM
Margaret Angula & Ester Haikola
Co-Authors
Immaculate Mogotsi
Stephanie Gaugoros
Tatendaishe Kanengoni
Partners:
Sponsors:
NGHRI
UNAM
SASSCAL
04-05 June 2025
Namibia - Germany Green Hydrogen Research and Development Conference - 2025
Open your mind
1

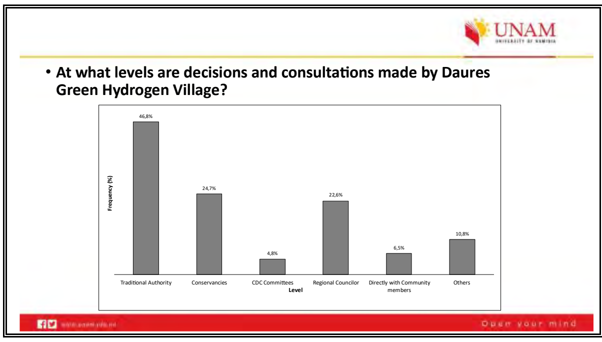

NGHRI
Presentation Outline
UNAM
Introduction
Methodology
Findings
Conclusions
Large quantities of brine are expected from seawater desalination
Open your mind
2


UNAM
Introduction
• To understand the socio-economic and socio-ecological implications of Green Hydrogen, case study of Daures Green Hydrogen Village.
• To assess community's knowledge, attitude and perceptions of green hydrogen development in Daures constituency and
Open your mind
3

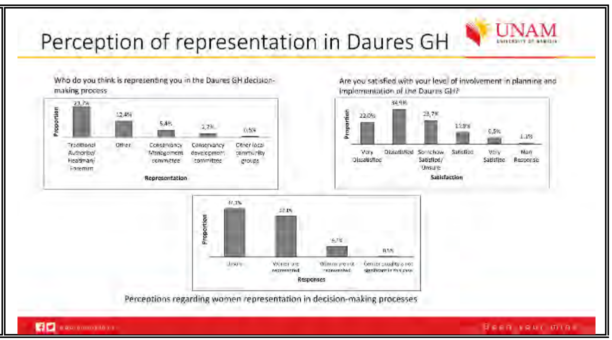

UNAM
Study area
Namibia
Botswana
Open your mind
4


UNAM
Daures Green Hydrogen Social Survey
• Survey conducted Okombahe, Uis, Tsiseb Conservancy, Sorris Sorris Conservancy, Daures Green Hydrogen Village and Henties Bay.
• Quantitative Survey, Systematic sampling
• Descriptive statistics (SPSS)
• 186 household questionnaire completed
• Respondents: Male (51.1%) and Female (48.9%)
• Unemployed respondents: 39.2
Open your mind
5

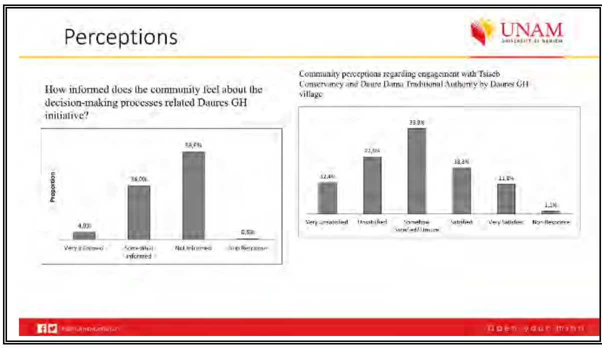

Awareness of GH and Daures GH Village
UNAM
Are you aware of the stakeholder engagement processes regarding the Dâures Green Hydrogen Initiative?
Aware of Daures GH Village?
Level of satisfaction regarding community participation on Daures GH
Have you been involved in any consultations or discussions regarding the green hydrogen project?
94% YES
6% NO
Satisfaction
Open your mind
6


UNAM
At what levels are decisions and consultations made by Daures Green Hydrogen Village?
Open your mind

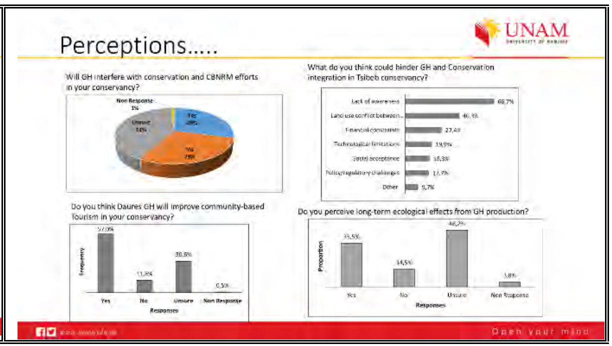
7


Perception of representation in Daures GH
UNAM
Perceptions regarding women representation in decision-making processes

8


Perceptions
UNAM
How informed does the community feel about the decision-making processes related Daures GH initiative?
Open your mind

9


Perceptions.....
UNAM
Will GH interfere with conservation and CBNRM efforts in your conservancy?
Do you think Daures GH will improve community-based tourism in your conservancy?
Do you perceive long-term ecological effects from GH production?

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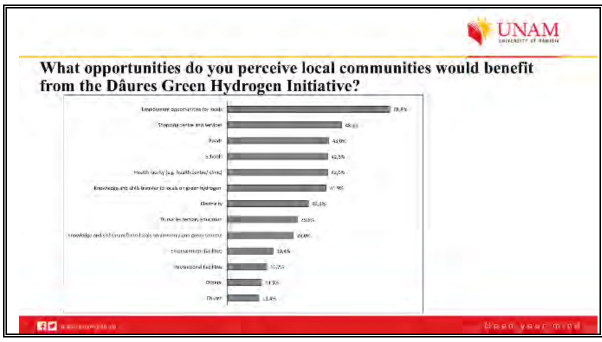
UNAM
What opportunities do you perceive local communities would benefit from the Dâures Green Hydrogen Initiative?

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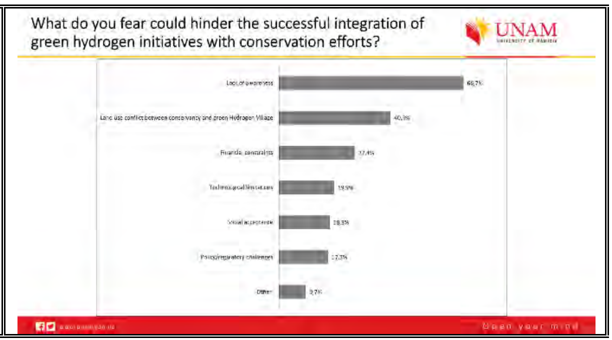
What do you fear could hinder the successful integration of green hydrogen initiatives with conservation efforts?
UNAM

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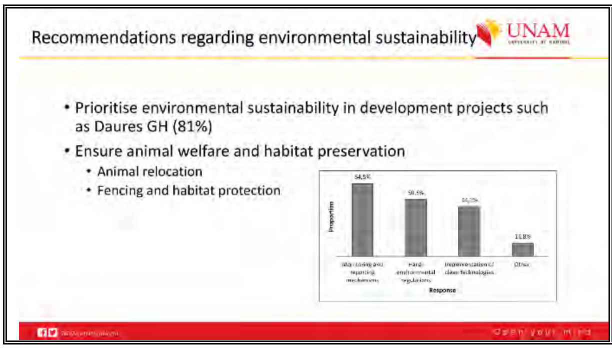


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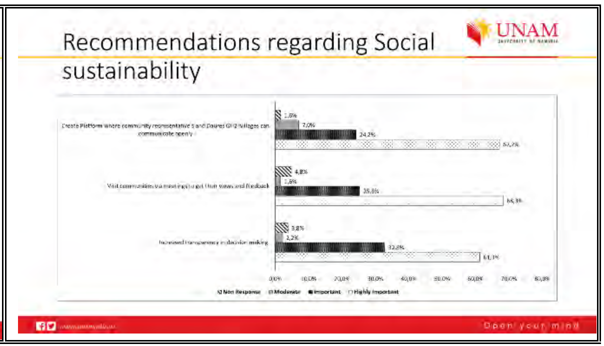


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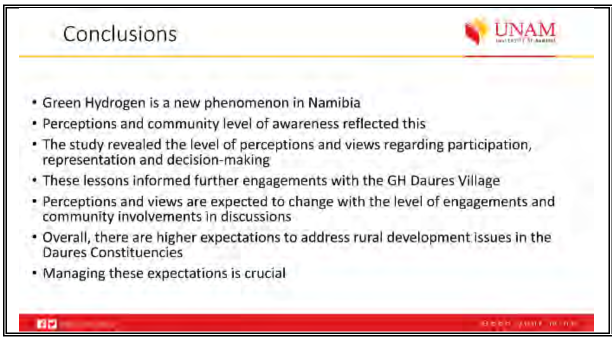


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# Application of $GH_2$-Based Ammonia-Derived Fertilizers in Improving Desert Soil Fertility at Daures Village

M Johannes[1*], V Uahengo[1], J Naimhwaka[1], T Plessing[3]

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[2]Dept of Biology, Chemistry and Physics, Namibia University of Science and Technology, Namibia

[3]Institut für Wasserstoff- und Energietechnik der Hochschule HOF, Germany

## Introduction

Namibia's agricultural potential remains largely untapped, despite possessing vast stretches of arable land such as the Namib desert due to factors such as low soil fertility (mainly gypcrete/ calcrete soil type) and water shortage. As a result, the country finds itself compelled to import a substantial portion of its food requirements to meet the demands of its population. With green hydrogen ($GH_2$) at the center stage in Namibia, green ammonia derived from GH2 presents an opportunity for application in the production of smart fertilizers to improve soil fertility at Daures Village, Namib Desert, Namibia. The research employed a quantitative approach. Liquid ammonia (NH4OH) generated and collected from the $H_2$ plant at Daures village was used to produce ammonium salts ($NH_4NO_3$, $NH_4SO_4$), which were processed further and applied to the sand collected from Daures village. Other soil parameters such as pH, soil type, moisture contents, alkalinity, salinity, etc. were established, before and after the treatment. A variety of crops were seeded and planted in the treated and untreated samples, results were compared. The results proved that neutralizing alkalinity and adjusting salinity of the course-structured sand soil was key to have crops germinating. In addition, the addition of organic matters in the form of dry grass or others such as peals of fruits (after seeds were removed) provide much needed anchor for crops to germinate easily. Transplanting trees has been recommended for the long-term sustainability smart agriculture to regulate temperature, however, in the short-term shade nets are feasible to protect crops from direct sun. Thus, tomatoes and cabbages were successfully seeded, grown and sown after 3 months in the treated soil, compared to nothing in the untreated control sample. Conclusively, $GH_2$ application can be applied towards producing smart fertilizer for enhancing soil fertility for crop growth in areas of need including the Namib Desert.

Ms. Matilde T. Johannes is a dedicated Namibian postgraduate student currently pursuing a Master of Science in Renewable Energy at the University of Namibia. She holds a Bachelor of Science in Medicinal Chemistry from the same institution. Matilde is a former recipient of the ERA Fellowship – Green Hydrogen for International Master's Students, funded by the BMBF through the German Academic Exchange Service (DAAD). She serves as a student research assistant at the Namibia Green Hydrogen Research Institute at UNAM, where she is actively engaged in a project focused on the production of green hydrogen-based ammonia-derived fertilizers and their application in improving desert soil fertility at Daures Village for sustainable agriculture, supported by the Daures Green Hydrogen Consortium. From November 2024 to March 2025, she interned at the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) in Germany, where she was primarily involved in the quality testing of these fertilizers.

**Application of GH2 - Based Ammonia - Derived Fertilizers in Improving Desert Soil Fertility at Daures Village**

M. JOHANNES, V. UAHENGO, J. NAIMHWAKA, T. PLESSING

Namibia German Green Hydrogen Research and Development Conference
Windhoek, Namibia
04 June 2025

1

## Background & Problem statement

- Namibia has vast desert land but faces challenges in farming due to: Poor soil fertility & Limited water availability.
- Daures Green Hydrogen Village is piloting green ammonia production using renewable energy.
- Project focuses on using green ammonia-based fertilizer.
- Goal: Enable the local community to crop growth directly in soil.

2

## Objectives & Study Significance

**Objectives:**

- Collection and characterization of the desert soil.
- Synthesize and characterize Ammonium Nitrate & Ammonium Sulphate fertilizer.
- Desert soil treatment and crop planting.

**Significances:**

- Improved desert soil fertility
- Support local agriculture
- Low-carbon farming

3

## Procedures

- **Lab Ammonium Nitrate (LAN) synthesis**
  - $NH_4OH_{(aq)} + HNO_{3\,(aq)} \longrightarrow NH_4NO_{3\,(aq)} + H_2O_{(l)}$ [1]
- **Lab Ammonium Sulphate (LAS) synthesis**
  - $2NH_3OH_{(aq)} + H_2SO_{4\,(aq)} \longrightarrow (NH_4)_2SO_{4\,(aq)} + 2H_2O_{(l)}$ [2]
- **Desert Soil Samples: Daures Green Hydrogen Village**
- **Qualitative Analysis done**: pH, Water Holding Capacity, FTIR, UV-Vis, Elemental composition, Nitrogen content, fertilizer moisture content & Soil particle size distribution

[1] Ese T. First degree programme in chemistry TableI: Course structure, Scheme of Instruction and Evaluation.
[2] Zhao L. Production of ammonium sulfate fertilizer using acid spray wet scrubbers. Agricultural Engineering International: CIGR Journal. 2015 Apr 26.

4

## Results & Discussions

- **Desert Sand pH Analysis & Water Holding Capacity**

| Trial | Sample | pH 1M KCl | pH 0.01M $CaCl_2$ |
|---|---|---|---|
| 1 | 1 | 8.06 | 9.06 |
| | 2 | 7.55 | 8.17 |
| | 3 | 7.76 | 8.46 |
| 2 | 1 | 8.07 | 8.93 |
| | 2 | 7.68 | 7.68 |
| | 3 | 7.74 | 7.74 |

[3]

1M KCl : 7.55 – 8.06; 0.01M $CaCl_2$ : 7.74 – 9.06

[4]

Water Holding Capacity : 32 -37% = Coarse Fr.

[3] Gavriloaiei T. The influence of electrolyte solutions on soil pH measurements. Rev.Chim. 2012 Apr 1;63(4):396-400.
[4] Klute, Arnold. Water retention: laboratory methods. *Methods of soil analysis: part 1 physical and mineralogical methods*, 1986, 5. Jg., S. 635-662.

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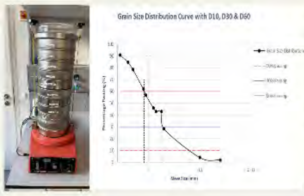
## Results & Discussions

- **Desert Sand Particle Size Distribution**




[5]

**Uniformity Coefficient**

$$C_u = \frac{D60}{D10} = \frac{1.21\ mm}{0.16\ mm} = 7.56$$

**Coefficient of Curvature**

$$C_c = \frac{(D30)^2}{D10\ X\ D60} = \frac{(0.53\ mm)^2}{0.16\ mm\ X\ 1.21\ mm} = 1.45$$

- (Cu > 4 and 1 < Cc < 3)- Moderately well-graded
- Directly influences various soil properties and processes, vital for plant growth

[5]Carter MR, Gregorich EG. Soil sampling and methods of analysis. CRC press; 2007 Aug 3.

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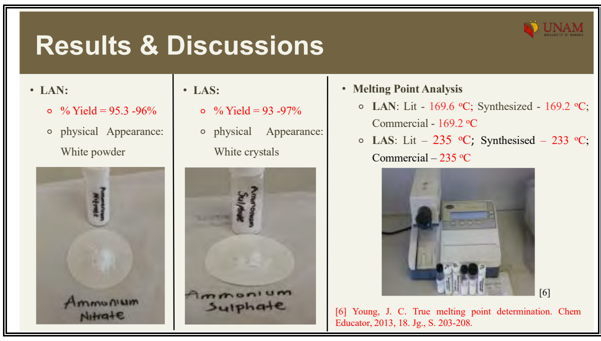
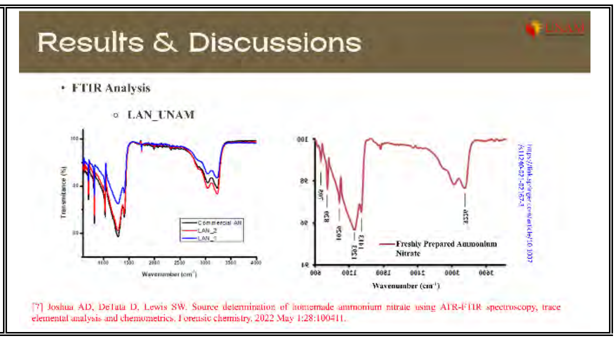

Results & Discussions
UNAM
LAN:
% Yield = 95.3 -96%
physical Appearance: White powder
LAS:
% Yield = 93 -97%
physical Appearance: White crystals
Melting Point Analysis
LAN: Lit - 169.6 °C; Synthesized - 169.2 °C; Commercial - 169.2 °C
LAS: Lit – 235 °C; Synthesised – 233 °C; Commercial – 235 °C
Ammonium Nitrate
Ammonium Sulphate
[6]
[6] Young, J. C. True melting point determination. Chem Educator, 2013, 18. Jg., S. 203-208.

7


Results & Discussions
FTIR Analysis
LAN_UNAM
Transmittance (%)
Wavenumber (cm⁻¹)
Freshly Prepared Ammonium Nitrate
Wavenumber (cm⁻¹)
[7] Joshua AD, DeLuca D, Lewis SW. Source determination of homemade ammonium nitrate using ATR-FTIR spectroscopy, trace elemental analysis and chemometrics. Forensic chemistry. 2022 May 1;28:100411.

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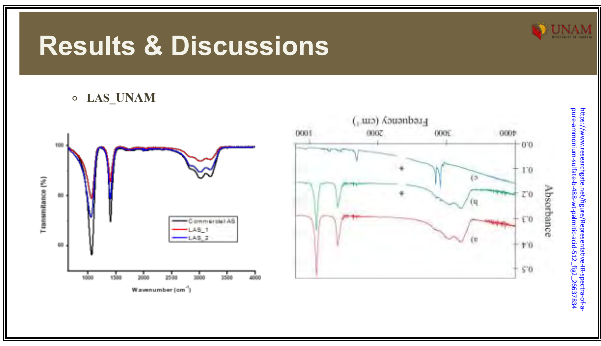
Results & Discussions
UNAM
LAS_UNAM
Transmittance (%)
Wavenumber (cm⁻¹)
Commercial AS
LAS_1
LAS_2
Frequency (cm⁻¹)
Absorbance

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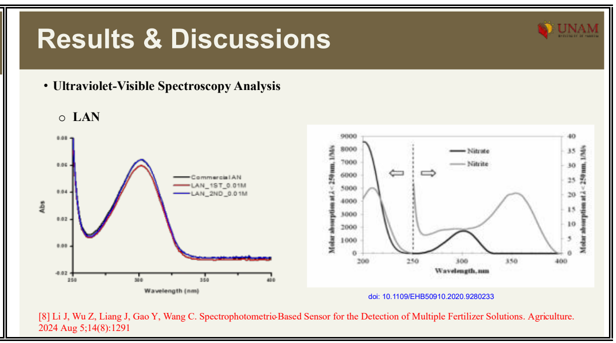
Results & Discussions
UNAM
Ultraviolet-Visible Spectroscopy Analysis
LAN
Abs
Wavelength (nm)
Commercial AN
LAN_1ST_0.01M
LAN_2ND_0.01M
Nitrate
Nitrite
Wavelength, nm
doi: 10.1109/EHB50910.2020.9280233
[8] Li J, Wu Z, Liang J, Gao Y, Wang C. Spectrophotometric-Based Sensor for the Detection of Multiple Fertilizer Solutions. Agriculture. 2024 Aug 5;14(8):1291

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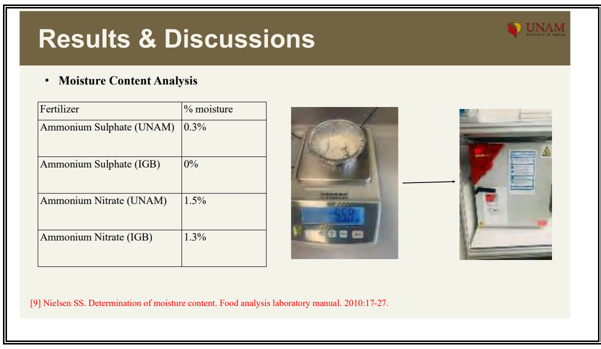
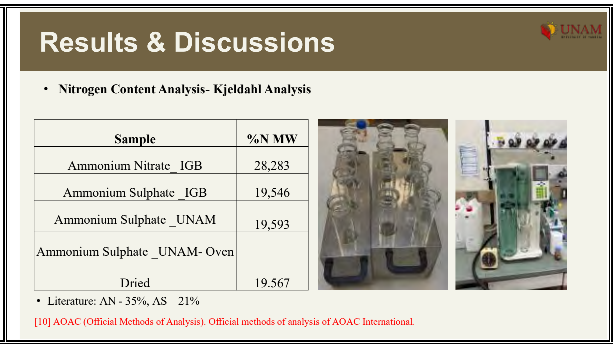

Results & Discussions
UNAM
Moisture Content Analysis
Fertilizer | % moisture
Ammonium Sulphate (UNAM) | 0.3%
Ammonium Sulphate (IGB) | 0%
Ammonium Nitrate (UNAM) | 1.5%
Ammonium Nitrate (IGB) | 1.3%
[9] Nielsen SS. Determination of moisture content. Food analysis laboratory manual. 2010:17-27.

11


Results & Discussions
UNAM
Nitrogen Content Analysis- Kjeldahl Analysis
Sample | %N MW
Ammonium Nitrate_ IGB | 28,283
Ammonium Sulphate _IGB | 19,546
Ammonium Sulphate _UNAM | 19,593
Ammonium Sulphate _UNAM- Oven Dried | 19.567
Literature: AN - 35%, AS – 21%
[10] AOAC (Official Methods of Analysis). Official methods of analysis of AOAC International.

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## Results & Discussions

- **Macro Nutrient Analysis**

| | Sample (mg/kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Element** | **IGB LAS** | **UNAM LAS** | **IGB LAN** | **Untreated sand** | **IGB LAS Treated Sand** | **UNAM LAS Treated Sand** | **IGB LAN Treated Sand** |
| **Calcium** | 13.8 | 8.37 | < 3 | 38.4 | 419 | 430 | 446 |
| **Potassium** | 5.61 | < 2 | < 2 | 25.1 | 81.1 | 82.3 | 84.5 |
| **Phosphorus** | 0.724 | < 0.6 | < 0.6 | 6.23 | 18.5 | 31.9 | 6.97 |

[11] Otero N, Vitoria L, Soler A, Canals A. Fertiliser characterisation: major, trace and rare earth elements. Applied geochemistry. 2005 Aug 1;20(8):1473-88

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## Results & Discussions

- **Micro Nutrient Analysis**

| | Sample (mg/kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Element** | **IGB LAS** | **UNAM LAS** | **IGB LAN** | **Untreated sand** | **IGB LAS Treated Sand** | **UNAM LAS Treated Sand** | **IGB LAN Treated Sand** |
| Manganese | 0.188 | 0.026 | < 0.02 | 0.115 | 0.368 | 0.394 | 0.155 |
| Iron | 0.447 | 1.28 | < 0.1 | 2.72 | 0.410 | 0.319 | 0.256 |
| Calcium | 13.8 | 8.37 | < 3 | 38.4 | 419 | 430 | 446 |
| Sodium | 12.3 | 2.86 | 6.17 | 28.5 | 29.2 | 27.5 | 28.1 |
| Magnesium | < 3 | < 3 | < 3 | 11.1 | 63.3 | 69.7 | 58.5 |

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## Results & Discussions

- **Heavy Metals Analysis**

| | Sample (mg/kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Element** | **IGB LAS** | **UNAM LAS** | **IGB LAN** | **Untreated sand** | **IGB LAS Treated Sand** | **UNAM LAS Treated Sand** | **IGB LAN Treated Sand** |
| Zinc | 0.331 | 0.754 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| | 0.23 | 0.750 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Lead | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 |
| | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 |
| Cadmium | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Cadmium | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |

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## Results & Discussions

- **Plant Growth – 4 Failed Trials**

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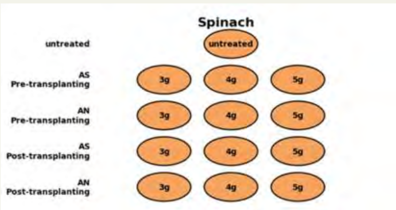
## Results & Discussions

- **Plant Growth - Design**

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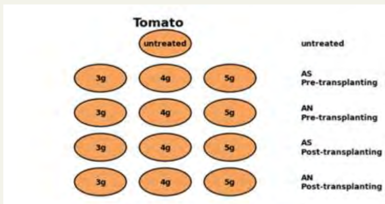
## Results & Discussions

- **Plant Growth - Design**

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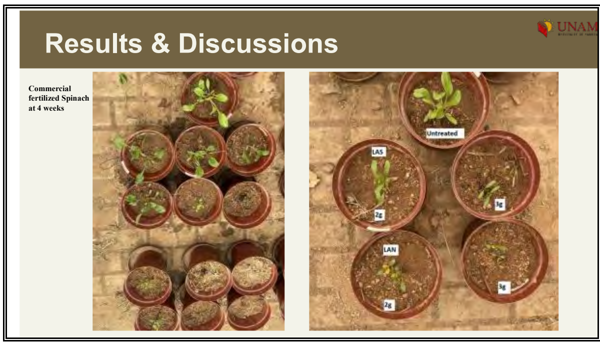


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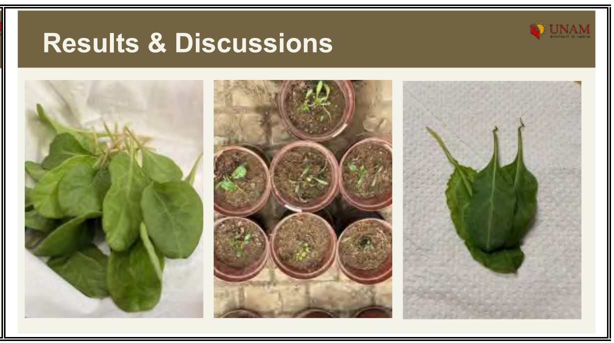


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THANK YOU
SASSCAL
NGHRI
UNAM
UNIVERSITY OF NAMIBIA
Fraunhofer
IGB

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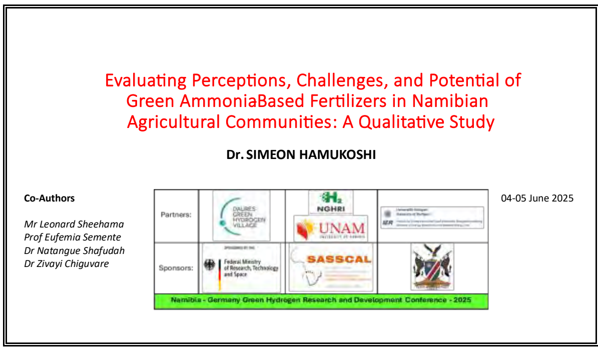
# National Needs Assessment for Green Ammonium Based Fertilizers: Evaluating Demand, Supply, and Sustainability

Simeon Hamukoshi[1*], Leonard Sheehama, Eufemia Semente, Natangue Shafudah, and Zivayi Chiguvare

NGHRI – University of Namibia

The effective crop yield and nutrient retention, as well as economic viability, of green ammonia derived fertilizers was assessed, using a qualitative research methodology, through the engagement with 30 individuals with diverse agricultural experiences. Namibians in Omaheke, Omusati, Kavango, Hardap, Otjozondjupa and other regions across the country depend on agriculture activities for food and financial sustenance. The study found that the participants preferred conventional (chemical) based traditional fertilizers because they believe they are better for the ecosystem and the soil. All the participants agreed that chemical fertilizers enhance soil quality and raise crop production levels. However, it became evident that individuals might not be able to use these imported fertilizers to their full potential due to their high cost. The existence of green ammonia-based fertilizers was, however, not well known by the farmers. The participants were curious to find out more about green ammonia and to observe its practical applications in the agricultural space. Results indicated that the regions mentioned would be ideal for testing and applying green ammonium-based fertilizers. It is recommended that the knowledge gap among farmers in the stated, and other, regions of Namibia be closed through demonstrations of effectiveness of environmentally friendly green ammonia-based fertilizers on plant growth and yields. Farmers should be encouraged to use green fertilizers as an alternative approach due to the said advantages. Introduction of policy measures that maximize the benefits of lower fertilizer pricing of locally produced green ammonia-based fertilizers, derived from green hydrogen production, is thus encouraged in Namibia

| | |
|---|---|
|  | Dr. Simeon Hamukoshi is a versatile professional with a PhD in Chemistry and cross-disciplinary expertise in science, policy, and emerging technologies. As a Strategic Projects Coordinator at the National Commission on Research, Science and Technology (NCRST), he advises the CEO, leads policy research, and supports the integration of Artificial Intelligence. He also serves as a Research Associate at the Namibia Green Hydrogen Research Institute, contributing to green hydrogen research, project management, and student supervision. Dr. Hamukoshi has lectured at the University of Namibia and worked as a Laboratory Chemist, ensuring quality control and compliance. His strategic insight is reflected in his service on national boards and task forces focused on green hydrogen and procurement. He is known for his strong leadership, communication, and project management skills, and remains actively engaged in initiatives that advance science and technology for national development. |


Evaluating Perceptions, Challenges, and Potential of Green AmmoniaBased Fertilizers in Namibian Agricultural Communities: A Qualitative Study
Dr. SIMEON HAMUKOSHI
Co-Authors
Mr Leonard Sheehama
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04-05 June 2025
Partners:
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SASSCAL
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• Green Ammonia-Based Fertilizers
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• Challenges to Adopting Green Ammonia Fertilizers
• Sustainability and Economic Advantages of Green Ammonia Fertilizers
• Role of Community and Research in Namibia
• Recommendations for Promoting Adoption
• Conclusion

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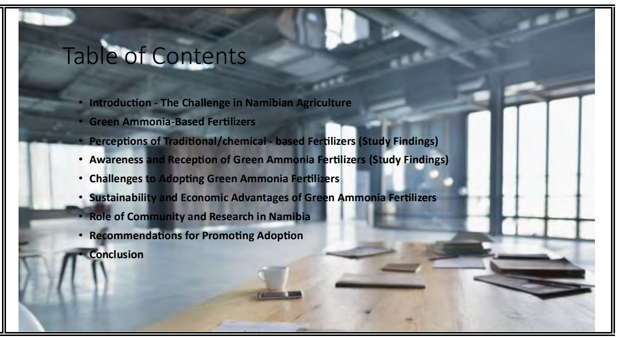
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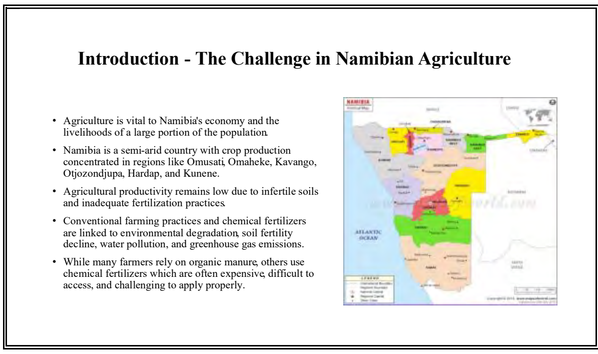
Introduction - The Challenge in Namibian Agriculture
• Agriculture is vital to Namibia's economy and the livelihoods of a large portion of the population.
• Namibia is a semi-arid country with crop production concentrated in regions like Omusati, Omaheke, Kavango, Otjozondjupa, Hardap, and Kunene.
• Agricultural productivity remains low due to infertile soils and inadequate fertilization practices.
• Conventional farming practices and chemical fertilizers are linked to environmental degradation, soil fertility decline, water pollution, and greenhouse gas emissions.
• While many farmers rely on organic manure, others use chemical fertilizers which are often expensive, difficult to access, and challenging to apply properly.
ATLANTIC OCEAN

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Green Ammonia-Based Fertilizers
• Green ammonia-based fertilizers are a sustainable fertilizer alternative.
• Green ammonia is produced using renewable energy sources (like wind, solar, hydropower) to electrolyze water for green hydrogen and nitrogen from the air via the Haber Bosch process. This production method eliminates the need for fossil fuels and reduces greenhouse gas emissions.
• When reacted with sulphuric acid, which is available locally in Namibia, green ammonia forms ammonium sulphate, a nitrogen-rich fertilizer with a lower environmental footprint.
• Namibia is well-positioned for this innovation due to abundant solar and wind resources and access to seawater for green hydrogen production at competitive costs.
• Namibia currently imports and re-exports ammonium-based fertilizers, indicating a market for locally produced options.
AMMONIUM SULPHATE

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## Perceptions of Traditional/chemical - based Fertilizers (Study Findings)

- Participants in the study **preferred traditional based fertilizers** because they believe they are **better for the ecosystem and the soil**.
- This preference aligns with a mindset prioritizing earth-friendly practices, although traditional practices sometimes involve substantial use of natural or organic fertilizers.
- Participants observed that adding organic matter to regular fertilizers improves soil health and crop productivity by altering soil composition, retaining water, and promoting microorganisms.
- The **high cost of imported conventional fertilizers** was identified as a significant barrier.
- Participants felt they might not be able to use imported fertilizers to their full potential due to their high cost.

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## Awareness and Reception of Green Ammonia Fertilizers (Study Findings)

- THE **EXISTENCE OF GREEN AMMONIA-BASED FERTILIZERS WAS NOT WELL KNOWN** BY THE FARMERS PARTICIPATING IN THE STUDY.
- INTERVIEWS SHOWED THE FARMING COMMUNITY HAS **VERY LITTLE UNDERSTANDING** OF THIS NEW TYPE OF FERTILIZER.
- PARTICIPANTS EXPRESSED A **SIGNIFICANT LACK OF AWARENESS AND KNOWLEDGE**, INDICATING A PERVASIVE INFORMATION VOID.
- DESPITE THE LACK OF DETAILED KNOWLEDGE, ONE PARTICIPANT RECOGNIZED TALK ABOUT GREEN AMMONIA BEING **VERY ENVIRONMENTALLY FRIENDLY**.
- PARTICIPANTS WERE **CURIOUS TO FIND OUT MORE** ABOUT GREEN AMMONIA AND TO OBSERVE ITS PRACTICAL APPLICATIONS IN THE AGRICULTURAL SPACE.
- SUGGESTIONS WERE MADE FOR PROVIDING **SAMPLES AND MORE INFORMATION** TO FOSTER UNDERSTANDING AND POTENTIAL ACCEPTANCE.

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## Challenges to Adopting Green Ammonia Fertilizers

- A significant obstacle is the **high initial cost** of producing green ammonia, including investing in renewable energy sources and electrolysis facilities.
- Currently, the production of green ammonia may be **less efficient** than conventional methods, potentially leading to higher costs.
- Farmers **lack of familiarity and awareness** is a major barrier to adoption.
- There is a **need for specialized equipment and facilities** to handle and use green ammonia fertilizers properly.
- Insufficient **technical experts** are available to oversee and maintain green ammonia production plants.
- Many areas **lack the necessary infrastructure** for electrolysis and renewable energy sources.
- Switching to green ammonia fertilizers will be **expensive and time-consuming**, requiring government assistance, such as tax breaks and funding.
- Insufficient **laws and infrastructure** supporting renewable energy can keep green ammonia production costs high.

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## Sustainability and Economic Advantages of Green Ammonia Fertilizers

| Environmental Advantages: | Agricultural Advantages: | Economic Advantages: |
|---|---|---|
| Reduces reliance on fossil fuels, minimizing carbon emissions in production and application. | Promotes nutrient retention in soil and increases crop yields. | Potential for **cheaper production costs** in Namibia due to local green hydrogen/ammonia production and renewable energy use. |
| Lowers environmental footprint compared to conventional nitrogen fertilizers. | Can significantly enhance soil fertility and crop productivity. | Stabilizes production costs by mitigating reliance on fluctuating fossil fuel prices. |
| Minimizes nitrous oxide emissions, a potent greenhouse gas. | Gradual nitrogen release minimizes nutrient losses and improves nitrogen use efficiency. | Reduces reliance on expensive imported fertilizers. |
| Reduces nitrogen runoff and leaching, mitigating soil degradation, water pollution, and eutrophication. | | Potential for **job growth** in renewable energy and green ammonia production/application industries. |
| | | Long-term benefits, including higher yields and reduced environmental cleanup costs, may **outweigh initial expenditures**. |

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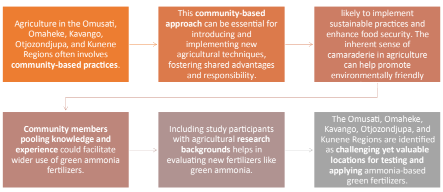
## Role of Community and Research in Namibia

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## Recommendations for Promoting Adoption in Namibia

- Launch **large-scale education and awareness campaigns** to inform farmers about the benefits and proper use of green ammonia-based fertilizers. These should involve agricultural extension workers, local leaders, and community influencers.
- Conduct **trials and case studies**, including demonstration farms, to visually show the effectiveness and advantages of these fertilizers on soil health and crop output. Providing samples is crucial.
- Researchers should investigate ways to provide **financial assistance or subsidies** to farmers to alleviate the cost burden of purchasing green fertilizers. Partnerships with governmental and non-governmental entities can help.
- **Advocate strongly for policies** that promote more affordable and ecologically friendly fertilizers, including financial incentives, tax breaks, and streamlined licensing/certification processes.

12

# Conclusions

- The study in the Omusati, Omaheke, Kavango, Otjozondjupa, and Kunene Regions reveals that farmers prefer traditional fertilizers due to perceived safety and soil benefits, despite the high cost of conventional options.
- There is a **significant lack of awareness** regarding green ammonia-based fertilizers among participants.
- Despite challenges like high initial costs and insufficient infrastructure/expertise, green ammonia-based fertilizers hold **immense potential** as an affordable and ecologically friendly alternative.
- They offer substantial environmental benefits (reduced emissions, pollution) and agricultural advantages (improved yields, soil health).
- Namibia's community-based agriculture and potential for local green ammonia production make these regions **valuable locations for testing and application**.
- Successful adoption will require **targeted interventions** focusing on education, awareness, practical demonstrations, financial support, and supportive policy frameworks.

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NGHRI

**THANK YOU**

| | | | |
|---|---|---|---|
| Partners: | DAURES GREEN HYDROGEN VILLAGE | NGHRI / UNAM | IER |
| Sponsors: | Federal Ministry of Research, Technology and Space | SASSCAL | |

**Namibia - Germany Green Hydrogen Research and Development Conference - 2025**

Pioneering Green Hydrogen Flagship Projects in Namibia

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# Auditing of Ptx Skills Localization Process at Daures Green Hydrogen Village Project Site During the Pilot Phase

Hina MuAshekele[1], and Shindume Hamukwaya[2]

As Namibia positions itself at the forefront of green hydrogen development, localized skills acquisition is critical to ensuring sustainable project outcomes. This paper presents an auditing study of the Power-to-X (PtX) skills localization process during the pilot phase of the Daures Green Hydrogen Village Project (DGHVP). Using a mixed-methods approach – including field surveys, stakeholder interviews, and institutional analysis – the research systematically evaluates demographic readiness, current workforce competencies, vocational training initiatives, and recruitment practices. The audit reveals strong community engagement and stakeholder interest but highlights substantial gaps in technical skills, vocational training access, and inclusive recruitment frameworks. Skills shortages are most pronounced in semi-skilled artisan trades and medium-level management roles, both essential for green hydrogen operations. Additionally, findings point to a misalignment between existing training programs and the operational needs of unit cost centres such as electrolysis, ammonia production, and renewable energy systems. The study offers strategic recommendations to address these gaps, including the establishment of decentralized vocational hubs, structured bridging programs for unskilled workers, strengthened public-private partnerships for skills development, and enhanced stakeholder-driven governance mechanisms. By critically examining the pilot phase implementation, this paper contributes to best practices for PtX workforce localization and capacity-building in emerging hydrogen economies.

Prof. Hina Jola Ali MuAshekele, is a retired Research Professor in Engineering, Technology and Innovation Management, focusing on the development of responsive and appropriate production techniques and system commercialization of local resources mobilization. His quest to find suitably production systems and innovations carried him through sectors such as civil engineering, fisheries, energy and IKS technologies, among others. He designed, fabricated and produced the Power Can (portable renewable energy, as well as designed, supervised/built and delivered low-income Built Together Houses for the Ministry of Housing and Rural Development, from local building materials and by local builders. He initiated, headed, coordinated and helped setting up the IKS research program at UNAM (including pharmaceutical and food research program streams), and has contributed various scientific publications, innovative and prototype products and system approaches to these thematic areas. He coordinated the research into the Auditing of the PtX Skills Localization/transfer at the Daures Green Hydrogen Village Pilot Project site, He served UNAM (as MRC Director), Namibian Government (as Coordinator of Cabinet Committee on Innovation and Value addition), UN Habitat (as Local Expert on the Development of Appropriate Housing and Infrastructure).

Dr. Shindume Lomboleni Hamukwaya is a Metallurgical Engineering Lecturer and Industrial Training Coordinator at the University of Namibia, School of Engineering and the Built Environment. He holds a Ph.D. in Materials Science and Engineering, and a master's degree in chemical engineering from China University of Geosciences, with a strong research background in renewable energy technologies, including perovskite solar cells, photocatalysis for hydrogen production, and sustainable energy systems. Dr. Hamukwaya is the lead project research manager in the auditing of Power-to-X (PtX) skills localization component of the Daures Green Hydrogen Village Project, where he plays a key role in assessing local capacity development during the pilot phase. His professional background spans academia and industry, including metallurgical laboratory leadership, quality assurance, and process optimization in mining operations. He has authored several peer-reviewed publications and received international recognition for innovation in low-carbon technologies. His work contributes significantly to building Namibia's future-ready hydrogen economy through inclusive skills development, and sustainable local participation.

UNAM
UNIVERSITY OF NAMIBIA

NGHRI

AUDITING PtX SKILLS LOCALIZATION PROCESS ACROSS THE DAURES GREEN HYDROGEN VILLAGE PILOT PROJECT VALUE CHAIN

Prof. Hina MuAshekele, Dr. Shindume Hamukwaya, Ms. Roswidis Akundungila,
Namibia Green Hydrogen Research Institute, UNAM

1

## Abstract

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- This report examines the localization of Power-to-X (PtX) skills at the Daures Green Hydrogen Village Project (DGHVP) in Namibia.
- Using surveys, interviews, and stakeholder input, it identifies gaps in technical skills, training access, and inclusive hiring.
- While community interest is strong, current programs in the market are misaligned with job demands and lack local integration.
- The study recommends inclusive and decentralized training program, recruitment, and stronger policy frameworks to address immediate and short-term skills gaps, taking community strengths into account.


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## Introduction

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- The Daures Green Hydrogen Village (DGHVP) is Namibia's flagship initiative under the national Green Hydrogen Strategy, designed to demonstrate the viability of producing hydrogen through renewable energy (solar PV) and to catalyze local economic participation.
- This site aims to not only showcase technological feasibility but also test models of inclusive growth through localized employment and training in Power-to-X (PtX) skills.
- Given Namibia's high solar irradiance, political commitment to the hydrogen economy, and rural unemployment challenges, DGHVP serves as a critical pilot to test how industrial-scale energy innovation can be implemented in an equitable and sustainable manner.
- This research audits the extent of skills localization at DGHVP, with specific attention to youth engagement, female participation, and the training-to-employment pipeline.
- The outcome of this audit informs future PtX workforce planning and identifies systemic gaps between policy intent and grassroots impact.

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## Objectives

- Audit PtX skills' profile on site
- Identify gaps in skills and qualifications
- Identification of unit cost centers most affected by skills' gap.
- Recommend inclusive remedial actions/policies

## Study Area

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- The Daures Constituency in Erongo Region hosts the DGHVP.
- The site was selected for its solar irradiance and proximity to community settlements.
- The region has limited industrial infrastructure but high potential for hydrogen technology roll-out.

### Methodology

- Quantitative Surveys: 244 respondents from surrounding communities and business stakeholder-interest groups
- Key Informant Interviews: 34 with project staff, traditional leaders, and government officials
- Focus Group Discussions (FGDs): Conducted in Okombahe and Omatjete
- Thematic and statistical analysis for validation

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## GENERAL RESULTS

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### Demographics

- Survey data shows that most respondents were aged 18–35, with the majority having only Grade 10–12 education.
- Women were underrepresented. Employment history in technical fields was limited, but interest in hydrogen-related roles was high.

### Skills'Gap Profile During Pilot Period

- Of **181** labourers 100% Namibians during construction period. 60% of these are local from Daures area.
- Only 10 artisans (out of 231 workers) are from the Daures Constituency, 45% are Namibians, gap 55%.
- In the medium level management category, the gap is estimated at 30%.
- For high level managers the gap is estimated to be less acute. Majority are Namibians.
- Total number of employees on site at survey time, March 2024, during construction time, was 428, exceeding, the targeted number of 100 employees.

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## GENERAL RESULTS Cont......

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### Unit Cost Centers Most Affected

- Critical unit cost centres likely to be affected by skills' gap are: the hydrogen production unit, ammonia plant unit, hydrogen and ammonia storage and transportation units.
- Critical skills will be in the work categories of: welding, fabrication, applied electrical, maintenance, safety, quality assurance, etc.

### Stakeholder Feedback

- Traditional leaders support the project but request more transparency in recruitment
- Local SMEs call for upskilling support and apprenticeship pathways, as well as possibility for collaboration
- Youths express concern about lack of communication on job openings and selection criteria

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# GENERAL RESULTS Cont…… 7

**Key Challenges**

- Low representation of local artisans
- Gender exclusion in technical hiring
- Absence of legal and operational technical standards and regulations.
- Absence of formal PtX curriculum in local institutions

**Opportunities for Localization**

- Decentralized PtX training centres
- Community engagement through Traditional Authorities
- Youth-targeted bridging and upskilling programs
- Curriculum and operational regulations and standards.

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# Results 8

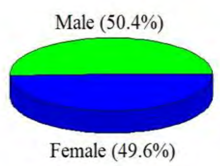


**Figure 1:** *Highest Level of Education Achieved*

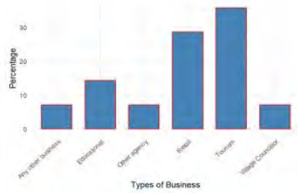


**Figure 2:** *Community Participants by Village*

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# Results in Graphs Cont…… 9

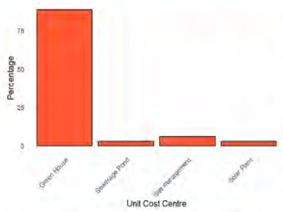


**Figure 3:** *Gender Representation in Survey Sample*

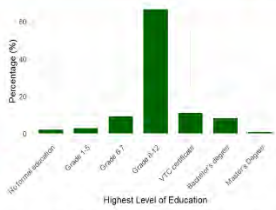


**Figure 4:** *Age Distribution of Respondents*

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# GENERAL RESULTS Cont…… 10

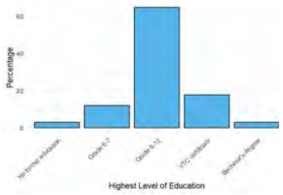


**Figure 5:** *Current Employment Status*

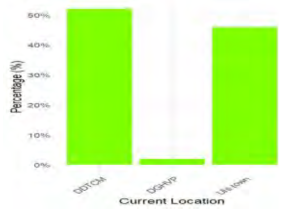


**Figure 6:** *Interest in Hydrogen Training*

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# GENERAL RESULTS Cont…… 11

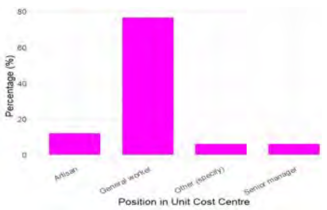


**Figure 7:** *Preferred Training Format*

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# Main Findings and Discussion 12

**Basis Short-term Actions**

- **45%** of artisans are Namibians and same Erongo region hosts, NIMT (Namibia Institute for Mining & Technology), a respected local VTC institute
- Huge interests and positive expectations from local community and business stakeholder-partners in the project
- **66.5%** hold Grade 10–12 education level, 11.0% hold VTC certificates (in total 77.5%) with Grade 12 certificate)
- Local demand for hands-on and modular PtX training is strong.

**Discussion**

- Workforce patterns show exclusion risks.
- Localization must be proactive, using bridging education, regional training hubs, and local engagement to align DGHVP with national hydrogen goals.

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## Conclusions

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- PtX workforce localization is crucial to Namibia's energy transition.
- The DGHVP must become a model for inclusive development by aligning policy ambitions with practical community expectations through education, engagement, and equitable hiring and procurement.

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## Recommendations

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- Develop modular PtX skills curriculum aligned to NQF levels, project needs, local community expectations and benchmarked to international standards
- Develop short-term training and upskilling competency - based programs, in response to identified immediate PtX skills' gaps across the DGHV project production value chain, in consultation with local community-interest groups.
- Incentivize local hiring through performance indicators
- Launch hydrogen awareness and recruitment campaigns in schools

14

## Acknowledgements

15

This study was conducted by the **Namibia Green Hydrogen Research Institute** with support from:

- University of Namibia
- Daman Traditional Authority
- Tsiseb Conservancy

**References**

1. Namibia Green Hydrogen Strategy (2022)
2. RENAC & GIZ. (2022). PtX Training Needs Assessment
3. Namibia Statistics Agency. (2021). Namibia Labour Force Survey
4. UNAM-IEC Research Policy Framework (2023)

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## References

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1. Namibia Green Hydrogen Strategy (2022)
2. RENAC & GIZ. (2022). PtX Training Needs Assessment
3. Namibia Statistics Agency. (2021). Namibia Labour Force Survey
4. UNAM-IEC Research Policy Framework (2023)

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## Research Team

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# Techno-Economic and social Analysis – TIMES Namibia Energy System Model

Laina Shipingana, Audrey Dobbins, Ulrich Fahl

Institute of Energy Economics and Rational Energy Use – University of Stuttgart, Heßbrühlstr. 49 a, D-70569 Stuttgart, Germany

Namibia's green hydrogen blueprint and strategy recognize that hydrogen could contribute to achievement of energy transition while positioning the country as a net-exporter of clean renewable energy. Apart from Namibia's long-term goal of reaching net zero emissions by 2050, Namibia 's Vision 2030 targets achievement of universal energy access and emissions reduction. Using TIMES optimization energy modelling tool, the study explores the role of hydrogen and derivatives in Namibia's energy system and social aspects. The model results are evaluated through scenario developments and analysis. The model constraints are Namibia's 2030 environmental and energy targets. The model input data is obtained from databases of reputable international agencies and local responsible institutions. The research proposes an appropriate solution crucial to reaching energy and environmental targets.

| | |
|---|---|
|  | Ms. Laina Shipingana holds a bachelor's degree in electrical engineering and a Master of science in Renewable Energy from the University of Namibia. She has an extensive experience in electrical engineering works, renewable energy systems and project management. Currently working a scientific researcher at the Institute of Energy Economic and Rational Energy Use (IER), Laina focuses on developing and analysing energy systems models, contributing to innovative solutions for a more sustainable energy system. As part of the Daures Green village research team, her study focuses on the green hydrogen economy; integration of hydrogen in energy transition pathways, and its socio-economic impacts. |


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IER Institute of Energy Economics and Rational Energy Use
Techno-Economic and Social Analysis of a Hydrogen Economy using ESM
04.06.2025
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Dr. Audrey Dobbins
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UNAM
SASSCAL

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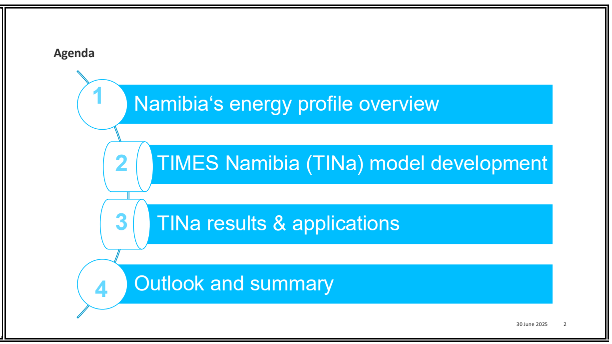
Agenda
1 Namibia's energy profile overview
2 TIMES Namibia (TINa) model development
3 TINa results & applications
4 Outlook and summary
30 June 2025 2

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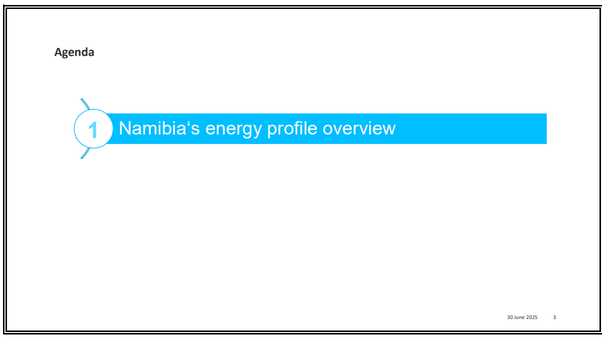
Agenda
1 Namibia's energy profile overview
30 June 2025 3

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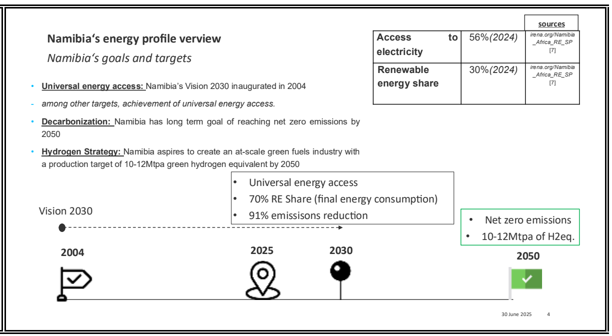
Namibia's energy profile verview
Namibia's goals and targets
Universal energy access: Namibia's Vision 2030 inaugurated in 2004
among other targets, achievement of universal energy access.
Decarbonization: Namibia has long term goal of reaching net zero emissions by 2050
Hydrogen Strategy: Namibia aspires to create an at-scale green fuels industry with a production target of 10-12Mtpa green hydrogen equivalent by 2050
sources
Access to electricity | 56%(2024) | irena.org/Namibia_Africa_RE_SP [7]
Renewable energy share | 30%(2024) | irena.org/Namibia_Africa_RE_SP [7]
Vision 2030
Universal energy access
70% RE Share (final energy consumption)
91% emissisons reduction
Net zero emissions
10-12Mtpa of H2eq.
2004
2025
2030
2050
30 June 2025 4

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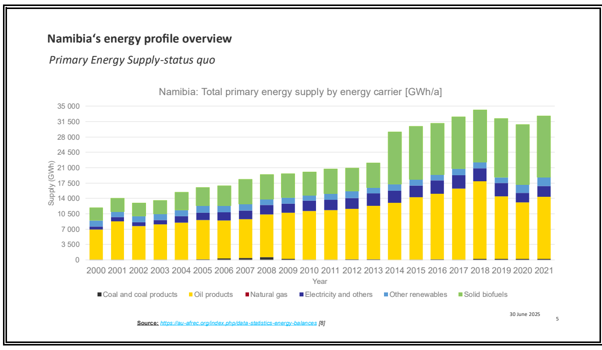
Namibia's energy profile overview
Primary Energy Supply-status quo
Namibia: Total primary energy supply by energy carrier [GWh/a]
Supply (GWh)
Year
Coal and coal products
Oil products
Natural gas
Electricity and others
Other renewables
Solid biofuels
30 June 2025 5

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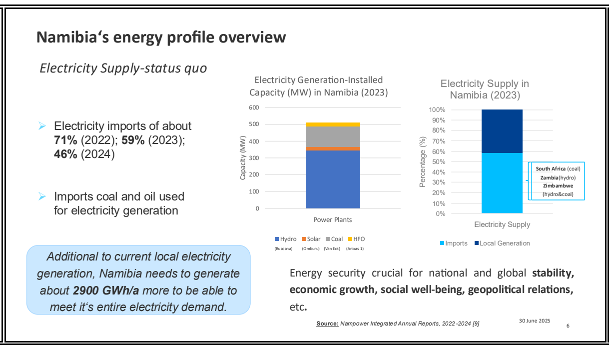
Namibia's energy profile overview
Electricity Supply-status quo
Electricity imports of about 71% (2022); 59% (2023); 46% (2024)
Imports coal and oil used for electricity generation
Electricity Generation-Installed Capacity (MW) in Namibia (2023)
Capacity (MW)
Power Plants
Hydro (Ruacana)
Solar (Omburu)
Coal (Van Eck)
HFO (Anixas 1)
Electricity Supply in Namibia (2023)
Percentage (%)
South Africa (coal)
Zambia (hydro)
Zimbambwe (hydro&coal)
Electricity Supply
Imports
Local Generation
Additional to current local electricity generation, Namibia needs to generate about 2900 GWh/a more to be able to meet it's entire electricity demand.
Energy security crucial for national and global stability, economic growth, social well-being, geopolitical relations, etc.
Source: Nampower Integrated Annual Reports, 2022-2024 [9]
30 June 2025 6

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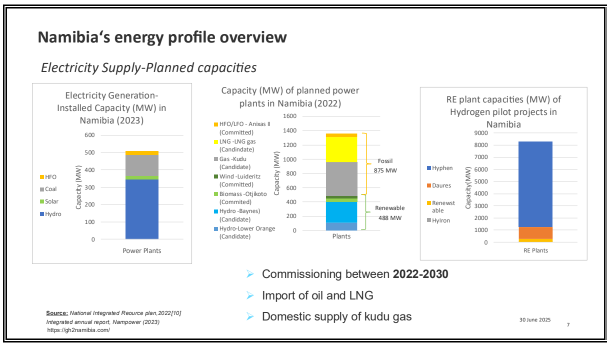
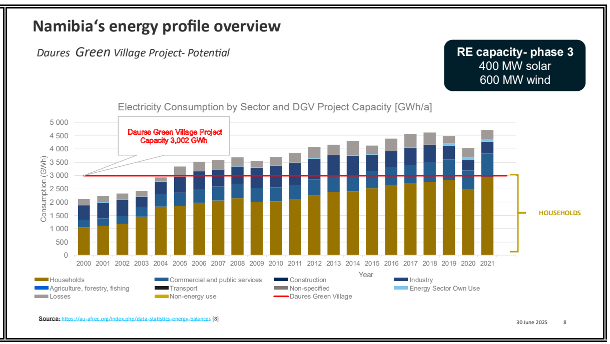

Namibia's energy profile overview
Electricity Supply-Planned capacities
Electricity Generation-Installed Capacity (MW) in Namibia (2023)
Capacity (MW) of planned power plants in Namibia (2022)
RE plant capacities (MW) of Hydrogen pilot projects in Namibia
Commissioning between 2022-2030
Import of oil and LNG
Domestic supply of kudu gas


Namibia's energy profile overview
Daures Green Village Project- Potential
RE capacity- phase 3
400 MW solar
600 MW wind
Electricity Consumption by Sector and DGV Project Capacity [GWh/a]
Daures Green Village Project Capacity 3,002 GWh
HOUSEHOLDS

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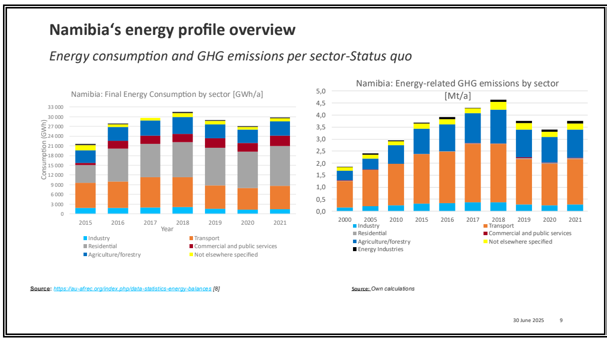
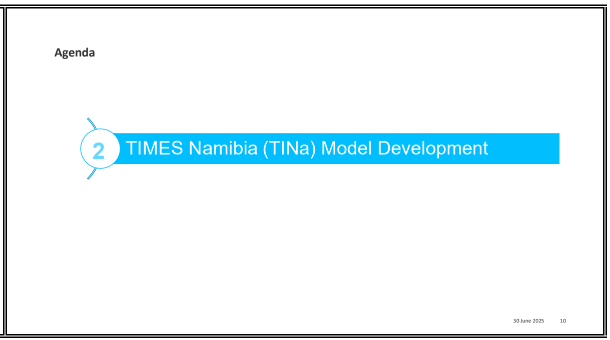

Namibia's energy profile overview
Energy consumption and GHG emissions per sector-Status quo
Namibia: Final Energy Consumption by sector [GWh/a]
Namibia: Energy-related GHG emissions by sector [Mt/a]


Agenda
2 TIMES Namibia (TINa) Model Development

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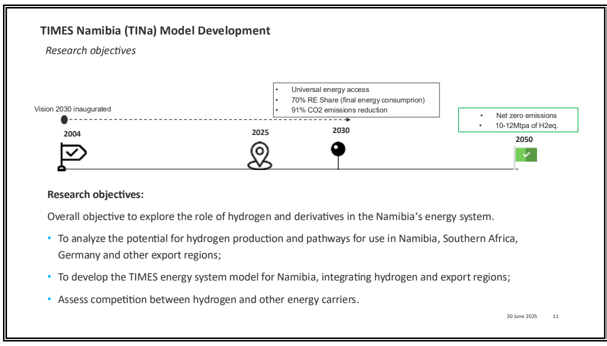
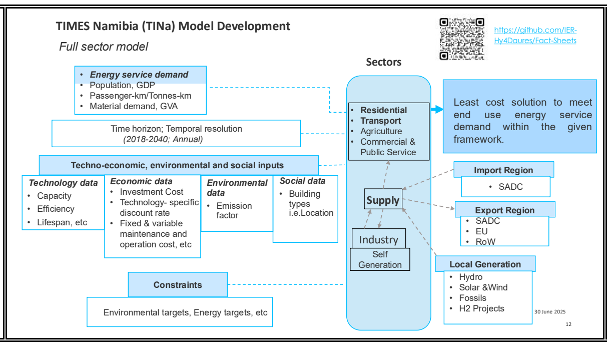

TIMES Namibia (TINa) Model Development
Research objectives
Vision 2030 inaugurated
2004
2025
2030
2050
Universal energy access
70% RE Share (final energy consumption)
91% CO2 emissions reduction
Net zero emissions
10-12Mtpa of H2eq.
Research objectives:
Overall objective to explore the role of hydrogen and derivatives in the Namibia's energy system.
To analyze the potential for hydrogen production and pathways for use in Namibia, Southern Africa, Germany and other export regions;
To develop the TIMES energy system model for Namibia, integrating hydrogen and export regions;
Assess competition between hydrogen and other energy carriers.


TIMES Namibia (TINa) Model Development
Full sector model
Energy service demand
Population, GDP
Passenger-km/Tonnes-km
Material demand, GVA
Time horizon; Temporal resolution
(2018-2040; Annual)
Techno-economic, environmental and social inputs
Technology data
Capacity
Efficiency
Lifespan, etc
Economic data
Investment Cost
Technology- specific discount rate
Fixed & variable maintenance and operation cost, etc
Environmental data
Emission factor
Social data
Building types
i.e.Location
Constraints
Environmental targets, Energy targets, etc
Sectors
Residential
Transport
Agriculture
Commercial & Public Service
Supply
Industry
Self Generation
Least cost solution to meet end use energy service demand within the given framework.
Import Region
SADC
Export Region
SADC
EU
RoW
Local Generation
Hydro
Solar &Wind
Fossils
H2 Projects

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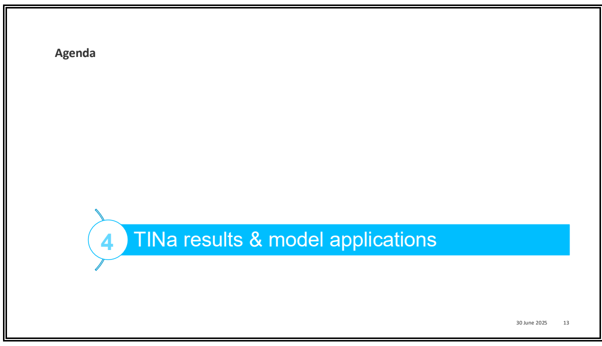


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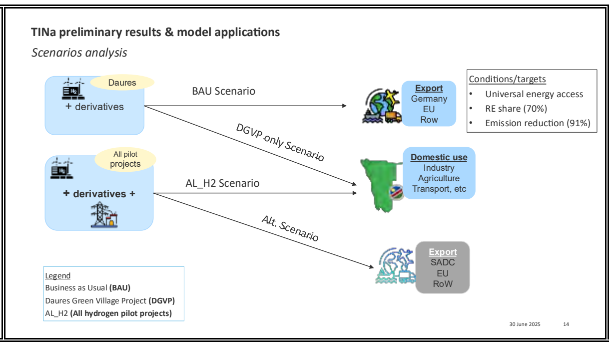


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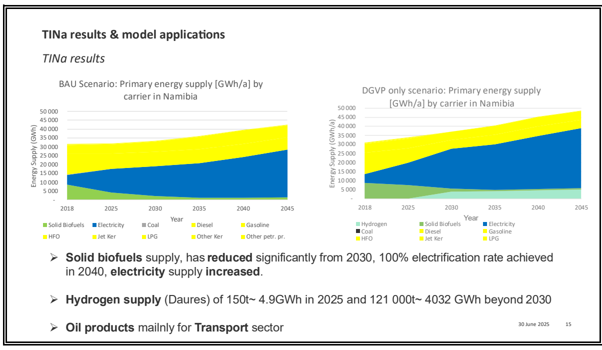


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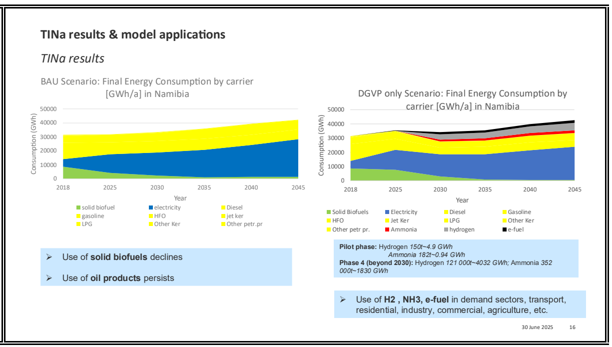


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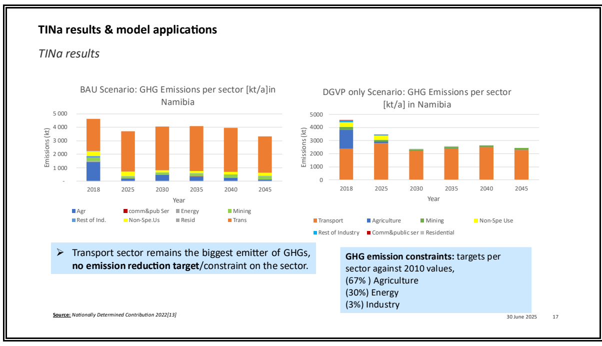


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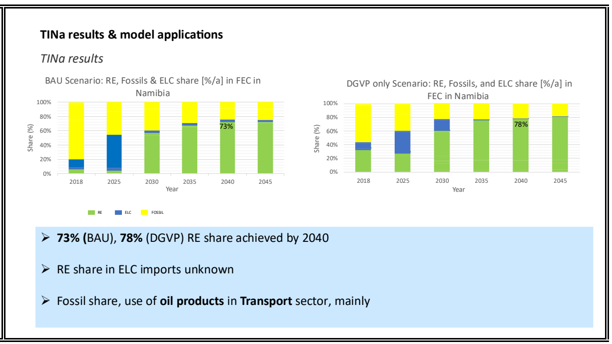


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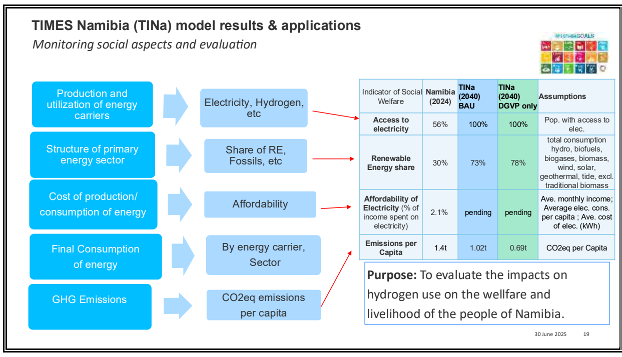


| Indicator of Social Welfare | Namibia (2024) | TINa (2040) BAU | TINa (2040) DGVP only | Assumptions |
|---|---|---|---|---|
| Access to electricity | 56% | 100% | 100% | Pop. with access to elec. |
| Renewable Energy share | 30% | 73% | 78% | total consumption hydro, biofuels, biogases, biomass, wind, solar, geothermal, tide, excl. traditional biomass |
| Affordability of Electricity (% of income spent on electricity) | 2.1% | pending | pending | Ave. monthly income; Average elec. cons. per capita ; Ave. cost of elec. (kWh) |
| Emissions per Capita | 1.4t | 1.02t | 0.69t | CO2eq per Capita |

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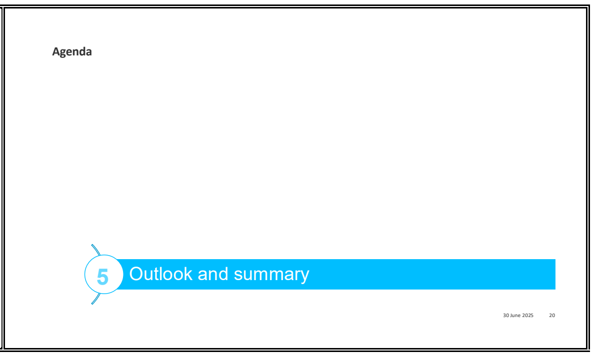


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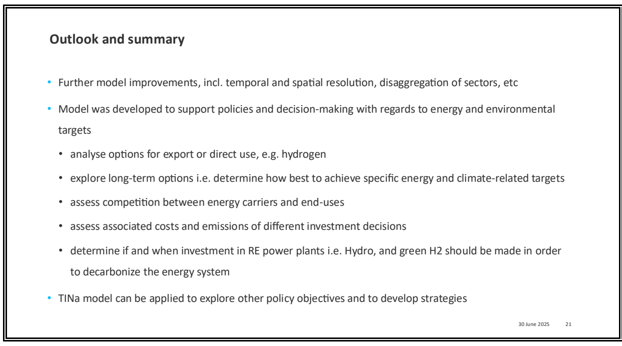


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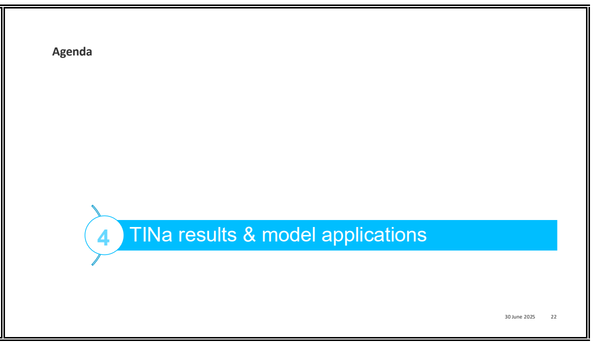


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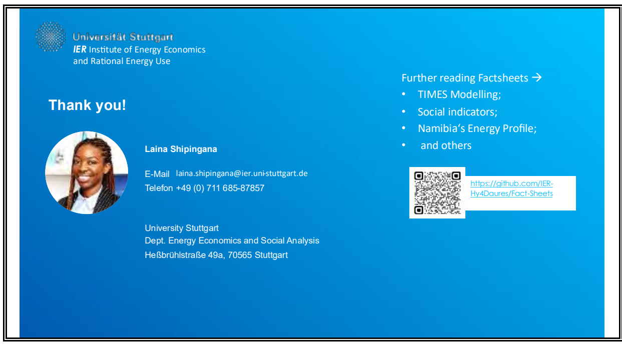


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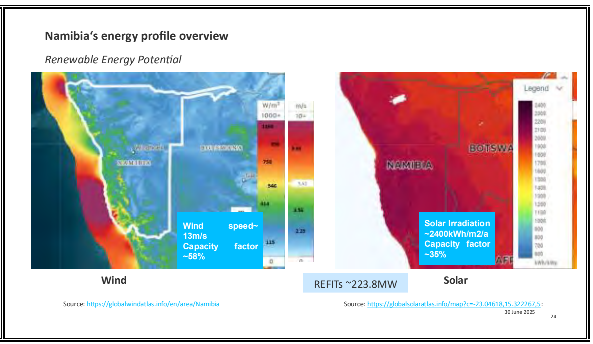


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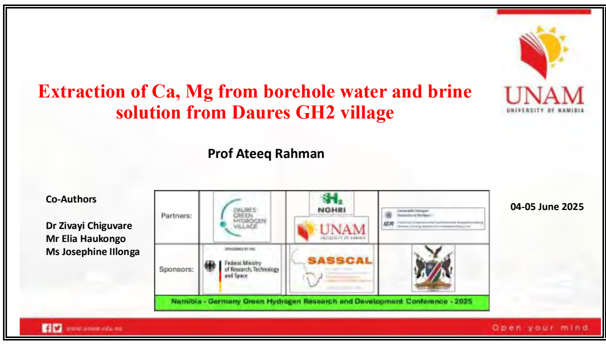
# Extraction of Ca, Mg from borehole water and brine solution from Daures $GH_2$ village

Ateeq Rahman, Elia Haukongo, Josephine Iilonga, and Zivayi Chiguvare

NGHRI – University of Namibia

The global market has become competitive in the area of Rare Earth Elements (REEs) /minerals due to the availability of different technologies for the processing of minerals. Namibia is a dry country, due to its climate conditions. As Namibia is land of resources. This study investigates the extraction and selective removal of minerals primarily calcium, magnesium, sodium, and lithium from borehole water and brine sources collected from the Daures village. The work focused on precipitation-based separation techniques using various bases, notably Sodium hydroxide NaOH, sodium carbonate $Na_2CO_3$, Calcium carbonate $Ca_2CO_3$ calcium hydroxide $Ca(HO)_2$, and sodium bicarbonate $NaHCO_3$, under different pH and temperature conditions. Samples were subjected to treatments at temperatures ranging from 60 °C to 90 °C and pH levels from 8 to 12.7, with the intent to optimize mineral recovery and understand removal efficiencies. Chemical Precipitation Index (CPI) analysis revealed high removal efficiency of calcium, particularly in samples treated with $Na_2CO_3$ at pH 10 and 90 °C, achieving up to ~99.2 % removal. Magnesium exhibited moderate to low removal across most conditions, consistent with literature noting its resistance to precipitation at lower pH values. Conversely, sodium and lithium concentrations were found to increase post-treatment in several cases, possibly due to possibly due to base interference, evaporation or concentration effects, rather than effective precipitation. The study highlights the crucial role of pH, base selection, and temperature in influencing the selectivity and effectiveness of mineral extraction from saline waters. The experimental findings align well with existing literature, reinforcing sodium carbonate's suitability for selective calcium removal, while also emphasizing the challenges associated with magnesium and lithium extraction via precipitation methods.

Prof. Ateeq Rahman is an Associate Professor and works at the Department of Physics, Chemistry and material science, University of Namibia. He has obtained his PhD from Jawaharlal Nehru Technological University, Hyderabad, Telangana, India in 2002. He pursued his post-doctoral fellows in Germany, Canada and South Africa. Prof. Rahman worked as faculty member in Saudi Arabia, Zimbabwe and Oman. His research areas include Nanotechnology, and Green Chemistry Catalysis and he had published articles in international reputed journals. His current projects are on $GH_2$ Daures project, Wastewater treatment, nano particles, catalysis for organic transformations, and thin films fabrication.


Extraction of Ca, Mg from borehole water and brine solution from Daures GH2 village
Prof Ateeq Rahman
Co-Authors
Dr Zivayi Chiguvare
Mr Elia Haukongo
Ms Josephine Illonga
Partners:
NGHRI
UNAM
Sponsors:
Federal Ministry of Research, Technology and Space
SASSCAL
Namibia - Germany Green Hydrogen Research and Development Conference - 2025
04-05 June 2025
UNAM
UNIVERSITY OF NAMIBIA
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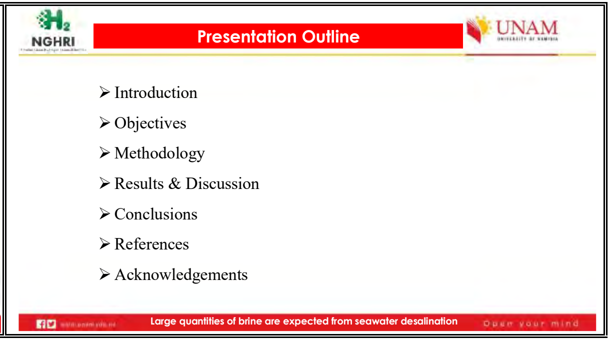
NGHRI
Presentation Outline
UNAM
➢ Introduction
➢ Objectives
➢ Methodology
➢ Results & Discussion
➢ Conclusions
➢ References
➢ Acknowledgements
Large quantities of brine are expected from seawater desalination
Open your mind

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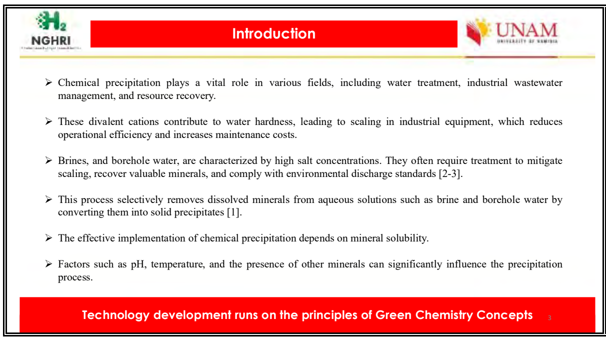
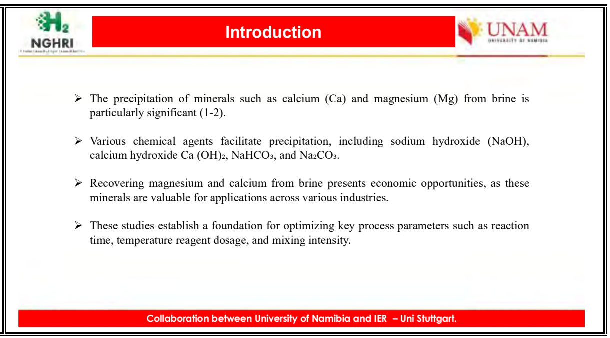

NGHRI
Introduction
UNAM
➢ Chemical precipitation plays a vital role in various fields, including water treatment, industrial wastewater management, and resource recovery.
➢ These divalent cations contribute to water hardness, leading to scaling in industrial equipment, which reduces operational efficiency and increases maintenance costs.
➢ Brines, and borehole water, are characterized by high salt concentrations. They often require treatment to mitigate scaling, recover valuable minerals, and comply with environmental discharge standards [2-3].
➢ This process selectively removes dissolved minerals from aqueous solutions such as brine and borehole water by converting them into solid precipitates [1].
➢ The effective implementation of chemical precipitation depends on mineral solubility.
➢ Factors such as pH, temperature, and the presence of other minerals can significantly influence the precipitation process.
Technology development runs on the principles of Green Chemistry Concepts

3


NGHRI
Introduction
UNAM
➢ The precipitation of minerals such as calcium (Ca) and magnesium (Mg) from brine is particularly significant (1-2).
➢ Various chemical agents facilitate precipitation, including sodium hydroxide (NaOH), calcium hydroxide Ca $(OH)_2$, $NaHCO_3$, and $Na_2CO_3$.
➢ Recovering magnesium and calcium from brine presents economic opportunities, as these minerals are valuable for applications across various industries.
➢ These studies establish a foundation for optimizing key process parameters such as reaction time, temperature reagent dosage, and mixing intensity.
Collaboration between University of Namibia and IER – Uni Stuttgart.

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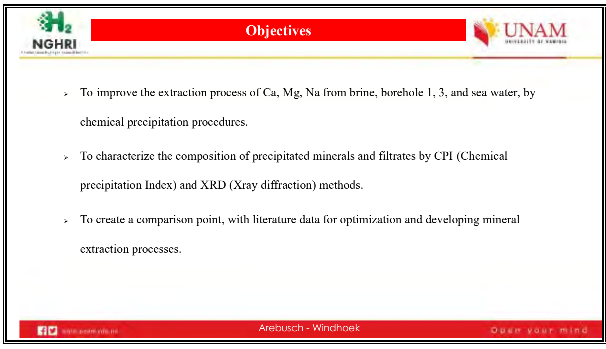
NGHRI
Objectives
UNAM
To improve the extraction process of Ca, Mg, Na from brine, borehole 1, 3, and sea water, by chemical precipitation procedures.
To characterize the composition of precipitated minerals and filtrates by CPI (Chemical precipitation Index) and XRD (Xray diffraction) methods.
To create a comparison point, with literature data for optimization and developing mineral extraction processes.
Arebusch - Windhoek
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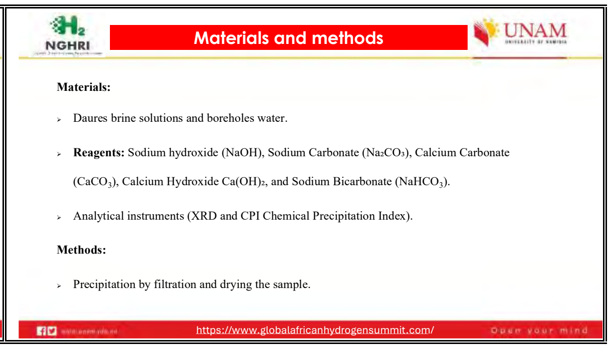
NGHRI
Materials and methods
UNAM
Materials:
Daures brine solutions and boreholes water.
Reagents: Sodium hydroxide (NaOH), Sodium Carbonate ($Na_2CO_3$), Calcium Carbonate ($CaCO_3$), Calcium Hydroxide $Ca(OH)_2$, and Sodium Bicarbonate ($NaHCO_3$).
Analytical instruments (XRD and CPI Chemical Precipitation Index).
Methods:
Precipitation by filtration and drying the sample.
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## Experimental procedures

**Precipitation of minerals using Borehole water (Boreholes 1 and 3)**

- 50 mL of borehole water (Borehole 1 and Borehole 3) was treated with crushed NaOH pellets (0.029g powder) to raise the pH to 10.
- The solution was stirred continuously for 15 minutes to stabilize the pH, while monitoring using a pH meter.
- The mixture was placed in an oven at 90°C for 1 hour to study the effect of temperature and pH on mineral precipitation.
- The solution was then left at room temperature overnight for crystallization.
- Precipitated minerals were separated by gravitational filtration, and solids were dried in an oven at 80°C.
- The filtrate were analyzed to determine the remaining mineral content.
- The same procedure was repeated for 100 mL of borehole water.

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## Experimental procedures

**Precipitation of minerals using Daures Brine**

**Reagent used**: Sodium hydroxide (NaOH)

**Procedures:**

- 100ml of brine solution was placed in a 500 ml beaker and sodium hydroxide base in powder form (0.029g) was slowly added to raise the pH to 10 (in one beaker), in another beaker, the brine solution was used without sodium hydroxide, at pH 8, both stirred for 15 minutes at room temperature then heated in an oven at 90 °C for 1 hour.
- Solutions were left overnight, at room temperature, for crystals to settle down, then and filtered.
- Then the residue of filtrate is dried in oven at 80°C.
- The dried samples were characterized by CPI, and XRD methods, to evaluate the mineral composition.

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## Results

| Sample | Reagent used | Temperature | Reagent mass | Final pH | Precipitate mass |
|---|---|---|---|---|---|
| **Orano EDP-INTAKE (100 mL)** | NaOH | 90°C | 0.0037g | 10 | 1.0158g |
| | $Na_2CO_3$ | 90°C | 0.5833g | 10 | 0.617g |
| | NaOH+$Na_2CO_3$ | 90°C | 0.2107g | 10 | 0.5955g |
| | NaOH | 50°C | 0.1132g | 10 | 1.1583g |
| | $Na_2CO_3$ | 50°C | 0.6525g | 10 | 0.5566g |
| **Orano EDP-RO PERMIT (100 mL)** | NaOH | 90°C | 0.0638g | 10 | No precipitate |
| | $Na_2CO_3$ | 90°C | 0.0031g | 10 | 0.2765g |
| | NaOH+$Na_2CO_3$ | 90°C | 0.0023g | 10 | 0.0133g |
| | NaOH | 50°C | 0.0012g | 10 | No precipitate |
| | $Na_2CO_3$ | 50°C | 0.6525g | 10 | 0.5566g |
| **Orano EDP –RO Brine (100 mL)** | NaOH | 90°C | 0.4143g | 10 | 0.1317g |
| | NaOH | 90°C | 0.0039g | 8 | No precipitate |
| | $Na_2CO_3$ | 90°C | 1.7704g | 10 | 2.1964g |
| | NaOH | 50°C | 0.1575g | 10 | 0.0386g |
| | $Na_2CO_3$ | 50°C | 3.0961g | 10 | 3.2389g |
| | $Na_2CO_3$ + NaOH | 90°C | 0.3076g | 10 | 0.5109g |
| **Daures Borehole 6 (100 mL)** | NaOH | 90°C | 0.0367g | 10 | 0.0235g |
| | NaOH | 90°C | No base added | 8 | 0.0008g |
| | $Na_2CO_3$ | 90°C | 0.8739g | 10 | 0.1626g |
| | NaOH | 50°C | 0.0035g | 10 | 0.0153g |
| | $Na_2CO_3$ | 50°C | 0.1953g | 10 | 0.1417g |
| | $Na_2CO_3$ + NaOH | 90°C | 0.1036g | 10 | 0.0587g |

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## Precipitation of minerals using – BRINE ORANO EDP

| Sample | Reagent used | Temperature | Reagent mass | Final pH | Precipitate mass |
|---|---|---|---|---|---|
| Brine ( Orano EDP) 100 mL | $Ca_2CO_3$ | 90°C | 7.3151g | 10 | 7.2g |
| | $Ca_2CO_3$ | 90°C | No base added | 8 | No visible precipitate |
| | NaOH | 90°C | 0.0224g | 10 | 0.22g |
| | NaOH | 90°C | No base added | 8 | No visible precipitate |
| | $Na_2CO_3$ | 90°C | 0.1332g | 10 | 0.66g |
| | $Na_2CO_3$ | 90°C | No base added | 8 | No visible precipitate |
| | NaOH + $Na_2CO_3$ | 90°C | 0.2234g | 10 | 0.27g |
| | No base added | 90°C | - | 8 | No visible precipitate |

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## Experimental procedure

**Precipitation of minerals using Borehole water(Boreholes 1 and 3)**

- 50 mL of borehole water (Borehole 1, and Borehole 3) were treated with crushed NaOH pellets (0.029g powder) to raise the pH to 10.
- The solution was stirred continuously for 15 minutes to stabilize the pH, while monitoring with a pH meter.
- The mixture was placed in an oven at 90°C for 1 hour to study the effect of temperature and pH on mineral precipitation.
- The solution was then left at room temperature overnight for crystallization.
- Precipitated minerals were separated by gravitational filtration, and the solids were dried in an oven at 80°C.
- The filtrate was stored for subsequent analysis to determine the remaining mineral content.
- The same procedure was repeated for 100 mL of borehole water.

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## Experimental procedures

**Precipitation of minerals using – BRINE from ORANO EDP**

**borehole 1 Procedures:** The maximum removal of calcium was performed first, followed by magnesium precipitation to minimize calcium interference during magnesium precipitation.

**Calcium precipitation:**

| Sample | Temperature | Reagent Used | Concentration of Reagent | Final pH | Precipitate Mass |
|---|---|---|---|---|---|
| Brine (100 mL) | 85°C | $Na_2CO_3$ | 39.36mg/mL | 9.7 | 0.4359g |
| Brine (100 mL) | 66°C | $NaHCO_3$ | 13.12mg/mL | 10.0 | 0.2904g |
| Borehole 1 (100mL) | 85°C | $Na_2CO_3$ | 15.2mg/mL | 8.2 | 0.1223g |
| Borehole 1 (100mL) | 66°C | $NaHCO_3$ | 4.988mg/mL | 8.0 | 0.1309g |

- The pH was raised gradually to the target values to facilitate precipitation.
- The suspensions were allowed to settle for 24 hours at room temperature.
- The precipitates were filtered.
- The filtrates were collected for further elemental analysis.

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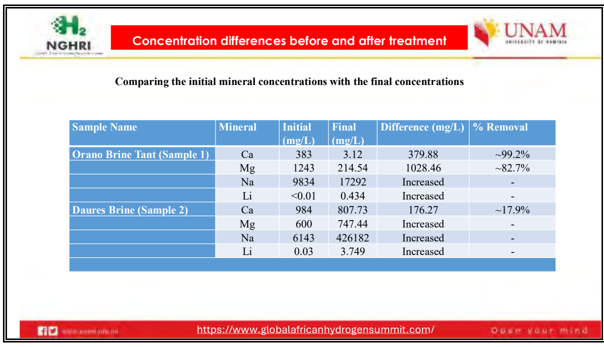


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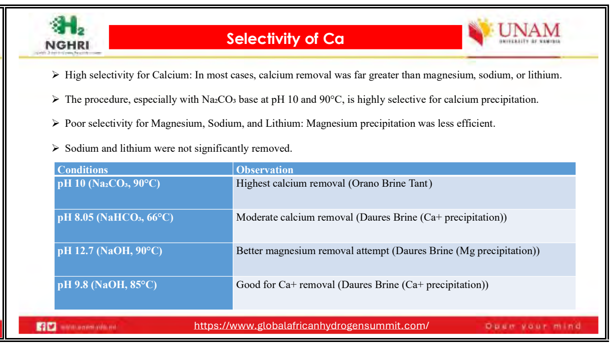


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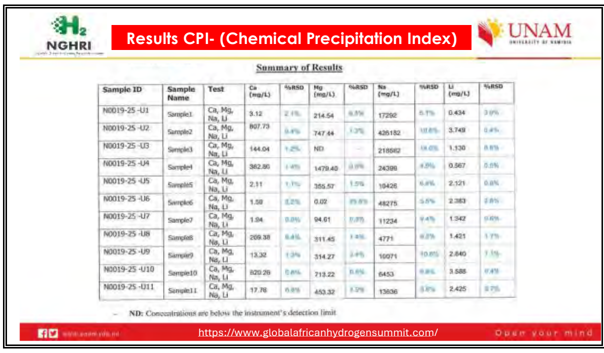


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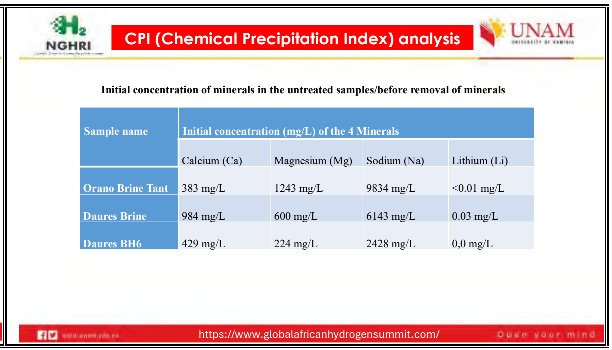


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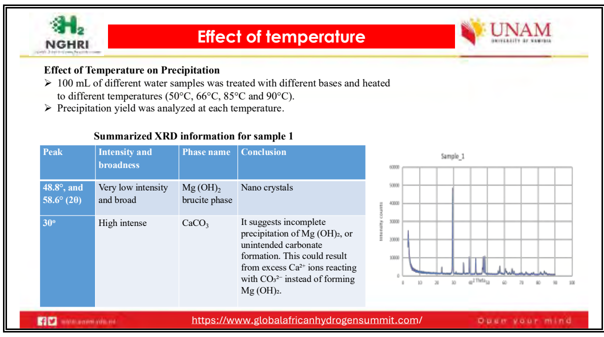


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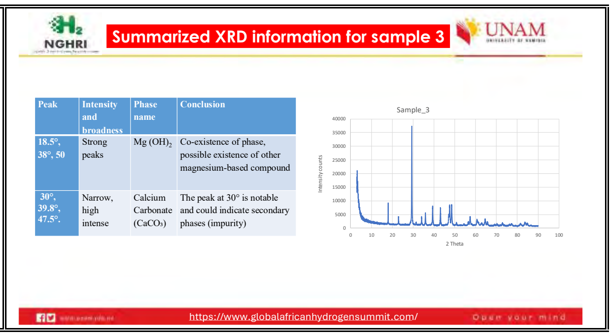


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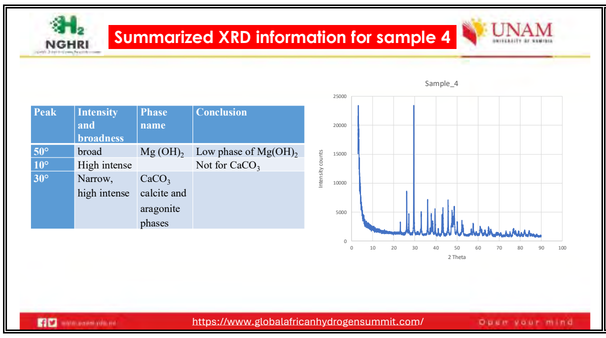

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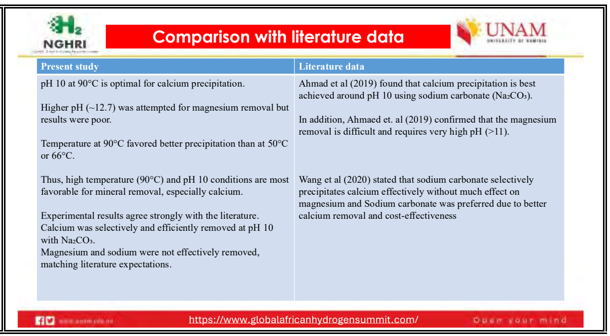

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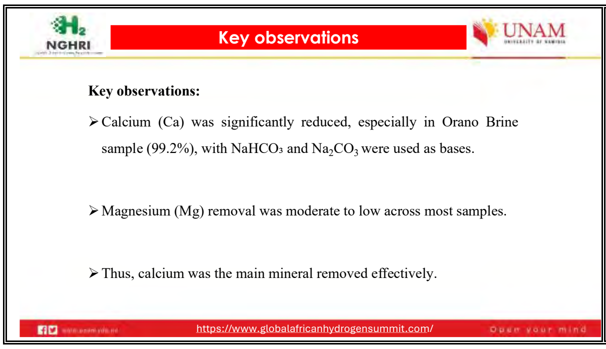

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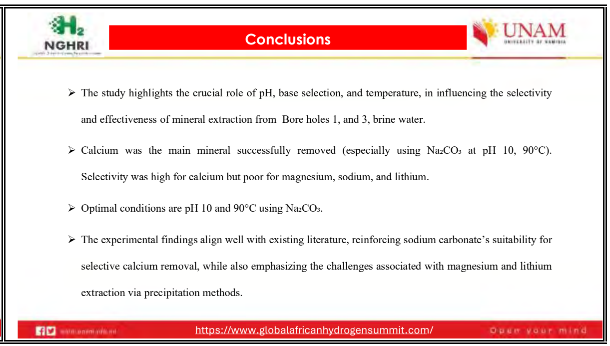

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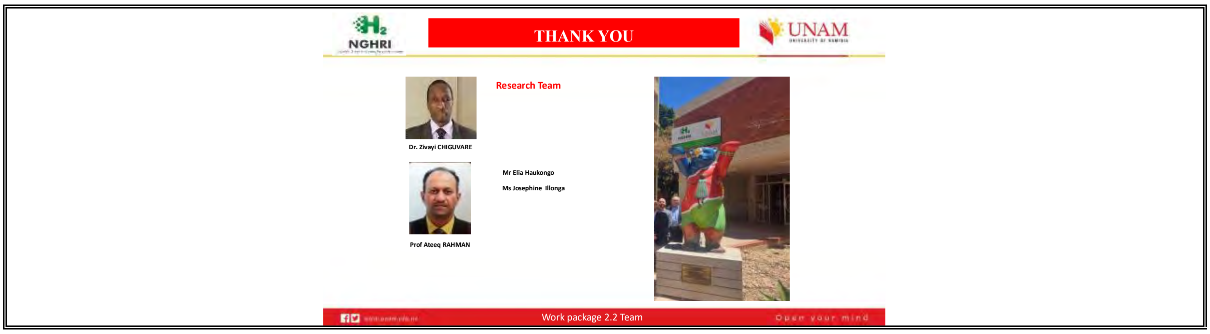

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# Macroeconomic modelling of the impacts of Green Hydrogen on the Namibian economy

Ulrich Fahl, and Claudia Hofer

Institute of Energy Economics and Rational Energy Use – University of Stuttgart, Heßbrühlstr. 49 a, D-70569 Stuttgart, Germany

This study employs a dynamic macroeconomic model to assess the potential impacts of green hydrogen development on Namibia's economy. With its abundant solar and wind resources, Namibia aims to position itself as a global exporter of green hydrogen. The analysis evaluates key economic indicators, including GDP growth, employment, international trade, and industrial diversification. Challenges such as upfront capital requirements, and potential trade-offs between export-oriented projects and equitable domestic energy access are taken into consideration as well. By integrating techno-economic data with socio-political dynamics, this study enables the exploration of different development pathways (scenarios) for green hydrogen in Namibia. Different policy options and their macroeconomic implications are systematically compared and evaluated.

| | |
|---|---|
|  | Dr. Ulrich Fahl, economist and optimisation expert, heads the Department 'Energy Economics and Social Analysis' (ESA) at the Institute of Energy Economics and Rationale Energy Use (IER) at the University of Stuttgart. He received his PhD in 1990 from the University of Stuttgart on a Decision Support System for energy economy and energy policy. Dr. Fahl is responsible for national and international research activities in the field of energy demand analysis, energy modelling, integrated resource planning, and energy, environment and climate. He co-ordinated numerous national and international projects. |


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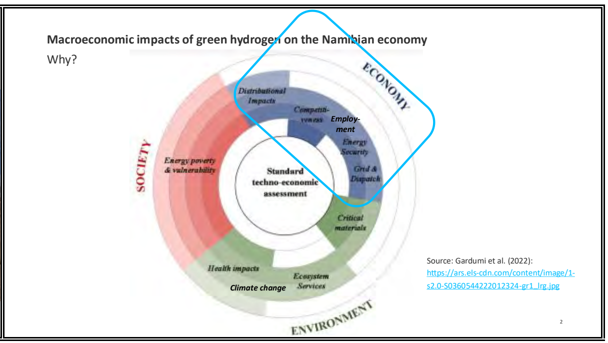


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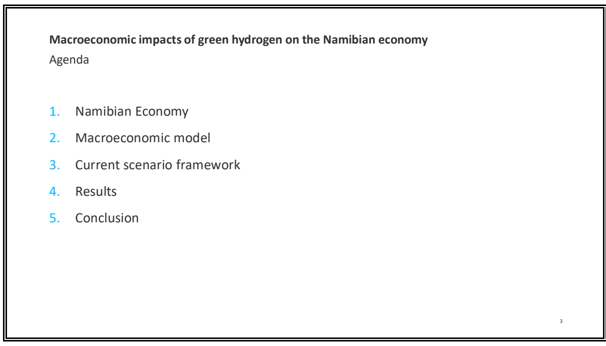
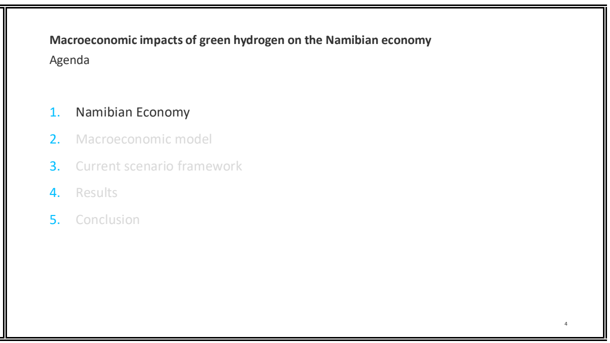

Macroeconomic impacts of green hydrogen on the Namibian economy
Agenda
1. Namibian Economy
2. Macroeconomic model
3. Current scenario framework
4. Results
5. Conclusion

3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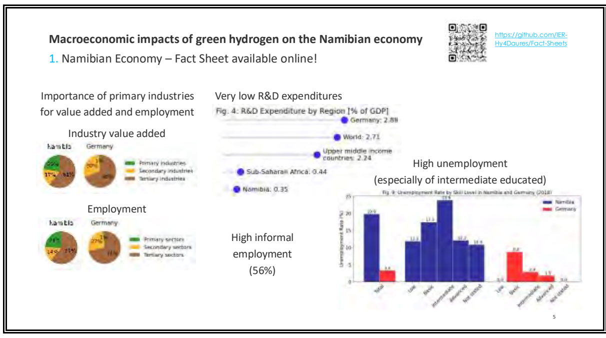
Macroeconomic impacts of green hydrogen on the Namibian economy
1. Namibian Economy – Fact Sheet available online!
https://github.com/IER-Hy4Doures/Fact-Sheets
Importance of primary industries for value added and employment
Industry value added
Employment
Very low R&D expenditures
Germany: 2.89
World: 2.71
Sub-Saharan Africa: 0.44
Namibia: 0.35
High unemployment
(especially of intermediate educated)
High informal employment
(56%)

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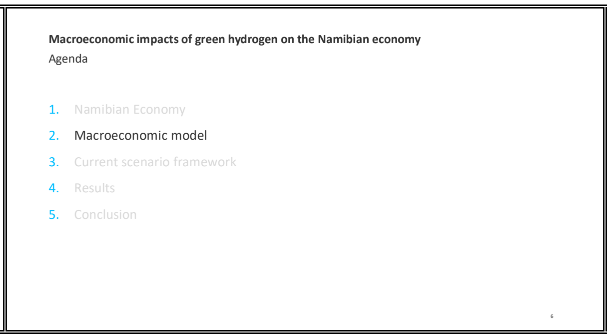
Macroeconomic impacts of green hydrogen on the Namibian economy
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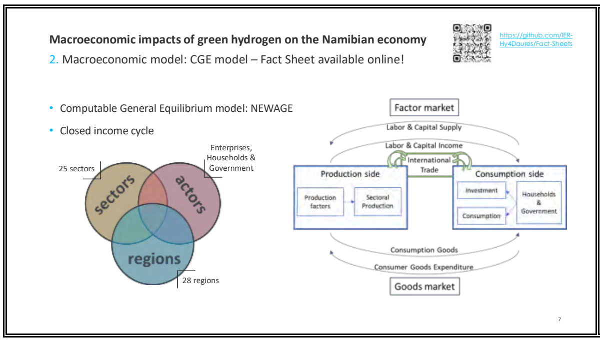
Macroeconomic impacts of green hydrogen on the Namibian economy
2. Macroeconomic model: CGE model – Fact Sheet available online!
Computable General Equilibrium model: NEWAGE
Closed income cycle
25 sectors
Enterprises, Households & Government
sectors
actors
regions
28 regions
Factor market
Labor & Capital Supply
Labor & Capital Income
International Trade
Production side
Production factors
Sectoral Production
Consumption side
Investment
Consumption
Households & Government
Consumption Goods
Consumer Goods Expenditure
Goods market

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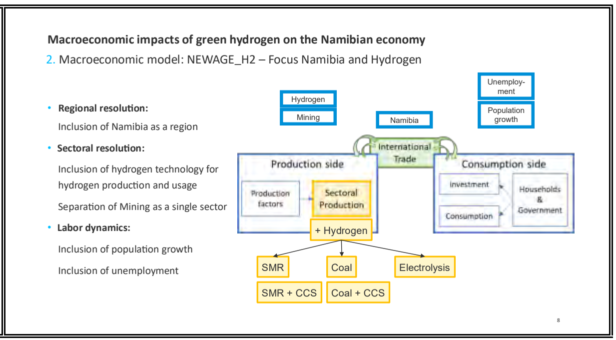
Macroeconomic impacts of green hydrogen on the Namibian economy
2. Macroeconomic model: NEWAGE_H2 – Focus Namibia and Hydrogen
Regional resolution:
Inclusion of Namibia as a region
Sectoral resolution:
Inclusion of hydrogen technology for hydrogen production and usage
Separation of Mining as a single sector
Labor dynamics:
Inclusion of population growth
Inclusion of unemployment
Hydrogen
Mining
Namibia
Unemploy-ment
Population growth
International Trade
Production side
Production factors
Sectoral Production
Consumption side
Investment
Consumption
Households & Government
+ Hydrogen
SMR
Coal
Electrolysis
SMR + CCS
Coal + CCS

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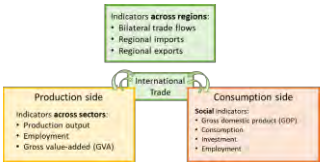
**Macroeconomic impacts of green hydrogen on the Namibian economy**

2. Macroeconomic model: NEWAGE_H2

- Development of different indicators across specified scenarios and over the modeled time horizon

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**Macroeconomic impacts of green hydrogen on the Namibian economy**

Agenda

1. Namibian Economy
2. Macroeconomic model
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**Macroeconomic impacts of green hydrogen on the Namibian economy**

3. Current scenario framework

- Namibias transformation towards a green hydrogen economy

| Scenario | Reference | Net Zero |
|---|---|---|
| Climate policy | Business-as-usual | Net-zero in 2050 (energy-related) |
| Hydrogen policy | - | - |
| Financing agent | - | - |

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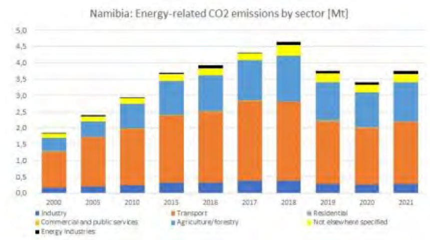
**Macroeconomic impacts of green hydrogen on the Namibian economy**

3. Current scenario framework – Reduction pathway for energy related CO2 emissions




Source: own calculations based on AFREC

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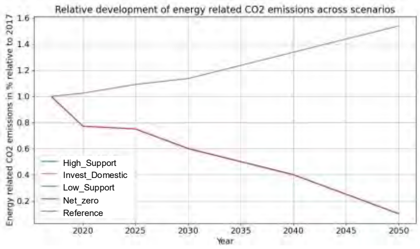
**Macroeconomic impacts of green hydrogen on the Namibian economy**

3. Current scenario framework – Reduction pathway for energy related CO2 emissions

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**Macroeconomic impacts of green hydrogen on the Namibian economy**

3. Current scenario framework

- Namibias transformation towards a green hydrogen economy

| Scenario | Reference | Net Zero | Low Support | Invest Domestic | High Support |
|---|---|---|---|---|---|
| Climate policy | Business-as-usual | Net-zero in 2050 (energy-related) | Net-zero in 2050 (energy-related) | Net-zero in 2050 (energy-related) | Net-zero in 2050 (energy-related) |
| Hydrogen policy | - | - | Low support on H2 production | Low support on H2 production | High support on H2 production |
| Financing agent | - | - | Germany | Namibia | Germany |

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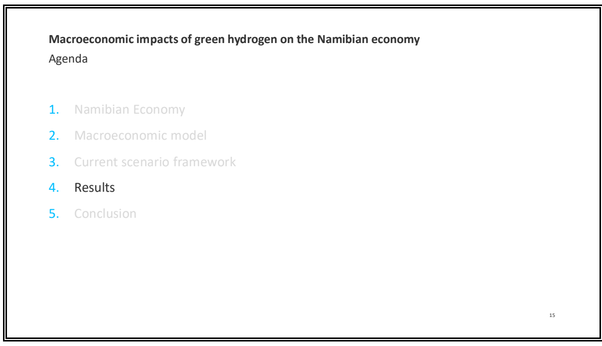


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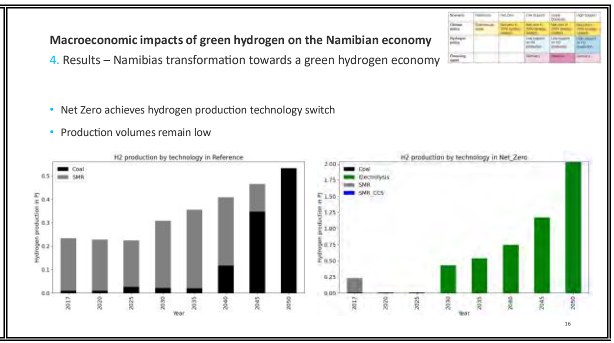


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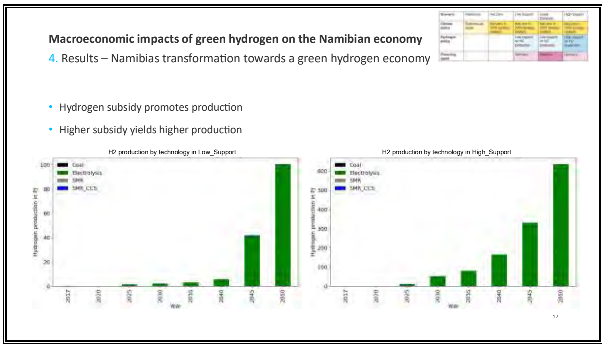


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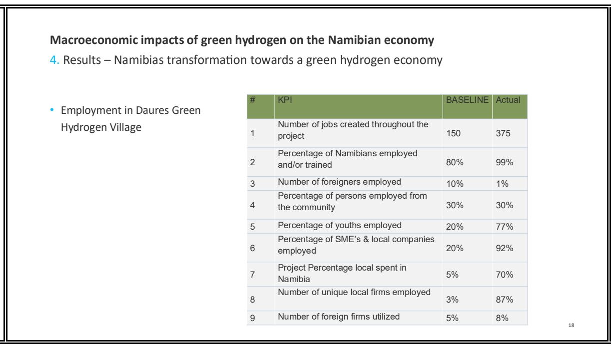
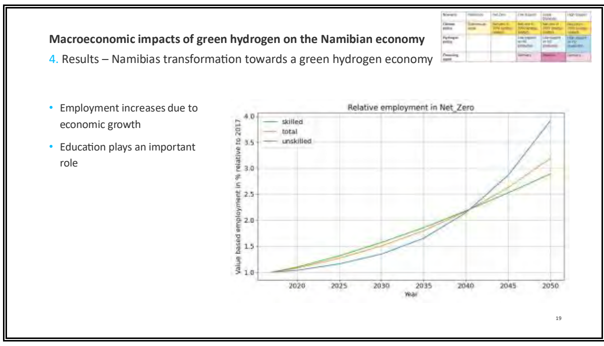



| # | KPI | BASELINE | Actual |
|---|---|---|---|
| 1 | Number of jobs created throughout the project | 150 | 375 |
| 2 | Percentage of Namibians employed and/or trained | 80% | 99% |
| 3 | Number of foreigners employed | 10% | 1% |
| 4 | Percentage of persons employed from the community | 30% | 30% |
| 5 | Percentage of youths employed | 20% | 77% |
| 6 | Percentage of SME's & local companies employed | 20% | 92% |
| 7 | Project Percentage local spent in Namibia | 5% | 70% |
| 8 | Number of unique local firms employed | 3% | 87% |
| 9 | Number of foreign firms utilized | 5% | 8% |

18

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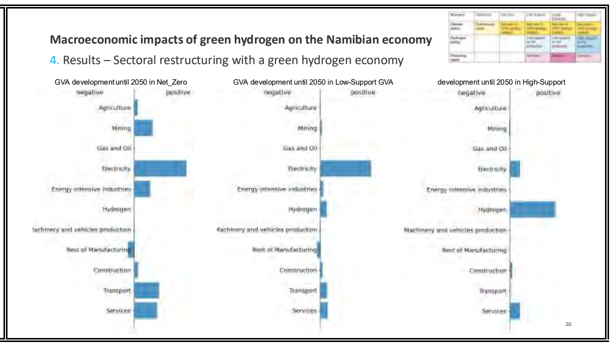


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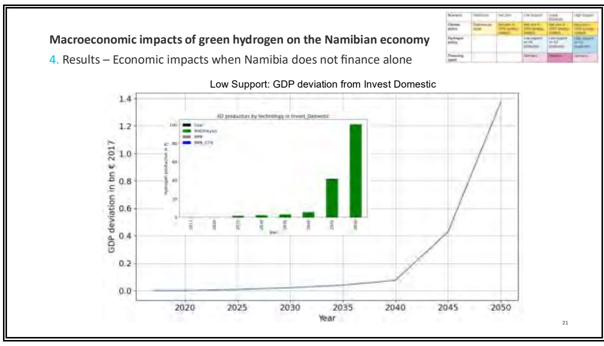
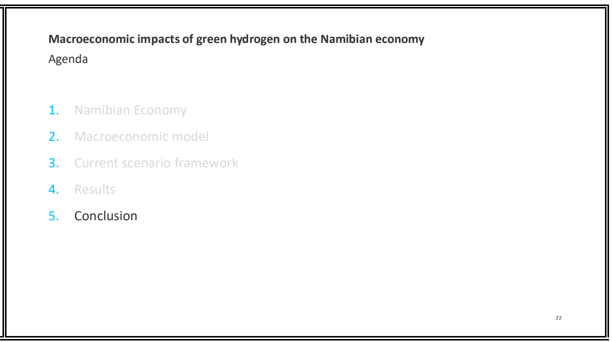
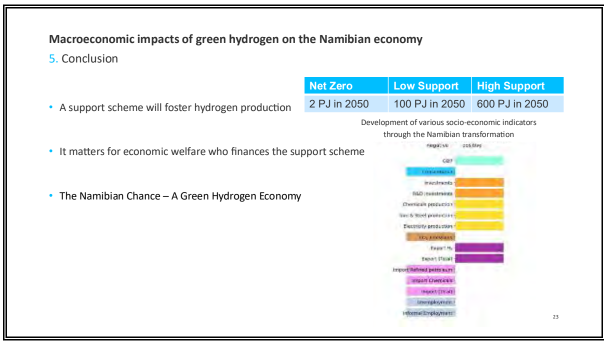

Macroeconomic impacts of green hydrogen on the Namibian economy
4. Results – Economic impacts when Namibia does not finance alone
Low Support: GDP deviation from Invest Domestic
GDP deviation in bn € 2017
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2025
2030
2035
2040
2045
2050
Year
21

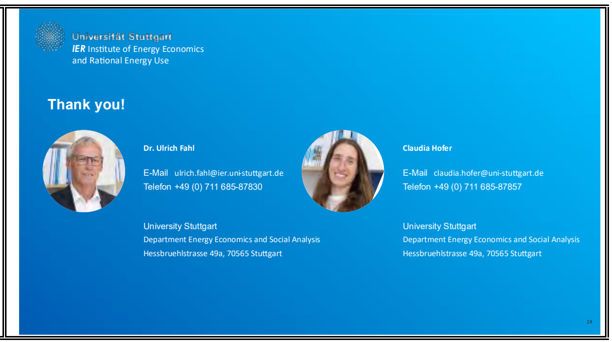
21


Macroeconomic impacts of green hydrogen on the Namibian economy
Agenda
1. Namibian Economy
2. Macroeconomic model
3. Current scenario framework
4. Results
5. Conclusion
22

22


Macroeconomic impacts of green hydrogen on the Namibian economy
5. Conclusion
A support scheme will foster hydrogen production
Net Zero
2 PJ in 2050
Low Support
100 PJ in 2050
High Support
600 PJ in 2050
It matters for economic welfare who finances the support scheme
The Namibian Chance – A Green Hydrogen Economy
Development of various socio-economic indicators through the Namibian transformation
23

23


Universität Stuttgart
IER Institute of Energy Economics and Rational Energy Use
Thank you!
Dr. Ulrich Fahl
E-Mail ulrich.fahl@ier.uni-stuttgart.de
Telefon +49 (0) 711 685-87830
University Stuttgart
Department Energy Economics and Social Analysis
Hessbruehlstrasse 49a, 70565 Stuttgart
Claudia Hofer
E-Mail claudia.hofer@uni-stuttgart.de
Telefon +49 (0) 711 685-87857
University Stuttgart
Department Energy Economics and Social Analysis
Hessbruehlstrasse 49a, 70565 Stuttgart
24

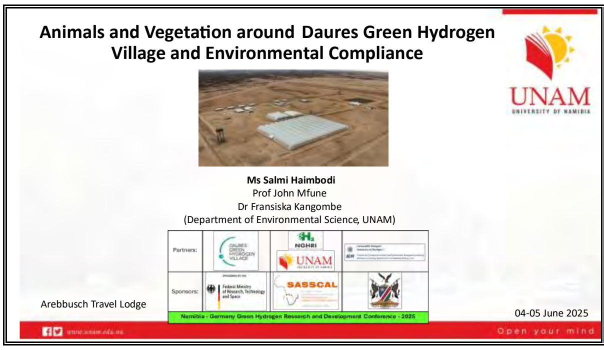
24

# Animal and Vegetation Survey and Environmental Compliance at Daures Green Hydrogen Village

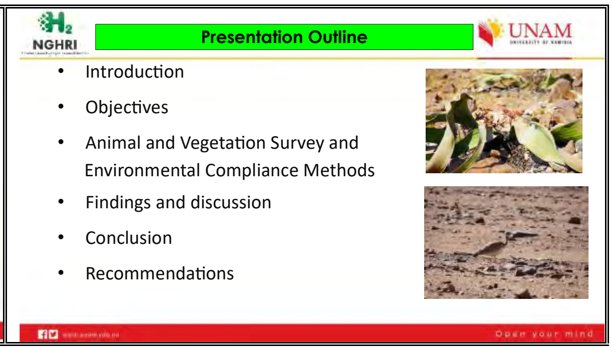
John K. E. Mfune, F. Kangombe, and Salmi Haimbodi
*Department of Environmental Science, University of Namibia*

The Daures Green Hydrogen Village (DGHV) project, like any other project of this scale, has potential environmental impacts. While an environmental impact assessment (EIA) has been carried out for the DGHV project and an environmental management plan (EMP) approved, assessment of environmental compliance to the EMP is an imperative practice. A survey was carried out during the construction phase of the DGHV project to document animals and vegetation at and around the DGHV. Assessment of environmental compliance with the EMP of the DGHV project was also carried out after commencement of operation of the DGHV project. The survey showed that plant species composition varied across habitats, with *Maerua schinzii*, *Salvadora persica*, *Vachelia* and *Senegalia* species occurring prominently along river channels. Species of conservation significance in the area include the iconic *Welwitschia mirabilis*, *Commiphora saxicola* (rock corkwood) and *Adenia pechuelii* (Elephant foot) which is the subject of poaching threat. Large mammals included *Oryx gazella* (oryx/ gemsbok), *Antidorcas marsupialis* (Springbok), *Canis mesomelas* (Black backed Jackal). *Micaelamys namaquensis* (rock mouse) were the only captured small mammals in the rocky outcrops and in the riverine channels. *Eupoditis sp (*Korhan) were commonly sighted large bird around the DGHV. The *Psammophis namibensis* (Namib sand snake) was recorded in the sandy gravel plain while a gecko was sighted in the river channels east west of the Village. A total of about 30 species of invertebrates were trapped in the gravel plain and riverine habitats. Some species had a restricted habitat. *Acrotylus azureus (Azure sand grasshopper)*, were only trapped in riverbeds, while others, such as *Messor denticornis (harvester ants)*, were exclusive to gravel plains. Generalist species like *Tathorhynchus exsiccata* (Alfalfa Looper moth) were present in both habitats while ants (Family Formicidae) especially *Solenopsis invicta* (red imported red ants) and *Camponatus marculatus* (carpenter ants) were the most abundant species. The paper recommends periodic monitoring of animals and assessment of environmental compliance vegetation during the operation of the DGHV.

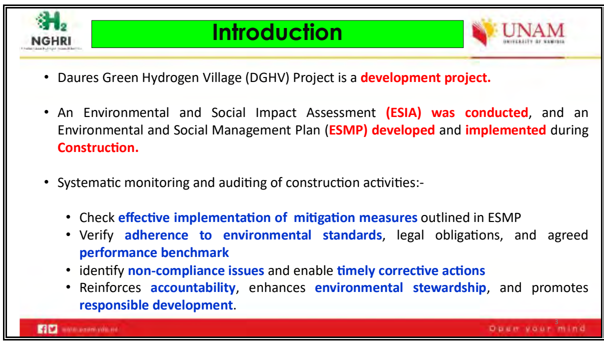
Ms. Salmi Haimbodi is a Lecturer at the University of Namibia (UNAM) in the Department of Environmental Science, specializing in Animal Ecology and Biodiversity Conservation. She holds a Master of Science in Biodiversity Management and Research. She has previously served as a part-time Laboratory Technologist and lectured in the Department of Environmental Sciences where she was responsible for facilitating practical sessions across various environmental science modules and actively mentoring undergraduate students in their research projects. Ms. Haimbodi currently served as a Research Assistant at the Namibia Green Hydrogen Research Institute, contributing to biodiversity assessments and environmental compliance studies related to the Daures Green Hydrogen Village. In addition, she has served as a part-time lecturer at the Namibia University of Science and Technology.


Animals and Vegetation around Daures Green Hydrogen Village and Environmental Compliance
UNAM
Ms Salmi Haimbodi
Prof John Mfune
Dr Fransiska Kangombe
(Department of Environmental Science, UNAM)
Partners:
Sponsors:
SASSCAL
Arebbusch Travel Lodge
04-05 June 2025
Open your mind

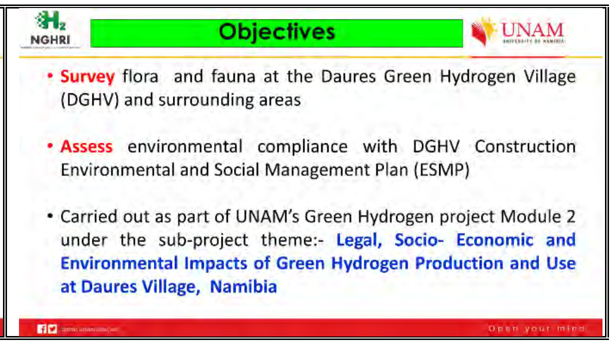
1


NGHRI
Presentation Outline
UNAM
Introduction
Objectives
Animal and Vegetation Survey and Environmental Compliance Methods
Findings and discussion
Conclusion
Recommendations
Open your mind

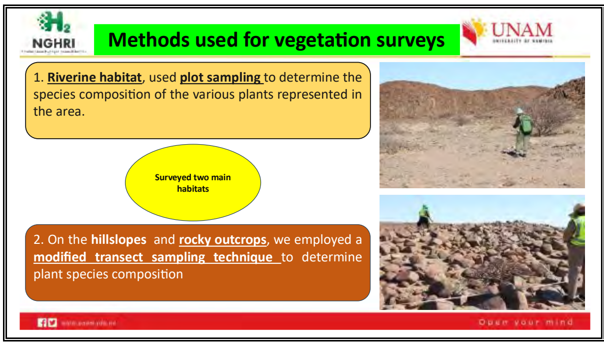
2


NGHRI
Introduction
UNAM
Daures Green Hydrogen Village (DGHV) Project is a development project.
An Environmental and Social Impact Assessment (ESIA) was conducted, and an Environmental and Social Management Plan (ESMP) developed and implemented during Construction.
Systematic monitoring and auditing of construction activities:-
Check effective implementation of mitigation measures outlined in ESMP
Verify adherence to environmental standards, legal obligations, and agreed performance benchmark
identify non-compliance issues and enable timely corrective actions
Reinforces accountability, enhances environmental stewardship, and promotes responsible development.
Open your mind

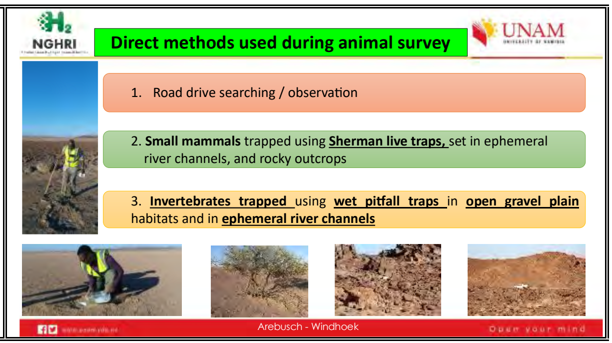
3


NGHRI
Objectives
UNAM
Survey flora and fauna at the Daures Green Hydrogen Village (DGHV) and surrounding areas
Assess environmental compliance with DGHV Construction Environmental and Social Management Plan (ESMP)
Carried out as part of UNAM's Green Hydrogen project Module 2 under the sub-project theme:- Legal, Socio- Economic and Environmental Impacts of Green Hydrogen Production and Use at Daures Village, Namibia
Open your mind

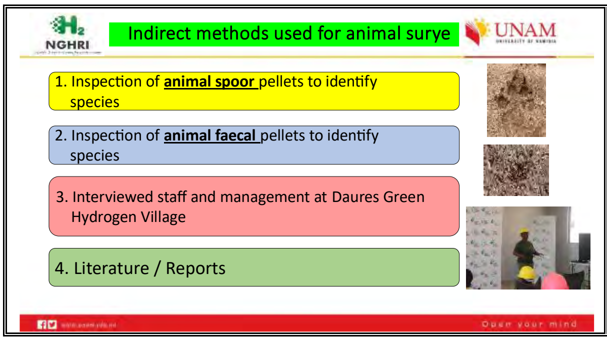
4


NGHRI
Methods used for vegetation surveys
UNAM
1. Riverine habitat, used plot sampling to determine the species composition of the various plants represented in the area.
Surveyed two main habitats
2. On the hillslopes and rocky outcrops, we employed a modified transect sampling technique to determine plant species composition
Open your mind

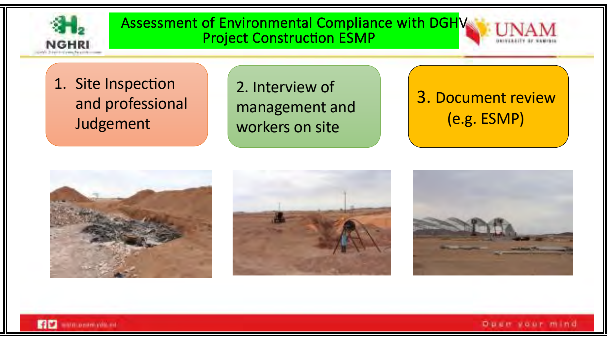
5


NGHRI
Direct methods used during animal survey
UNAM
1. Road drive searching / observation
2. Small mammals trapped using Sherman live traps, set in ephemeral river channels, and rocky outcrops
3. Invertebrates trapped using wet pitfall traps in open gravel plain habitats and in ephemeral river channels
Arebusch - Windhoek
Open your mind

6


Indirect methods used for animal surye
1. Inspection of animal spoor pellets to identify species
2. Inspection of animal faecal pellets to identify species
3. Interviewed staff and management at Daures Green Hydrogen Village
4. Literature / Reports

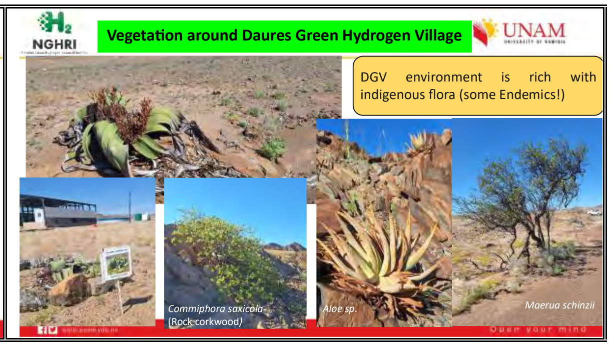
7


Assessment of Environmental Compliance with DGHV Project Construction ESMP
1. Site Inspection and professional Judgement
2. Interview of management and workers on site
3. Document review (e.g. ESMP)

8


Findings and Discussion

9


Vegetation around Daures Green Hydrogen Village
DGV environment is rich with indigenous flora (some Endemics!)
Commiphora saxicola (Rock corkwood)
Aloe sp.
Maerua schinzii

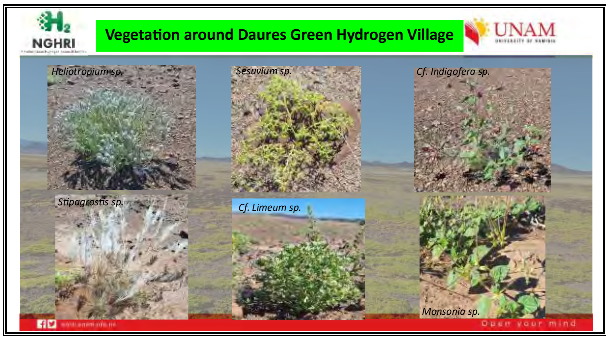
10


Vegetation around Daures Green Hydrogen Village
Adenia pechuelii (Elephant foot) is a slow-growing Namibian endemic species which is currently under poaching threat (allegedly for the Asian markets)
"Critically Threatened Species" in Namibia.

11


Vegetation around Daures Green Hydrogen Village

12

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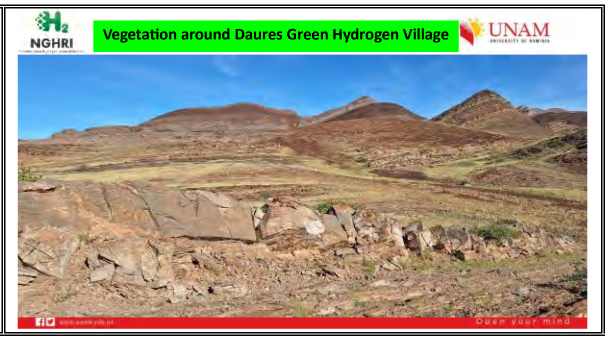


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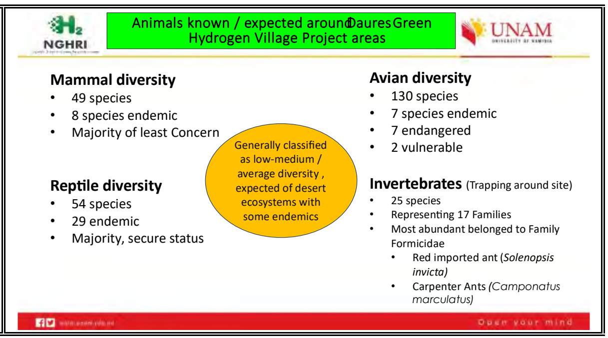


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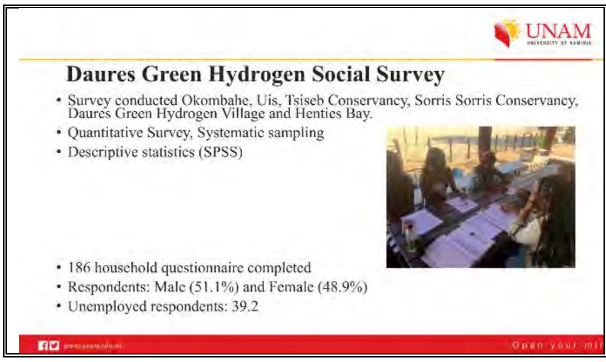


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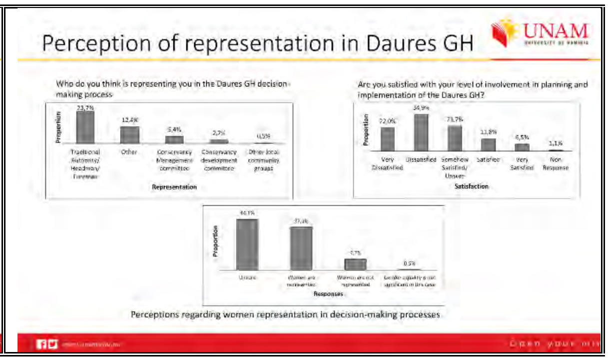


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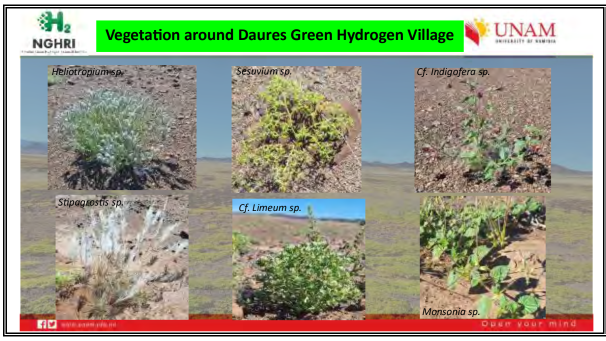


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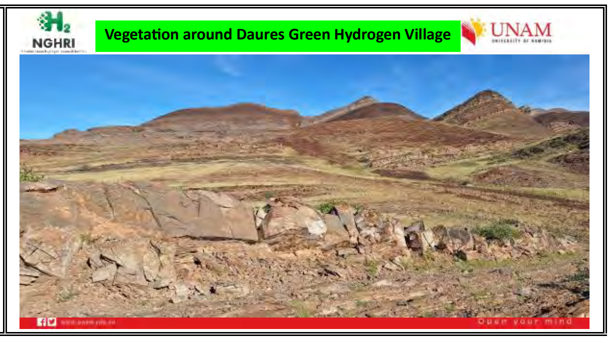


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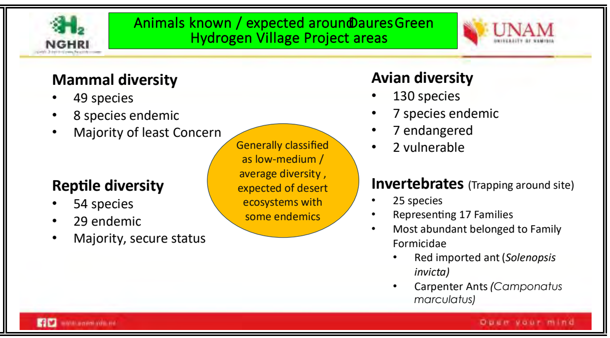


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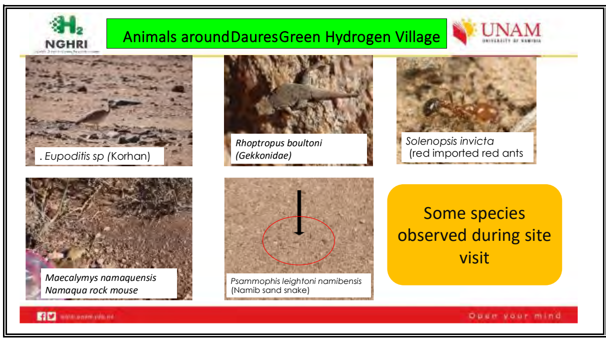


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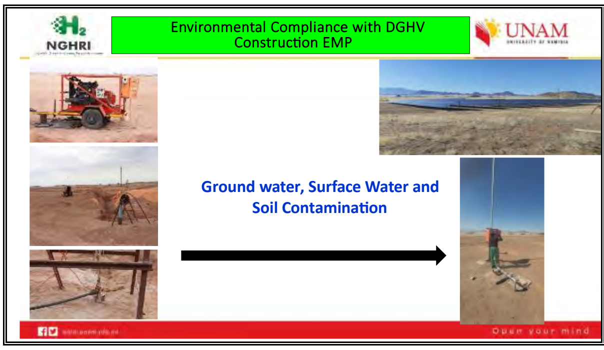


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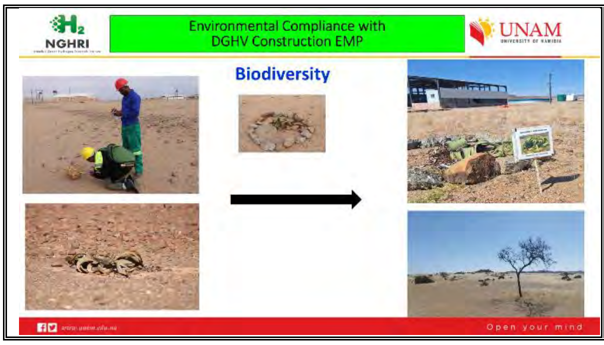


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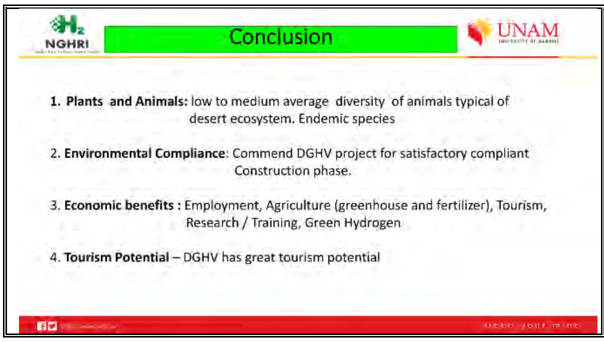


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26

# Electrochemical properties, and potential applications of copper-cobaltite thin films fabricated by the aqueous spray method

Philipus N. Hishimone,[1,*] and Samuel M. N. Hauwanga[1]

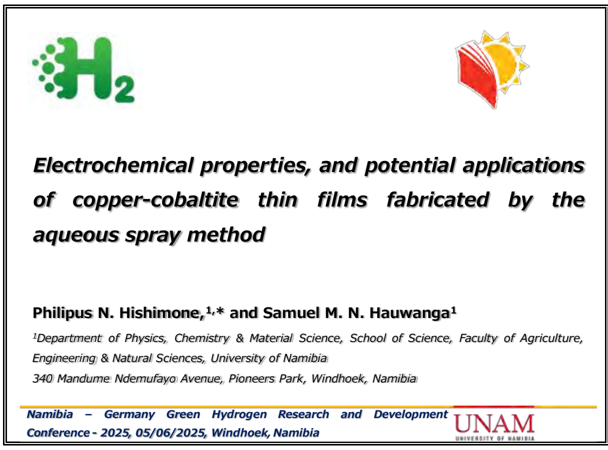
[1] *Department of Physics, Chemistry & Material Science, School of Science, Faculty of Agriculture, Engineering & Natural Science, University of Namibia, Namibia*

*E-mail: phishimone@unam.na

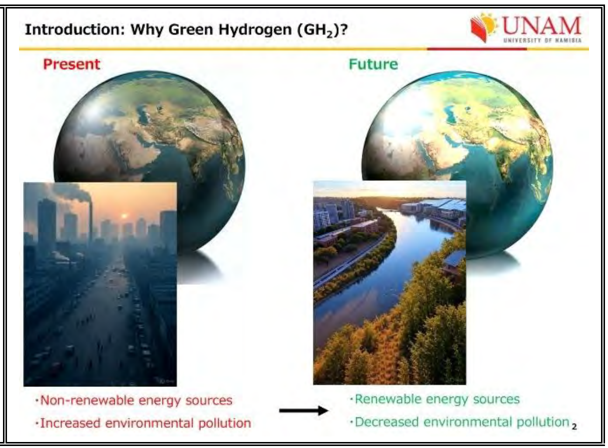
Noble metal-based electrocatalysts, especially platinum group metals, have been used as viable electrodes since they possess insignificant overpotential and outstanding kinetics for hydrogen evolution reactions (HER). However, these metals are scarce and expensive, which hinders their widespread and cost-effective use for the global production of hydrogen. Due to their unique electrocatalytic properties, copper cobaltite thin films are promising materials for the hydrogen evolution reaction (HER). These thin films combine the benefits of copper and cobalt, offering a cost-effective and efficient alternative to noble metal catalysts.

Recently, the aqueous spray method has emerged as a simple and cost-effective method for the fabrication of thin films for various functional materials. In the current study, aqueous precursor solutions containing variable amounts of $Cu^{2+}$ and $Co^{2+}$ complexes were prepared and spray-coated onto pre-heated quartz-glass substrates. After annealing the as-sprayed films, translucent and electrically conducting thin films were obtained. In this presentation, the structural, morphological, and electrochemical properties of the resultant thin films will be presented. The potential applications of these thin films will also be discussed.

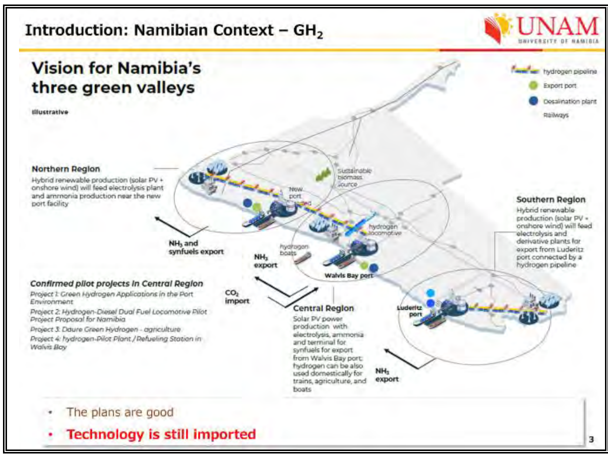
| | |
|---|---|
|  | Dr. Philipus N. Hishimone obtained his BSc-Hons, and MSc degrees from the University of Namibia and a PhD from Kogakuin University in Japan.<br>He possesses 12 years of work and employment experience at the University of Namibia.<br>Dr. Hishimone is currently the Head of Department and Senior Lecturer in the Department of Physics, Chemistry & Material Science, School of Science, Faculty of Agriculture, Engineering and Natural Sciences at UNAM. His research work includes the fabrication of functional thin films, energy materials, and other aspects involving coordination Chemistry. |


H2
Electrochemical properties, and potential applications of copper-cobaltite thin films fabricated by the aqueous spray method
Philipus N. Hishimone,[1,*] and Samuel M. N. Hauwanga[1]
[1]Department of Physics, Chemistry & Material Science, School of Science, Faculty of Agriculture, Engineering & Natural Sciences, University of Namibia
340 Mandume Ndemufayo Avenue, Pioneers Park, Windhoek, Namibia
Namibia – Germany Green Hydrogen Research and Development Conference - 2025, 05/06/2025, Windhoek, Namibia
UNAM
UNIVERSITY OF NAMIBIA

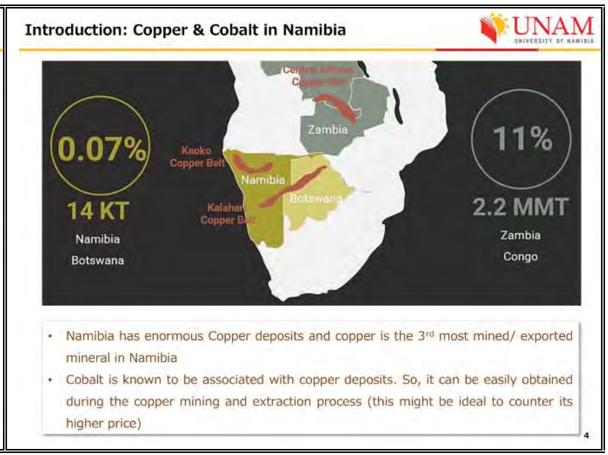
1


Introduction: Why Green Hydrogen (GH$_2$)?
UNAM
Present
Future
·Non-renewable energy sources
·Increased environmental pollution
·Renewable energy sources
·Decreased environmental pollution
2

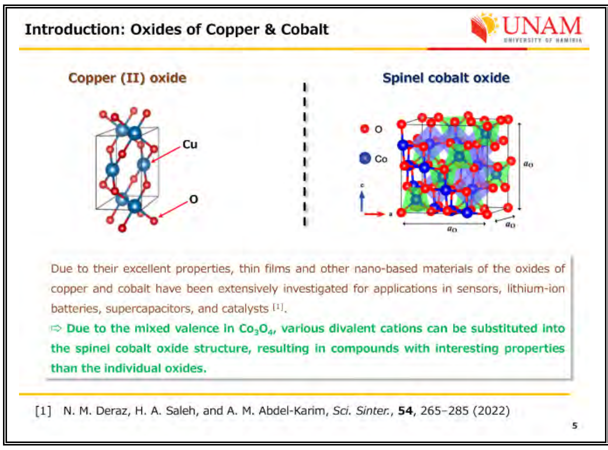
2


Introduction: Namibian Context – GH$_2$
UNAM
Vision for Namibia's three green valleys
Illustrative
Northern Region
Southern Region
Confirmed pilot projects in Central Region
Central Region
Walvis Bay port
NH$_3$ and synfuels export
NH$_3$ export
CO$_2$ import
• The plans are good
• Technology is still imported
3

3


Introduction: Copper & Cobalt in Namibia
UNAM
0.07%
14 KT
Namibia
Botswana
11%
2.2 MMT
Zambia
Congo
Kaoko Copper Belt
Kalahari Copper Belt
Namibia
Botswana
Zambia
• Namibia has enormous Copper deposits and copper is the 3rd most mined/ exported mineral in Namibia
• Cobalt is known to be associated with copper deposits. So, it can be easily obtained during the copper mining and extraction process (this might be ideal to counter its higher price)
4

4


Introduction: Oxides of Copper & Cobalt
UNAM
Copper (II) oxide
Cu
O
Spinel cobalt oxide
O
Co
Due to their excellent properties, thin films and other nano-based materials of the oxides of copper and cobalt have been extensively investigated for applications in sensors, lithium-ion batteries, supercapacitors, and catalysts [1].
⇨ Due to the mixed valence in Co$_3$O$_4$, various divalent cations can be substituted into the spinel cobalt oxide structure, resulting in compounds with interesting properties than the individual oxides.
[1] N. M. Deraz, H. A. Saleh, and A. M. Abdel-Karim, Sci. Sinter., 54, 265–285 (2022)
5

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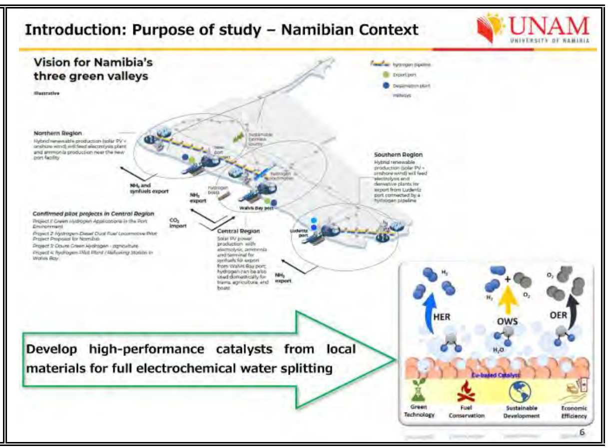
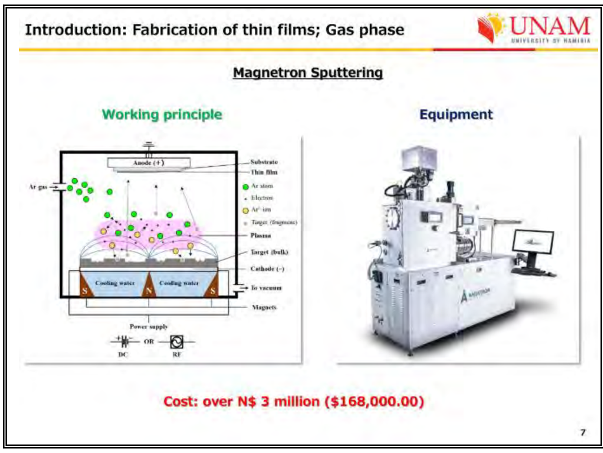
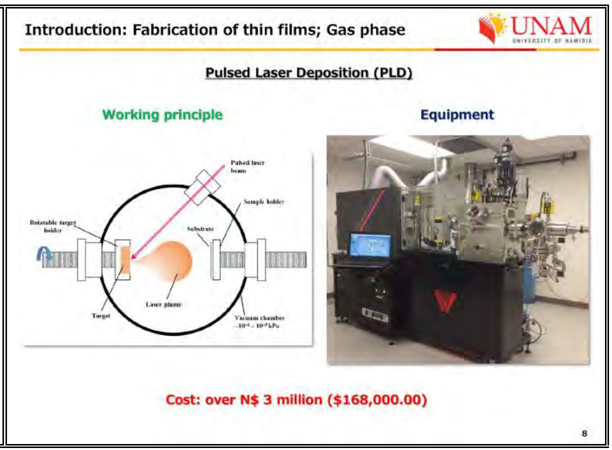

Introduction: Purpose of study – Namibian Context
UNAM
Vision for Namibia's three green valleys
Develop high-performance catalysts from local materials for full electrochemical water splitting
HER
OWS
OER
6

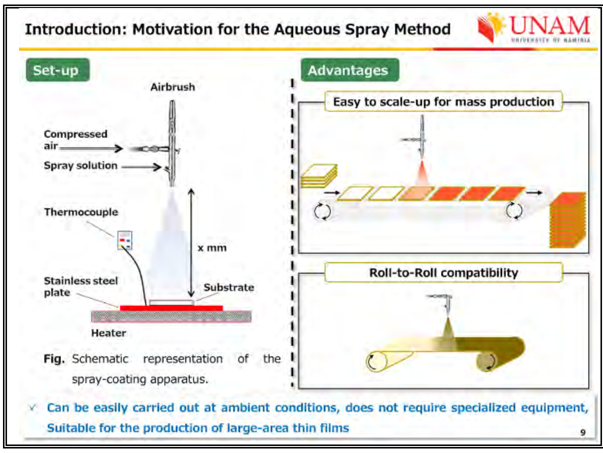
6


Introduction: Fabrication of thin films; Gas phase
UNAM
Magnetron Sputtering
Working principle
Equipment
Cost: over N$ 3 million ($168,000.00)
7

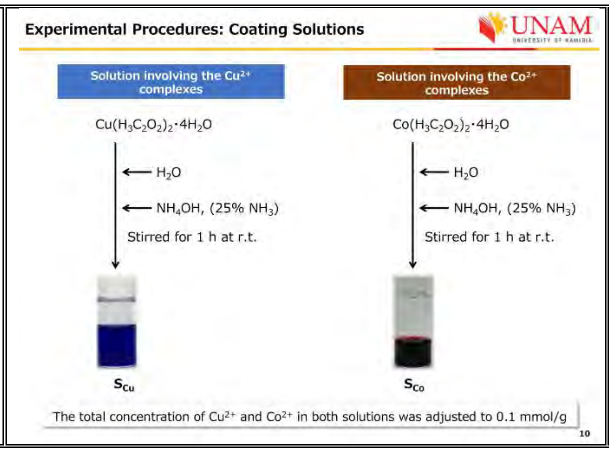
7


Introduction: Fabrication of thin films; Gas phase
UNAM
Pulsed Laser Deposition (PLD)
Working principle
Equipment
Cost: over N$ 3 million ($168,000.00)
8

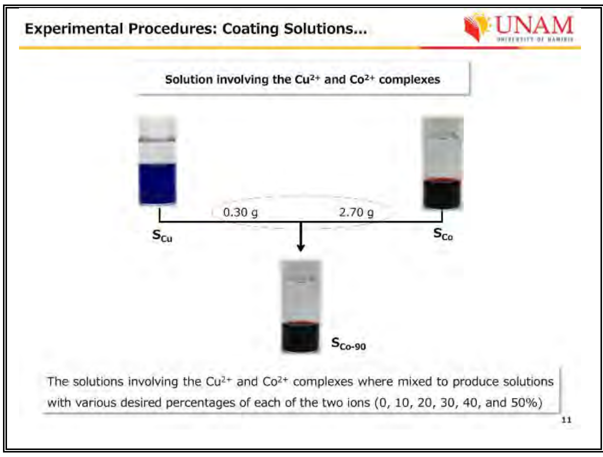
8


Introduction: Motivation for the Aqueous Spray Method
UNAM
Set-up
Airbrush
Compressed air
Spray solution
Thermocouple
x mm
Stainless steel plate
Substrate
Heater
Fig. Schematic representation of the spray-coating apparatus.
Advantages
Easy to scale-up for mass production
Roll-to-Roll compatibility
Can be easily carried out at ambient conditions, does not require specialized equipment, Suitable for the production of large-area thin films
9

9


Experimental Procedures: Coating Solutions
UNAM
Solution involving the Cu²⁺ complexes
Solution involving the Co²⁺ complexes
Cu(H₃C₂O₂)₂·4H₂O
Co(H₃C₂O₂)₂·4H₂O
H₂O
NH₄OH, (25% NH₃)
Stirred for 1 h at r.t.
S_Cu
S_Co
The total concentration of Cu²⁺ and Co²⁺ in both solutions was adjusted to 0.1 mmol/g
10

10


Experimental Procedures: Coating Solutions…
UNAM
Solution involving the Cu²⁺ and Co²⁺ complexes
S_Cu
S_Co
0.30 g
2.70 g
S_Co-90
The solutions involving the Cu²⁺ and Co²⁺ complexes where mixed to produce solutions with various desired percentages of each of the two ions (0, 10, 20, 30, 40, and 50%)
11

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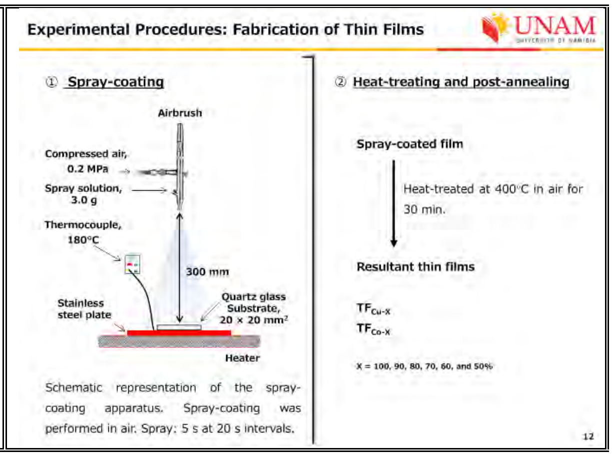
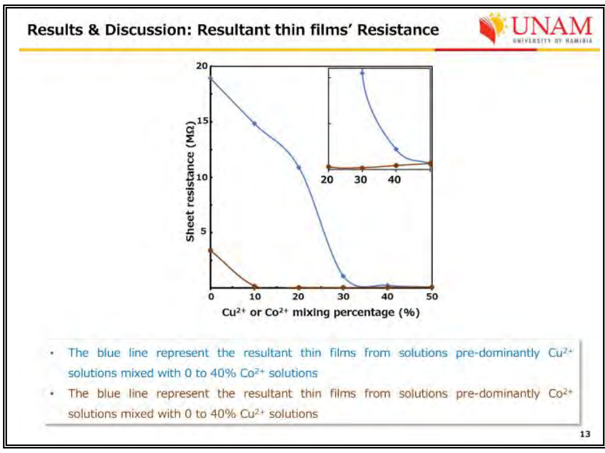

Experimental Procedures: Fabrication of Thin Films
UNAM
① Spray-coating
Airbrush
Compressed air, 0.2 MPa
Spray solution, 3.0 g
Thermocouple, 180°C
300 mm
Stainless steel plate
Quartz glass Substrate, 20 × 20 mm²
Heater
Schematic representation of the spray-coating apparatus. Spray-coating was performed in air. Spray: 5 s at 20 s intervals.
② Heat-treating and post-annealing
Spray-coated film
Heat-treated at 400°C in air for 30 min.
Resultant thin films
TF_Cu-X
TF_Co-X
X = 100, 90, 80, 70, 60, and 50%
12

12

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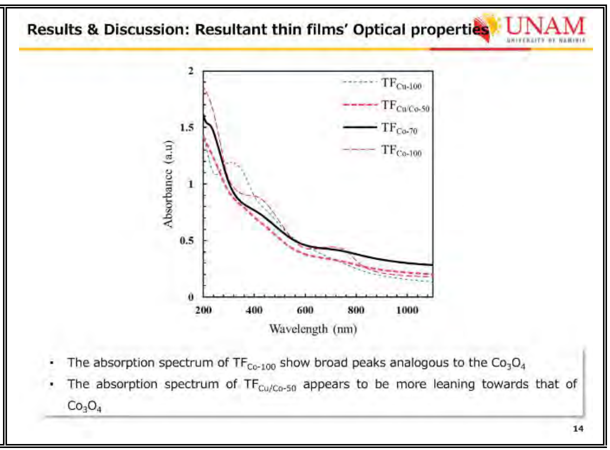


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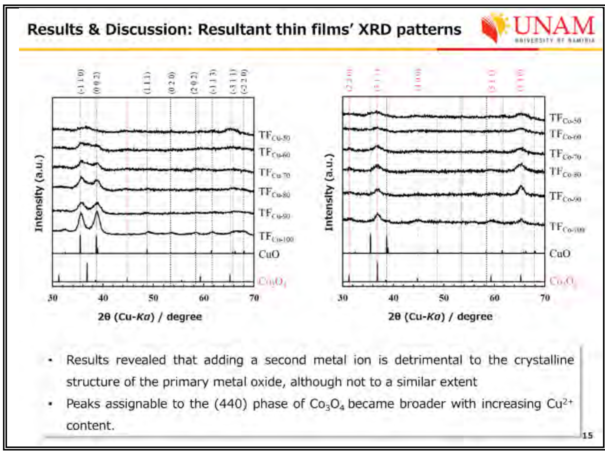


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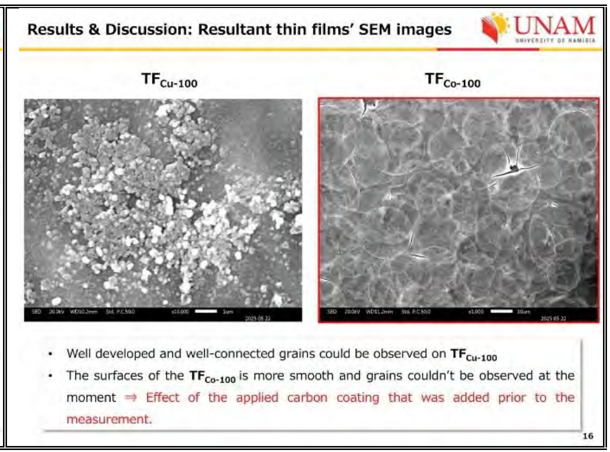


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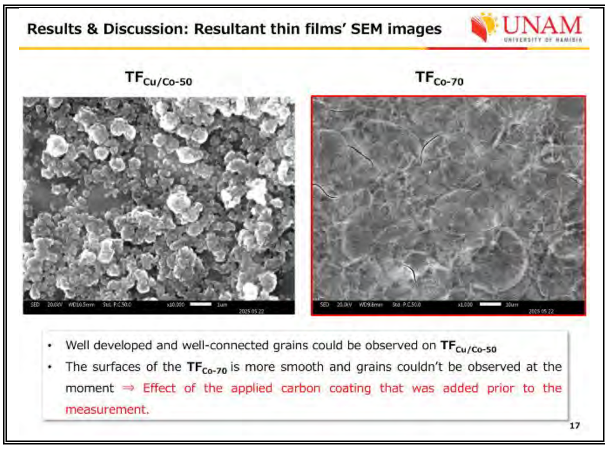


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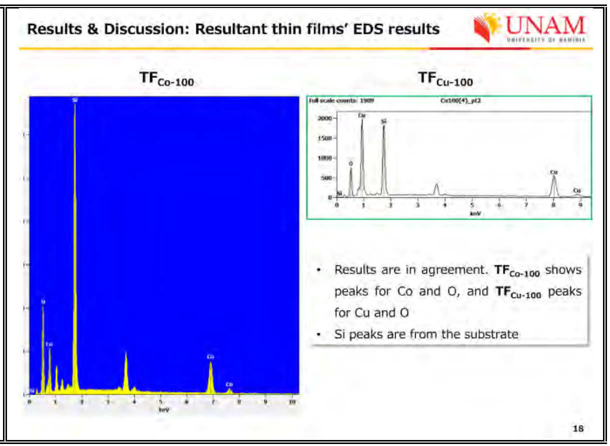


18

**Results & Discussion: Resultant thin films' EDS results**

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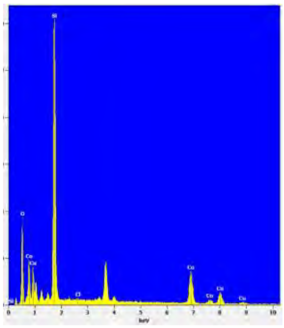
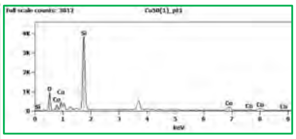
$TF_{Co-70}$



$TF_{Cu/Co-50}$



- Results are in agreement. Cobalt and Copper doping can be observed.
- Si peaks are from the substrate

19

19

**Summary**

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- Clear and stable spray solutions were successfully prepared and used in the fabrication of copper oxide and cobalt oxide thin films
- Using various mixing percentages ("doping"), the sheet resistance of the resultant thin films could be manipulated. More specifically, the sheet resistance of the pure oxides were drastically reduced with the addition of two metal ions used in the current study. (other properties might also be influenced?)
- The benefits of spray-coating cannot be overstated. In addition, the use of aqueous-based solutions is a handling safety advantage for the industries
- The catalytic performance of these thin films are being evaluated and will be published soon.

20

20

**Acknowledgements**

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*Thank you for your kind attention!*

| | | | |
|---|---|---|---|
| Partners: | DAURES GREEN HYDROGEN VILLAGE | H2 NGHRI / UNAM UNIVERSITY OF NAMIBIA | Universität Stuttgart / University of Stuttgart / IER |
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# Corrosion-Resistant Zirconia Thin Film Coatings for Green Hydrogen Infrastructure in Coastal Namibia

[1]Natangue Shafudah*, [1]Essley Kalola, [2]Hango Ithete, [2]Thomas Alweendo, and [1]Zivayi Chiguvare

[1] *Department of Physics, Chemistry & Material Science, School of Science, Faculty of Agriculture, Engineering & Natural Science, University of Namibia, Namibia*

[2] *Department of Mechanical & Metallurgical Engineering, School of engineering & the Built Environment, Faculty of Agriculture, Engineering & Natural Science, University of Namibia, Namibia*

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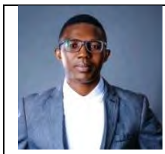
The rapid development of green hydrogen infrastructure in Namibia's coastal regions demands durable materials capable of withstanding aggressive marine environments. One of the major challenges is the corrosion of metallic components due to salt-laden air, humidity, and temperature fluctuations. This study explores the fabrication of zirconia ($ZrO_2$) thin film coatings as corrosion-resistant barriers for mild steel substrates commonly used in hydrogen systems. Zirconia coatings were deposited by molecular based precursor technique, followed by controlled heat treatments ranging from 200°C to 800°C. The influence of thermal treatment on the structural integrity, phase transformation, adhesion, and corrosion resistance of the coatings was systematically analysed using XRD, SEM, amongst others. Results indicate that heat treatment significantly affects the crystallinity, porosity, and protective performance of the coatings. Notably, films treated between 400°C and 600°C exhibited optimal corrosion resistance due to improved densification and phase stability, whereas treatments above 700°C led to microcrack formation and reduced performance. These findings provide critical insights into optimizing zirconia coatings for long-term durability of green hydrogen infrastructure in corrosive coastal environments



Dr. Natangue Shafudah holds a BSc-Hons and MSc from the University of Namibia and a PhD from Kogakuin University in Japan. He is currently an MBA Candidate, at the Namibia Business School (NBS) at the University of Namibia. He poses more than 12 years of work and research experience at the University of Namibia. He is also a Senior Lecturer at the department of Physics, Chemistry & Material Science, School of Science, Faculty of Agriculture, Engineering and Natural Sciences. Dr. Shafudah research and project roles involves those as project manager for the Biogas Project at his working department. He is also a Project Coordinator at the Namibia Green Hydrogen Research Institute (NGHRI) at UNAM and his research work includes the fabrication of Functional thin films for energy materials applications.

**Work package 3.1: Innovative Anticorrosion Coatings for structural Components in Namibia Coastal Areas**

**Dr. Natangue Heita Shafudah**

Senior Lecturer: School of Science, Department of PCMS

Projects Coordinator: Namibia Green Hydrogen Research Institute

Team Leader: Daures Research Project on Innovative Anticorrosion Coatings

Email: nshafudah@unam.na

Team Members:

Essley Kalola, Hango Ithete, Thomas Alweendo, Zivayi Chiguvare

E=mc² 1

1

## Meteorogical Data:D3.1.1.1

| Month [Sept 2022 – Sept 2023] | Average Air Temperature [°C] | Humidity [%] | Wind Speed [m/s] | Maximum Wind direction [°] | Rainfall [mm] |
|---|---|---|---|---|---|
| September 2022 | 14.40773611 | 88.23146036 | 11.36 | 198.4 | 1.3 |
| October 2022 | 15.64073925 | 89.74436828 | 8.92 | 304.8 | 2.8 |
| November 2022 | 16.57306944 | 84.43809722 | 12.47 | 198.1 | 1 |
| December 2022 | 17.99771505 | 85.88204301 | 9.87 | 206.4 | 1.4 |
| January 2023 | 19.24524194 | 85.43803763 | 11.46 | 202.2 | 0.4 |
| February 2023 | 18.85653274 | 86.91803571 | 8.3 | 294.7 | 0.1 |
| March 2023 | 17.07375 | 89.47010753 | 10.98 | 192.9 | 0.9 |
| April 2023 | 17.02769444 | 88.48215278 | 9.89 | 197.7 | 2.5 |
| May 20223 | 14.6465457 | 93.44540323 | 8.59 | 197 | 2.2 |
| June 2023 | 12.50025478 | 86.68446089 | 8.24 | 185.6 | 1.4 |
| July 2023 | 15.28869624 | 65.82436828 | 17.48 | 48.88 | 1.4 |
| August 2023 | 13.81047043 | 80.30922043 | 15.39 | 47.08 | 0.6 |
| September 2023 | 12.72421667 | 83.26811667 | 15.33 | 196.5 | 0.2 |

E=mc² 2

2

## Report on Corrosion Agents at Daures:D3.1.1.2

At the Daures GH site, corrosion agents primarily include moisture, atmospheric pollutants, and chemical exposure from the surrounding environment. Key factors contributing to corrosion include:

**Moisture**: High humidity levels facilitate rust formation, especially on metal surfaces.

**Pollutants**: Industrial emissions and dust can create corrosive compounds that accelerate deterioration.

**Soil Chemistry**: The presence of sulfates and chlorides in the soil can exacerbate corrosion of buried structures and pipelines. Regular monitoring and maintenance strategies are essential to mitigate these corrosion risks and extend the lifespan of materials used at the site.

E=mc² 3

3

## Report on selected coatings:D.1.3.1

ELSEVIER

Ceramics International

Volume 40, Issue 2, March 2014, Pages 2857-2861

Corrosion protection by zirconia-based thin films deposited by a sol–gel spin coating method

Mohsen Norouzi [a], Abbas Afrasiabi Garekani [a b]

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https://doi.org/10.1016/j.ceramint.2013.10.027

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## Selection for anticorrosion coatings(motivation)

Zirconia thin film coatings are gaining attention for their anti-corrosion properties, primarily due to their excellent mechanical and chemical stability.

Zirconia (ZrO2) is often applied in its tetragonal or cubic forms, which enhance its toughness and resistance to crack propagation.

These coatings provide a protective barrier against corrosive environments, including acidic and alkaline conditions.

Common deposition techniques for zirconia coatings include sputtering, chemical vapor deposition (CVD), and sol-gel processes.

Each method influences the coating's microstructure and performance.

Zirconia can be doped with other elements (e.g., yttrium) to improve its properties, such as thermal stability and hardness, further enhancing its protective capabilities.

Zirconia coatings are used in various industries, including aerospace, automotive, and marine, where corrosion resistance is critical.

E=mc² 5

5

## Solution Preparations:D.1.3.1

Nitrilotriacetic Acid(NTA); 0.47 g

- Ethanol; 5 g
- Isopropanol; 5 g
- Butylamine; 0.36 g

Stirred for 2 h

- Zirconium butoxide; 1.11 g

Stirred for 2 h

- Hydrogen peroxide; 0.31 g

Stirred for 2 h

**S** ($Zr^{4+}$; 0.20 mmol $g^{-1}$)

S

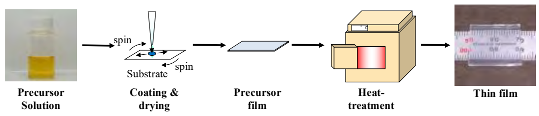
**NTA: BuNH$_2$: TBZR: H$_2$O$_2$ = 1: 2: 1: 1.1**

6

6

## Deposition method:D1.3.2

**Fabrication process**




✓ Deposition was done on a steel substrate

[3] H. Nagai, M. Sato, "*Heat treatment*", (Intech, 2012) 7

7

## Preliminary results:D1.3.2

**Experimental Procedure**

✓ Solution: SA (Zr(IV)-NTA precursor)

✓ Volume deposited: 50 µL

Spin-coating parameters:

1. First step: 500 rpm for 5 seconds
2. Second step: 2000 rpm for 30 seconds

✓ Pre-heating: 70°C for 10 minutes in drying oven

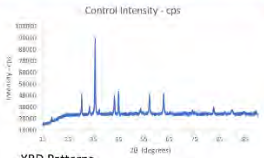
✓ Final heat treatment: In a range of 200-800°C for 1 hour

[3] H. Nagai, M. Sato, "*Heat treatment*", (Intech, 2012) 8

8

## Preliminary results:D1.3.2

uncoated Mild Steel




XRD Patterns

- The control XRD confirms a crystalline BCC iron structure, typical of uncoated mild steel.
- No significant evidence of oxides or other phases is visible, indicating a clean, unmodified surface.

[3] H. Nagai, M. Sato, "*Heat treatment*", (Intech, 2012) 9

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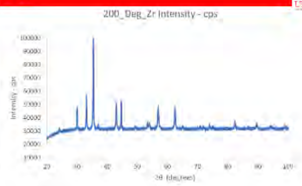
## Preliminary results:D1.3.2

Zirconia based thin films, heated at 200 degrees



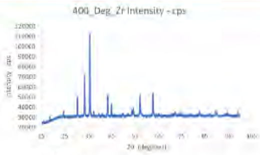

- The zirconia coating is in an incipient or amorphous-to-nanocrystalline state, as expected at this relatively low calcination temperature.
- The appearance of weak reflections near 28° and 31° 2θ may correspond to incipient monoclinic or tetragonal $ZrO_2$, but confirmation would require comparison with JCPDS cards.
- The steel substrate's diffraction peaks dominate, suggesting the coating is either very thin or not fully crystallized.

[3] H. Nagai, M. Sato, "*Heat treatment*", (Intech, 2012) 10

10

## Preliminary results:D1.3.2

Zirconia based thin films: heated at 400 degrees




XRD Patterns

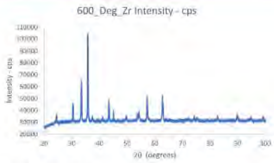
- At 400°C, the zirconia coating transitions from an amorphous/nanocrystalline state to a more crystalline form.
- The emergence of sharper and more intense peaks in the 28°–35° region indicates nucleation of crystalline $ZrO_2$.
- α-Fe peaks remain strong, suggesting the coating is still thin, but crystallization is clearly underway.

[3] H. Nagai, M. Sato, "*Heat treatment*", (Intech, 2012) 11

11

## Preliminary results:D1.3.2

Zirconia based thin films: heated at 600 degrees

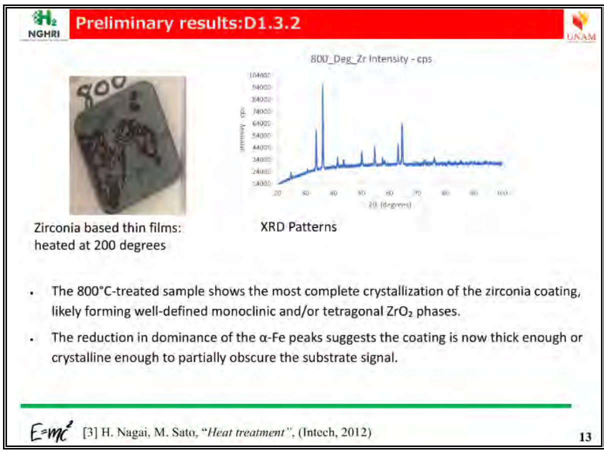



XRD Patterns

- At 600°C, the zirconia coating has significantly crystallized, with stronger and sharper reflections suggesting the development of monoclinic and/or tetragonal $ZrO_2$.
- The substrate is still contributing strongly to the diffraction pattern, but zirconia peaks are now more competitive in intensity.
- The crystalline structure of the coating is becoming more dominant, indicating effective thermal activation at this temperature.

[3] H. Nagai, M. Sato, "*Heat treatment*", (Intech, 2012) 12

12


NGHRI
Preliminary results:D1.3.2
UNAM
800_Deg_Zr Intensity - cps
Zirconia based thin films:
heated at 200 degrees
XRD Patterns
The 800°C-treated sample shows the most complete crystallization of the zirconia coating, likely forming well-defined monoclinic and/or tetragonal ZrO₂ phases.
The reduction in dominance of the α-Fe peaks suggests the coating is now thick enough or crystalline enough to partially obscure the substrate signal.
E=mc²
[3] H. Nagai, M. Sato, "Heat treatment", (Intech, 2012)
13

13


NGHRI
THANK YOU
UNAM
THANK YOU
E=mc²
14

14

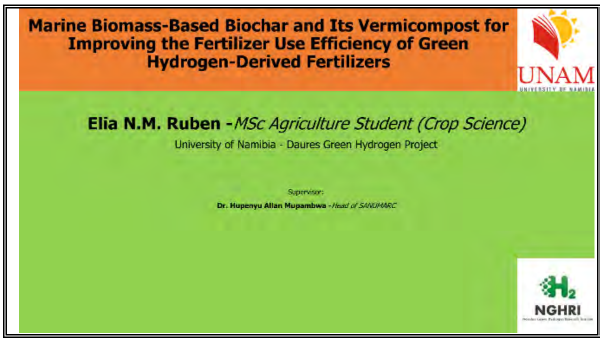
# Marine Biomass-Based Biochar and its Vermicompost for Improving Fertilizer Use Efficiency of Green Hydrogen-Derived Fertilizers

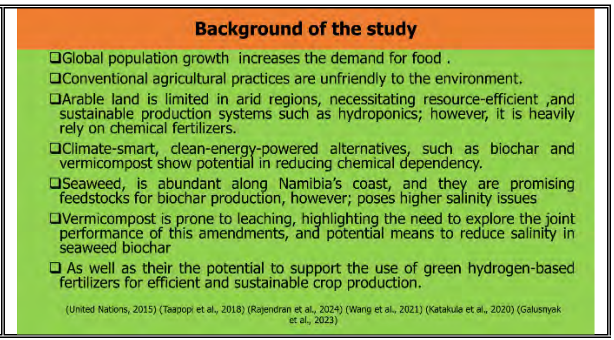
Elia N Ruben, Handura Bethold, Allan H. Mupambwa, and Simeon Hamukoshi

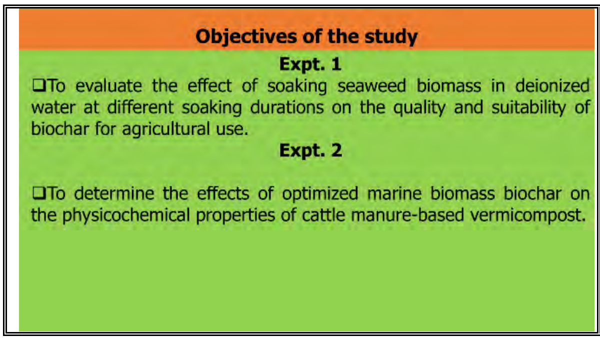
NGHRI – University of Namibia

Enhancing nutrient use efficiency in hydroponic systems is crucial for advancing sustainable agriculture. This study examined the potential of biochar derived from seaweed biomass (Laminaria pallida and Graciriopsis funicularis), along with its vermicompost, as organic amendments to improve the efficacy of green hydrogen-based fertilizers. In the first experiment, the biochar was subjected to a water-soaking treatment to reduce its salinity. In the second experiment, optimized biochar was combined with cattle manure and wastepaper for vermicomposting. Both the biochar and resulting vermicompost were evaluated for quality and suitability parameters (pH, electrical conductivity (EC), extractable phosphorus, ammonium, nitrite, nitrate, extractable cations, and heavy metals). This study emphasizes the potential of utilizing organic amendments, such as biochar from marine seaweed, to enhance crop productivity, improve green fertilizer use efficiency, and minimize dependence on harmful synthetic inputs. The findings support the development of eco-friendly nutrient solutions that align with green hydrogen agriculture initiatives.

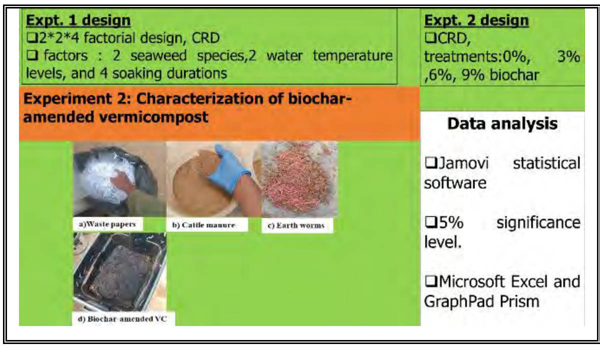
| | |
|---|---|
|  | Mr. Elia N. Ruben is a final-year MSc student in Agriculture (Crop Science) at the University of Namibia, Ogongo Campus, specializing in sustainable nutrient management in hydroponic systems. He currently serves as a student research assistant under the Namibia Green Hydrogen Project at the Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC). His MSc research focuses on optimizing seaweed-derived biochar and its vermicompost to enhance the fertilizer-use efficiency of green hydrogen-based fertilizers. Ruben holds a BSc in Agriculture (Crop Science) from the University of Namibia (2024) and has received several academic excellence awards. He has hands-on experience in greenhouse crop production, organic growing media amendments, and studies on improving fertilizer efficiency |

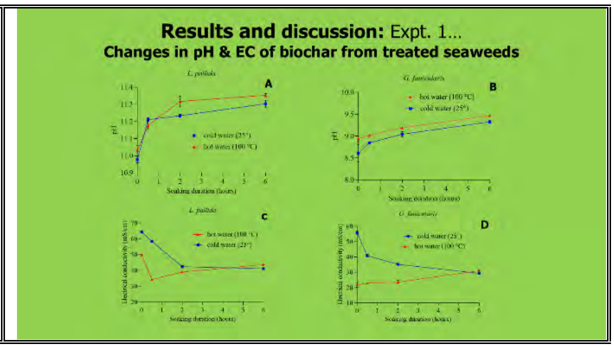

Marine Biomass-Based Biochar and Its Vermicompost for Improving the Fertilizer Use Efficiency of Green Hydrogen-Derived Fertilizers
UNAM
Elia N.M. Ruben -MSc Agriculture Student (Crop Science)
University of Namibia - Daures Green Hydrogen Project
Supervisor:
Dr. Hupenyu Allan Mupambwa -Head of SANUMARC
NGHRI
1

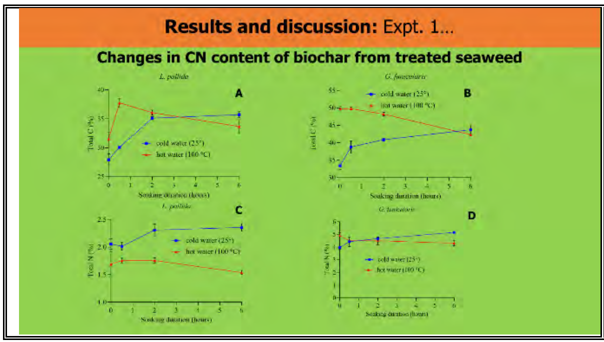

Background of the study
❑Global population growth increases the demand for food .
❑Conventional agricultural practices are unfriendly to the environment.
❑Arable land is limited in arid regions, necessitating resource-efficient ,and sustainable production systems such as hydroponics; however, it is heavily rely on chemical fertilizers.
❑Climate-smart, clean-energy-powered alternatives, such as biochar and vermicompost show potential in reducing chemical dependency.
❑Seaweed, is abundant along Namibia's coast, and they are promising feedstocks for biochar production, however; poses higher salinity issues
❑Vermicompost is prone to leaching, highlighting the need to explore the joint performance of this amendments, and potential means to reduce salinity in seaweed biochar
❑ As well as their the potential to support the use of green hydrogen-based fertilizers for efficient and sustainable crop production.
(United Nations, 2015) (Taapopi et al., 2018) (Rajendran et al., 2024) (Wang et al., 2021) (Katakula et al., 2020) (Galusnyak et al., 2023)
2

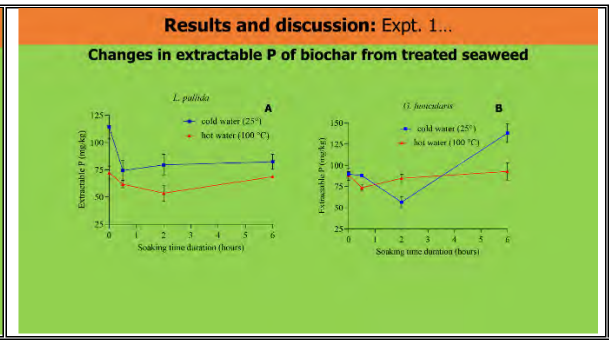

Objectives of the study
Expt. 1
❑To evaluate the effect of soaking seaweed biomass in deionized water at different soaking durations on the quality and suitability of biochar for agricultural use.
Expt. 2
❑To determine the effects of optimized marine biomass biochar on the physicochemical properties of cattle manure-based vermicompost.
3


Materials and methods
Experiment 1: Preparation and characterization of biochar
a) G. funicularis
b) L. Pallida
c) Muffle furnace
d) biochar
e) Multimeter
f) Atomic Absorption Spectrometer
4


Expt. 1 design
❑2*2*4 factorial design, CRD
❑ factors : 2 seaweed species,2 water temperature levels, and 4 soaking durations
Expt. 2 design
❑CRD, treatments:0%, 3% ,6%, 9% biochar
Experiment 2: Characterization of biochar-amended vermicompost
a)Waste papers
b) Cattle manure
c) Earth worms
d) Biochar amended VC
Data analysis
❑Jamovi statistical software
❑5% significance level.
❑Microsoft Excel and GraphPad Prism
5

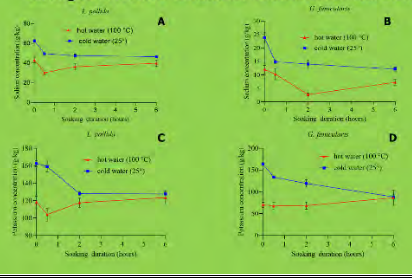

Results and discussion: Expt. 1...
Changes in pH & EC of biochar from treated seaweeds
A
B
C
D
6


Results and discussion: Expt. 1...
Changes in CN content of biochar from treated seaweed
A
B
C
D
7


Results and discussion: Expt. 1...
Changes in extractable P of biochar from treated seaweed
L. pallida
A
cold water (25°)
hot water (100 °C)
Extractable P (mg/kg)
Soaking time duration (hours)
G. funicularis
B
cold water (25°)
hot water (100 °C)
Extractable P (mg/kg)
Soaking time duration (hours)
8

**Results and discussion:** Expt. 1...

**Changes in Na & K in biochar from treated seaweed**




9

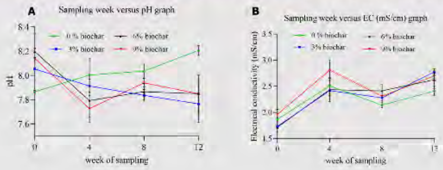
## Expt. 1 conclusions and recommendations

- ❑Water soaking of seaweed biomass is a crucial step to consider before agricultural biochar preparation.
- ❑Seaweed biochar has a potential to enrich soils with macro- and micro nutrients, particularly at optimized treatments.
- ❑ Based on results obtained, best biochar can be obtained from *G. funicularis* soaked subjected to cold water treatment for 6 hr.
- ❑Integrating this biochar in vermicomposting was recommended to further optimize its chemical properties.

10

**Results and discussion:** Expt. 2

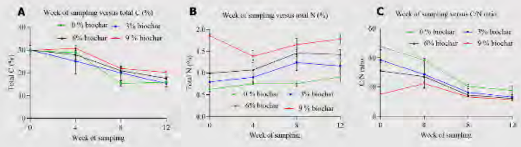
**Changes in pH & EC of biochar-amended vermicompost**




11

**Results and discussion:** Expt. 2

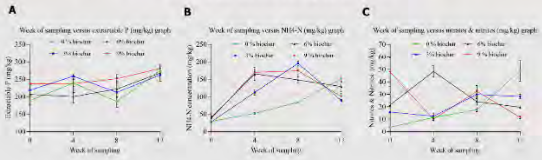
**Changes in CN content of biochar-amended vermicompost**




12

**Results and discussion:** Expt. 2

**Changes in extractable P,NH4-N,NO3/NO2-N of biochar-amended vermicompost**

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## Expt. 2 Conclusions and recommendations

- ❑Incorporating optimized seaweed biochar in vermicompost improves nutrient dynamics and vermidegradation.
- ❑ 9% biochar incorporation rate in vermicomposting appears optimal, improving nutrient content and pH without compromising compost quality, however, Nitrogen supplementation should be considered.
- ❑This can be done by blending it with other N-rich fertilizers such as Green Ammonium Sulfate fertilizers.
- ❑Hence, this aligns with sustainable nutrient management and its eco-friendly approach.

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## Experiment 3. Potential of Biochar-amended vermicompost to improve GREEN ammonium sulfate fertilizer use efficiency

❑This expt. will investigate the potential of optimized biochar-amended vermicompost to improve fertilizer use efficiency of Green Ammonium Sulfate in planting media

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| Sponsors | Federal Ministry of Education and Research | SASSCAL | |


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# Mining from Brine – An Economic Opportunity from Desalination Wastewater

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Chemical compositions of water samples from 3 boreholes, and brine from desalination of the mixed samples, at Daures Green Hydrogen Village in Erongo Region of Namibia were compared with samples from the Atlantic Ocean at University of Namibia's Henties Bay Campus, and at Oranos, Desalination plants. The four chemicals that were in abundance in the samples include Calcium, Sodium Chloride, and Magnesium. Precipitation methods were employed to extract specific chemicals, and the largest yield was calcite. An economic analysis to check the viability of extraction of chemicals from the brine, for profit, was conducted, and will be reported on.

| | |
|---|---|
|  | Dr. Zivayi Chiguvare is the Acting Director of Namibia Green Hydrogen Research Institute, and a senior lecturer in the Department of Physics, Chemistry, and Material Science at the University of Namibia. From 2013 to 2017 he was the Director of Namibia Energy Institute, at the Namibia University of Science and Technology. He holds a Doctor of Sciences degree in Physics from the University of Oldenburg - Germany, completed in 2005, specializing in Materials and photovoltaic Physics. He has experience in solar photovoltaic system installation and inspection, as well as Projects Management. He was a Meteorologist (1997-9) and participated in energy studies for Climate Change communications for the UNFCCC. In 1999 he became the Renewable Energy Programme Coordinator at the Faculty of Engineering of the University of Zimbabwe, where he was a lecturer for than 8 years (1999-2006), and liaised with the Government of Zimbabwe, international non-governmental organisations, industry, and end-users, and advised on renewable energy issues. In 2006 he became a Projects Manager within the Zimbabwe National Biodiesel Project. From 2008 -13 he was a lecturer at the University of the Witwatersrand, where they set up solar cell and nanotechnology research laboratories. He authored 2 books/monograms, 6 chapters in published books, and 25 papers in internationally refereed Journals. |


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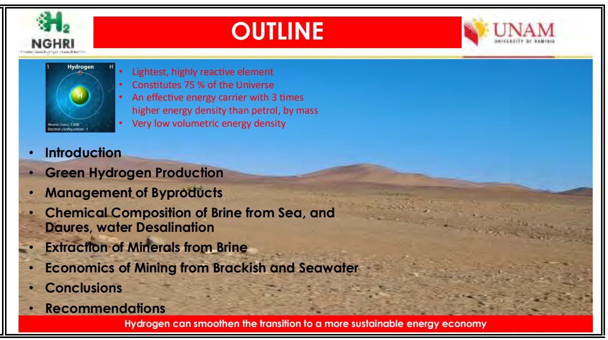


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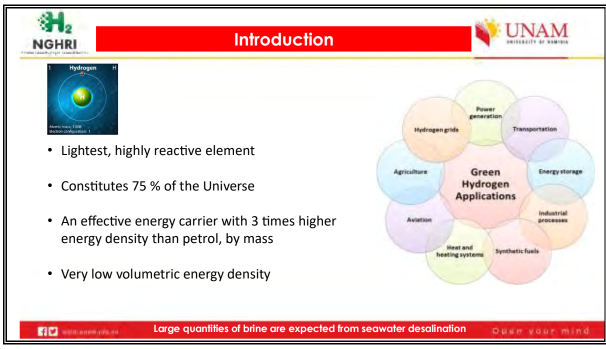


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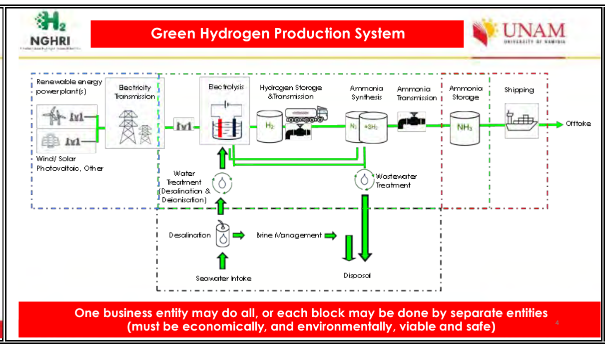


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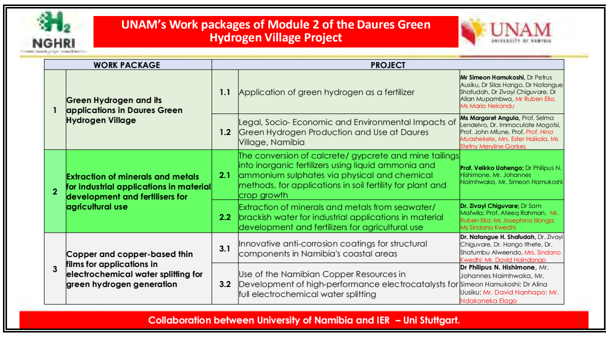


| WORK PACKAGE | | PROJECT | | |
|---|---|---|---|---|
| 1 | Green Hydrogen and its applications in Daures Green Hydrogen Village | 1.1 | Application of green hydrogen as a fertilizer | Mr Simeon Hamukoshi, Dr Petrus Ausiku, Dr Silas Hango, Dr Natangue Shafudah, Dr Zivayi Chiguvare, Dr Allan Mupambwa, Mr Ruben Elia, Ms Maria Nekandu |
| | | 1.2 | Legal, Socio- Economic and Environmental Impacts of Green Hydrogen Production and Use at Daures Village, Namibia | Ms Margaret Angula, Prof. Selma Lendelvo, Dr. Immaculate Mogotsi, Prof. John Mfune, Prof. Prof. Hina Muashekele, Mrs. Ester Haikola, Ms Stefny Meryline Garises |
| 2 | Extraction of minerals and metals for industrial applications in material development and fertilisers for agricultural use | 2.1 | The conversion of calcrete/ gypcrete and mine tailings into inorganic fertilizers using liquid ammonia and ammonium sulphates via physical and chemical methods, for applications in soil fertility for plant and crop growth | Prof. Veikko Uahengo; Dr Philipus N. Hishimone, Mr. Johannes Naimhwaka, Mr. Simeon Hamukoshi |
| | | 2.2 | Extraction of minerals and metals from seawater/ brackish water for industrial applications in material development and fertilizers for agricultural use | Dr. Zivayi Chiguvare; Dr Sam Mafwila; Prof. Ateeq Rahman, Mr. Ruben Elia; Ms Josephina Ilonga; Ms Sindano Kwedhi |
| 3 | Copper and copper-based thin films for applications in electrochemical water splitting for green hydrogen generation | 3.1 | Innovative anti-corrosion coatings for structural components in Namibia's coastal areas | Dr. Natangue H. Shafudah, Dr. Zivayi Chiguvare, Dr. Hango Ithete, Dr. Shatumbu Alweendo, Mrs. Sindano Kwedhi; Mr. David Haindongo |
| | | 3.2 | Use of the Namibian Copper Resources in Development of high-performance electrocatalysts for full electrochemical water splitting | Dr Philipus N. Hishimone, Mr. Johannes Naimhwaka, Mr. Simeon Hamukoshi; Dr Alina Uusiku; Mr. David Nanhapo; Mr. Ndakoneka Elago |

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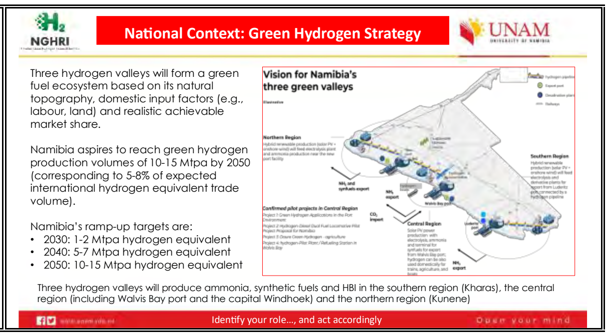


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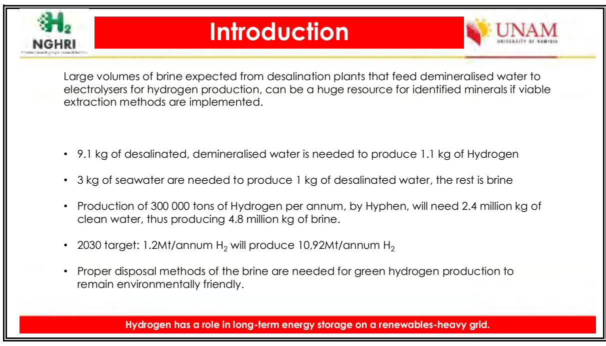


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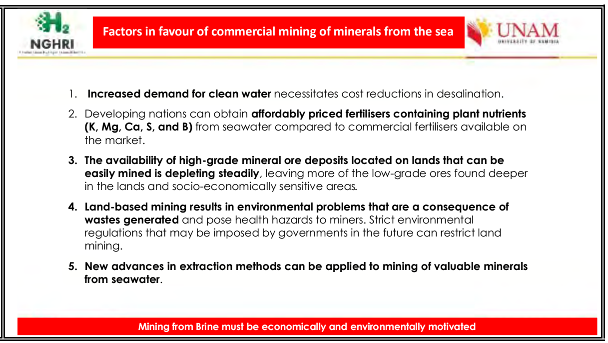


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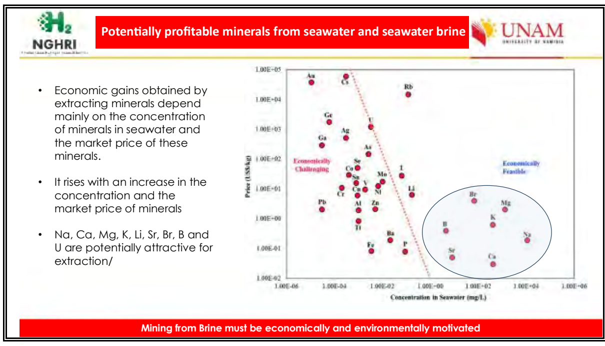


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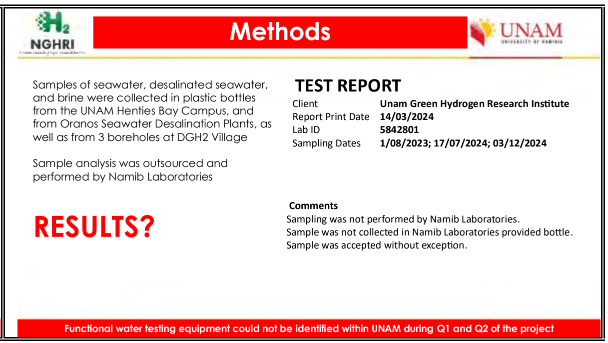


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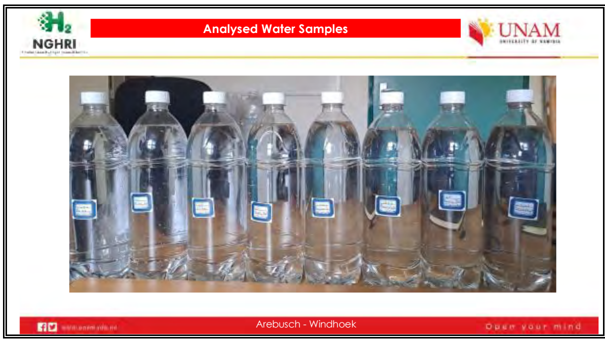


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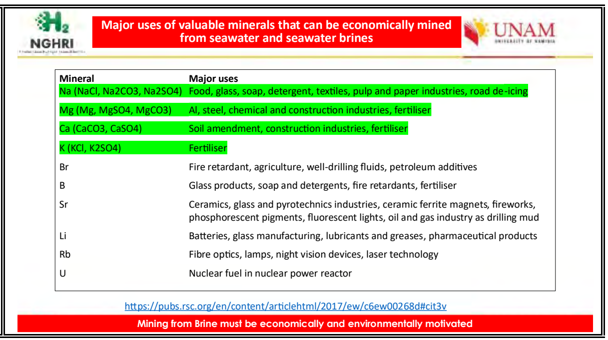


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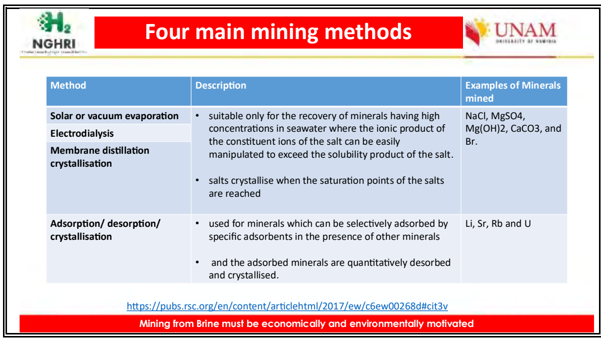


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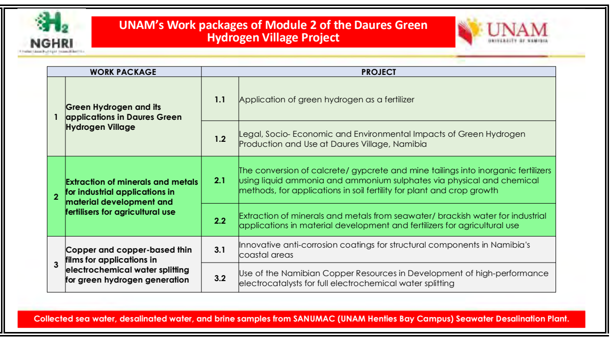


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## Major ion composition of seawater (mg/L)

| Chemical | Typical Seawater | Eastern Mediterranean | Arabian Gulf at Kuwait | Red Sea at Jeddah |
|---|---|---|---|---|
| Chloride ($Cl^-$) | 18.980 | 21.200 | 23.000 | 22.219 |
| Sodium ($Na^+$) | 10.556 | 11.800 | 15.850 | 14.255 |
| Sulfate ($SO_4^{2-}$) | 2.649 | 2.950 | 3.200 | 3.078 |
| Magnesium ($Mg^{2+}$) | 1.262 | 1.403 | 1.765 | 742 |
| Calcium ($Ca^{2+}$) | 400 | 423 | 500 | 225 |
| Potassium ($K^+$) | 380 | 463 | 460 | 210 |
| Bicarbonate ($HCO_3^-$) | 140 | - | 142 | 146 |
| Strontium ($Sr^{2+}$) | 13 | - | - | - |
| Bromide ($Br^-$) | 65 | 155 | 80 | 72 |
| Borate ($BO_3^{3-}$) | 26 | 72 | - | - |
| Fluoride ($F^-$) | 1 | - | - | - |
| Silicate ($SiO_3^{2-}$) | 1 | - | 1.5 | - |
| Iodide ($I^-$) | <1 | 2 | - | - |
| Others | - | - | - | - |
| **Total dissolved solids (TDS)** | **34.483** | **38.600** | **45.000** | **41.000** |

Currently the world uses 11.000 desalination plants to produce daily 20 million cubic meters per day.

They mostly use seawater with an average TDS of 40.000 ppm and brackish water with an average TDS of 10.000 ppm and can be found in each continent.

https://www.lenntech.com/composition-seawater.html

Mining from Brine must be economically and environmentally motivated

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## Major ion composition of seawater (mg/L)

| Chemical | Typical Seawater | Eastern Mediterranean | Arabian Gulf at Kuwait | Red Sea at Jeddah | Atlantic Ocean at Henties Bay, Namibia? |
|---|---|---|---|---|---|
| Chloride ($Cl^-$) | 18 980 | 21 200 | 23 000 | 22 219 | - |
| Sodium ($Na^+$) | 10 556 | 11 800 | 15 850 | 14 255 | 11 760.0 |
| Sulfate ($SO_4^{2-}$) | 2 649 | 2 950 | 3 200 | 3 078 | - |
| Magnesium ($Mg^{2+}$) | 1 262 | 1 403 | 1 765 | 742 | 1 555.50 |
| Calcium ($Ca^{2+}$) | 400 | 423 | 500 | 225 | 396.50 |
| Potassium ($K^+$) | 380 | 463 | 460 | 210 | 780.50 |
| Bicarbonate ($HCO_3^-$) | 140 | - | 142 | 146 | - |
| Strontium ($Sr^{2+}$) | 13 | - | - | - | 6.50 |
| Bromide ($Br^-$) | 65 | 155 | 80 | 72 | - |
| Borate ($BO_3^{3-}$) | 26 | 72 | - | - | - |
| Fluoride ($F^-$) | 1 | - | - | - | - |
| Silicate ($SiO_3^{2-}$) | 1 | - | 1.5 | - | - |
| Iodide ($I^-$) | <1 | 2 | - | - | - |
| Others | - | - | - | - | - |
| **Total dissolved solids (TDS)** | **34.483** | **38.600** | **45.000** | **41.000** | - |

https://www.lenntech.com/composition-seawater.html

Potassium ion quantities are above average in Namibian sea water

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## Analysis of Water Samples from UNAM Henties Bay Desalination Plant: Opportunity for Brine Mining

Results: Cations in Raw Sea Water, Desalinated Water and Brine Samples

| Cations | Raw Seawater mg/L | Desalinated Seawater mg/L | Brine mg/L | Increase (%) |
|---|---|---|---|---|
| Calcium as Ca | 396.50 | 0.67 | 646.0 | 62.9 |
| Magnesium as Mg | 1555.50 | 2.23 | 2307.0 | 48.3 |
| Sodium as Na | 11 760.0 | 78.11 | 18 070.0 | 53.7 |
| Lithium as Li | <0.001 | 0.01 | <0.001 | - |
| Strontium as Sr | 6.50 | 0.01 | 9.95 | 53.1 |
| Boron as B | 4.60 | 0.98 | 5.40 | 17.4 |
| Potassium as K | 780.50 | 8.14 | 1170.0 | 49.9 |
| Rubidium as Rb | 0.76 | 0.01 | 1.0 | 31.6 |

Sodium, Potassium, Magnesium, and Calcium Ions were found to be in large amounts

Mining from Brine must be economically and environmentally motivated

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## Results: Chemicals in Daures Borehole water

| Date of sampling | 2024/07/16 | 2024/07/16 | 2024/07/16 | 2024/07/22 | |
|---|---|---|---|---|---|
| Test item number | I242334/8 | I242334/1 | I242334/3 | I242334/5 | |
| Description of sampling point | DGH2 Borehole 1 | DGH2 Borehole 3 | DGH2 Borehole 6 | DGH2 Brine | |
| Parameter | Value | Value | Value | Value | Units |
| p H | 7,4 | 7,4 | 7,8 | 8,1 | |
| Electrical Conductivity | 1405 | 1450 | 1590 | 3640 | mS/m |
| Total Dissolved Solids (calc.) | 9424 | 9715 | 10653 | 24388 | mg/l |
| P-Alkalinity as $CaCO_3$ | 0 | 0 | 0 | 0 | mg/l |
| Total Alkalinity as $CaCO_3$ | 200 | 205 | 280 | 510 | mg/l |
| Bicarbonate as $HCO_3^-$ | 244 | 250 | 342 | 622 | mg/l |
| Carbonate as $CO_3^{2-}$ | 0 | 2 | 0 | 0 | mg/l |
| Total Hardness as $CaCO_3$ | 0 | 0 | 0 | 0 | mg/l |
| Ca-Hardness as $CaCO_3$ | 0 | 0 | 0 | 0 | mg/l |
| Mg-Hardness as $CaCO_3$ | 0 | 0 | 0 | 0 | |
| Chloride as $Cl^-$ | 3846 | 3970 | 4467 | 11167 | mg/l |
| Fluoride as $F^-$ | 1,6 | 1,6 | 1,8 | 3,5 | mg/l |
| Sulphate as $SO_4^{2-}$ | 1430 | 1466 | 1700 | 7667 | mg/l |
| Bromide as $Br^-$ | 7 | 7,2 | 6,6 | 16 | mg/l |
| Iodine as $I^-$ | 1,7 | 1,5 | 1,5 | 4 | mg/l |
| Silica as $SiO_2$ | 19 | 20 | 20 | 56 | mg/l |

Concentrations of chemicals are higher in brine

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## Results: Chemicals in Daures Borehole water


| Sample details | Water | Water | Water | Water | |
|---|---|---|---|---|---|
| Location of sampling point - | ODP, Erongo | ODP, Erongo | ODP, Erongo | ODP, Erongo | |
| Date of sampling | 2024/07/17 | 2024/07/17 | 2024/07/17 | 2024/07/16 | |
| Test item number | I242334/4 | I242334/6 | I242334/2 | I242334/7 | |
| Description of sampling point | ODP Intake | ODP Brine TNT | ODP Brine RO | ODP Permit RO | |
| Parameter | Value | Value | Value | Value | Units |
| p H | 7,5 | 7,9 | 7,4 | 9 | |
| Electrical Conductivity | 5380 | 5550 | 9950 | 22,6 | mS/m |
| Total Dissolved Solids (calc.) | 36046 | 36850 | 66665 | 151 | mg/l |
| P-Alkalinity as $CaCO_3$ | 0 | 0 | 0 | 5 | mg/l |
| Total Alkalinity as $CaCO_3$ | 115 | 120 | 185 | 15 | mg/l |
| Bicarbonate as $HCO_3^-$ | 140 | 146 | 226 | 6 | mg/l |
| Carbonate as $CO_3^{2-}$ | 0 | 0 | 0 | 6 | mg/l |
| Chloride as $Cl^-$ | 20100 | 21341 | 89334 | 65 | mg/l |
| Fluoride as $F^-$ | 0,6 | 0,7 | 0,9 | ≤ 0,1 | mg/l |
| Sulphate as $SO_4^{2-}$ | 4459 | 5268 | 4326 | 5 | mg/l |
| Bromide as $Br^-$ | 56 | 66 | 90 | 0,4 | mg/l |
| Iodine as $I^-$ | 1,9 | ≤ 0,05 | 2,2 | ≤ 0,05 | mg/l |
| Silica as $SiO_2$ | 4,1 | 3,1 | 7,3 | ≤ 0,2 | mg/l |

Concentrations of chemicals are higher in brine

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## Daures and OranosOranos Desalination Plants, Erongo, Namibia

| Date of sampling | 2024/07/16 | 2024/07/16 | 2024/07/16 | 2024/07/22 | |
|---|---|---|---|---|---|
| Test item number | I242334/8 | I242334/1 | I242334/3 | I242334/5 | |
| Description of sampling point | DGH2 Borehole 1 | DGH2 Borehole 3 | DGH2 Borehole 6 | DGH2 Brine | |
| Parameter | Value | Value | Value | Value | Units |
| p H | 7,4 | 7,4 | 7,8 | 8,1 | |
| Electrical Conductivity (mS/m) | 1405 | 1450 | 1590 | 3640 | mS/m |
| Total Dissolved Solids (calc.) (mg/l) | 9414 | 9715 | 10653 | 24388 | mg/l |
| P-Alkalinity as $CaCO_3$ (mg/l) | 0 | 0 | 0 | 0 | mg/l |
| Total Alkalinity as $CaCO_3$ (mg/l) | 200 | 205 | 280 | 510 | mg/l |
| Bicarbonate as $HCO_3^-$ (mg/l) | 244 | 250 | 342 | 622 | mg/l |
| Carbonate as $CO_3^{2-}$ (mg/l) | 0 | 0 | 0 | 0 | mg/l |
| Total Hardness as $CaCO_3$ (mg/l) | 1847 | 1780 | 1994 | 4928 | mg/l |
| Ca-Hardness as $CaCO_3$ (mg/l) | 949 | 911 | 1071 | 2457 | mg/l |
| Mg-Hardness as $CaCO_3$ (mg/l) | 898 | 869 | 922 | 2471 | mg/l |
| Chloride as $Cl^-$ (mg/l) | 3846 | 3970 | 4467 | 11167 | mg/l |
| Fluoride as $F^-$ (mg/l) | 1,6 | 1,6 | 1,8 | 3,5 | mg/l |
| Sulphate as $SO_4^{2-}$ (mg/l) | 1430 | 1466 | 1700 | 7667 | mg/l |
| Sodium as Na (mg/l) | 2046 | 2220 | 2428 | 6143 | mg/l |
| Potassium as K (mg/l) | 43 | 42 | 67 | 118 | mg/l |
| Magnesium as Mg (mg/l) | 218 | 211 | 224 | 600 | mg/l |
| Calcium as Ca (mg/l) | 380 | 365 | 429 | 984 | mg/l |
| Bromide as $Br^-$ (mg/l) | 7 | 7,2 | 6,6 | 16 | mg/l |
| Iodine as $I^-$ (mg/l) | less than 0,5 | 1,5 | 1,5 | 4 | mg/l |
| Gallium as Ga (mg/l) | less than 0,01 | less than 0,01 | less than 0,01 | 0,01 | mg/l |
| Rubidium as Rb (mg/l) | 0,04 | 0,03 | 0,03 | 0,09 | mg/l |
| Lithium as Li (mg/l) | 0,01 | 0,01 | 0 | 0,03 | mg/l |
| Strontium as Sr (mg/l) | 18 | 20 | 21 | 63 | mg/l |
| Boron as B (mg/l) | 3,8 | 4,2 | 4,4 | 10 | mg/l |
| Silica as $SiO_2$ (mg/l) | 19 | 20 | 20 | 56 | mg/l |

| | 2024/07/17 | 2024/07/17 | 2024/07/17 | 2024/07/16 | |
|---|---|---|---|---|---|
| | I242334/4 | I242334/6 | I242334/2 | I242334/7 | |
| Description of sampling point | ODP Intake | ODP Brine TNT | ODP Brine RO | ODP Permit RO | |
| Parameter | Value | Value | Value | Value | Units |
| p H | 7,5 | 7,9 | 7,4 | 9 | |
| Electrical Conductivity | 5380 | 5550 | 9950 | 22,6 | mS/m |
| Total Dissolved Solids (calc.) | 36046 | 36850 | 66665 | 151 | mg/l |
| P-Alkalinity as $CaCO_3$ | 0 | 0 | 0 | 5 | mg/l |
| Total Alkalinity as $CaCO_3$ | 115 | 120 | 185 | 15 | mg/l |
| Bicarbonate as $HCO_3^-$ | 140 | 146 | 226 | 6 | mg/l |
| Carbonate as $CO_3^{2-}$ | 0 | 0 | 0 | 6 | mg/l |
| Total Hardness as $CaCO_3$ | 5502 | 6075 | 14292 | 7 | mg/l |
| Ca-Hardness as $CaCO_3$ | 824 | 956 | 2337 | 1 | mg/l |
| Mg-Hardness as $CaCO_3$ | 4678 | 5119 | 11955 | 5 | mg/l |
| Chloride as $Cl^-$ | 20100 | 21341 | 44667 | 65 | mg/l |
| Fluoride as $F^-$ | 0,6 | 0,7 | 0,9 | ≤ 0,1 | mg/l |
| Sulphate as $SO_4^{2-}$ | 4459 | 5268 | 4326 | 5 | mg/l |
| **Sodium as Na** | 8900 | 9834 | 24600 | 35 | mg/l |
| Potassium as K | 330 | 375 | 876 | 1.8 | mg/l |
| Magnesium as Mg | 1136 | 1243 | 2903 | 1.3 | mg/l |
| Calcium as Ca | 330 | 383 | 936 | 0.5 | mg/l |
| Bromide as $Br^-$ | 56 | 66 | 90 | ≤ 0.5 | mg/l |
| Iodine as $I^-$ | 1,9 | ≤ 0,05 | 2,2 | ≤ 0.5 | mg/l |
| Gallium as Ga | 0.01 | 0.01 | 0.01 | ≤ 0.01 | mg/l |
| Rubidium as Rb | 0.03 | 0.04 | ≤0.01 | ≤ 0.01 | mg/l |
| Lithium as Li | ≤0.01 | ≤0.01 | ≤0.01 | ≤ 0.01 | mg/l |
| Strontium as Sr | 15 | 18 | 33 | 0.01 | mg/l |
| Boron as B | 3,3 | 3,8 | 9,4 | 0,43 | mg/l |
| Silica as $SiO_2$ | 4,1 | 3,1 | 7,3 | ≤ 0,2 | mg/l |

Desalination concentrates chemicals significantly

20

## Daures and OranosOranos Desalination Plants, Erongo, Namibia

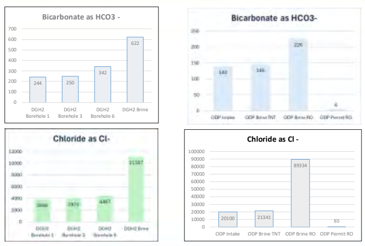

More TDS in seawater

More Cl⁻ in seawater

Desalination concentrates chemicals significantly

21

## Daures and OranosOranos Desalination Plants, Erongo, Namibia

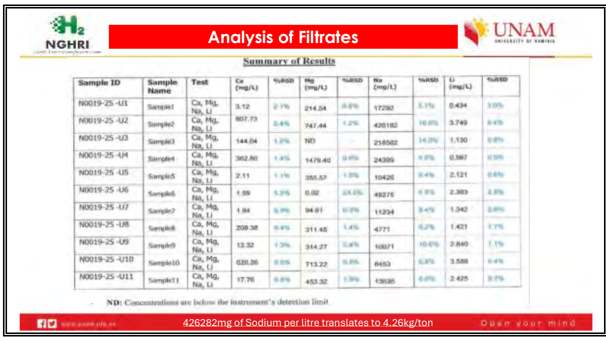



More bicarbonate at Daures

Less Cl- at Daures

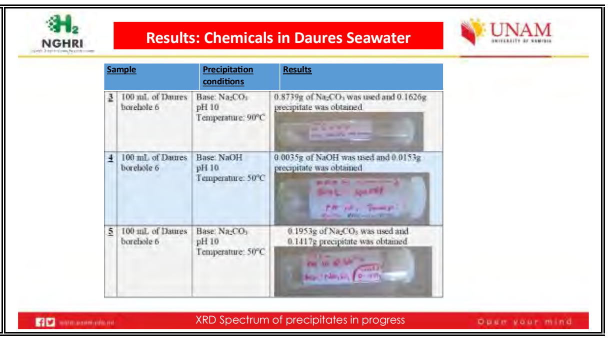
Desalination concentrates chemicals significantly

22



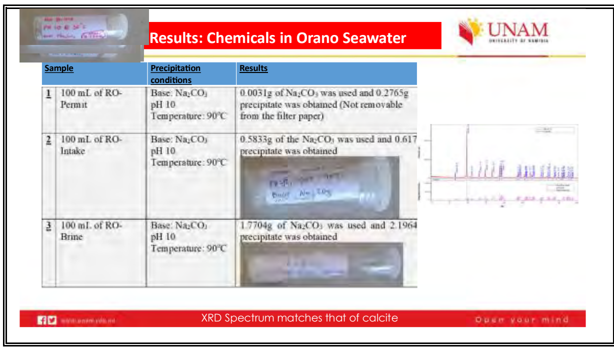

| Sample ID | Sample Name | Test | Ca (mg/L) | %RSD | Mg (mg/L) | %RSD | Na (mg/L) | %RSD | Li (mg/L) | %RSD |
|---|---|---|---|---|---|---|---|---|---|---|
| N0019-25 -U1 | Sample1 | Ca, Mg, Na, Li | 3.12 | [illegible] | 214.54 | [illegible] | 17292 | [illegible] | 0.434 | [illegible] |
| N0019-25 -U2 | Sample2 | Ca, Mg, Na, Li | 807.73 | [illegible] | 747.44 | [illegible] | 426182 | [illegible] | 3.749 | [illegible] |
| N0019-25 -U3 | Sample3 | Ca, Mg, Na, Li | 144.04 | [illegible] | ND | - | 216502 | [illegible] | 1.130 | [illegible] |
| N0019-25 -U4 | Sample4 | Ca, Mg, Na, Li | 362.80 | [illegible] | 1479.40 | [illegible] | 24399 | [illegible] | 0.567 | [illegible] |
| N0019-25 -U5 | Sample5 | Ca, Mg, Na, Li | 2.11 | [illegible] | 355.57 | [illegible] | 10420 | [illegible] | 2.121 | [illegible] |
| N0019-25 -U6 | Sample6 | Ca, Mg, Na, Li | 1.59 | [illegible] | 0.02 | [illegible] | 48275 | [illegible] | 2.383 | [illegible] |
| N0019-25 -U7 | Sample7 | Ca, Mg, Na, Li | 1.84 | [illegible] | 94.61 | [illegible] | 11234 | [illegible] | 1.342 | [illegible] |
| N0019-25 -U8 | Sample8 | Ca, Mg, Na, Li | 209.38 | [illegible] | 311.45 | [illegible] | 4771 | [illegible] | 1.421 | [illegible] |
| N0019-25 -U9 | Sample9 | Ca, Mg, Na, Li | 13.32 | [illegible] | 314.27 | [illegible] | 10071 | [illegible] | 2.840 | [illegible] |
| N0019-25 -U10 | Sample10 | Ca, Mg, Na, Li | 620.26 | [illegible] | 713.22 | [illegible] | 8453 | [illegible] | 3.588 | [illegible] |
| N0019-25 -U11 | Sample11 | Ca, Mg, Na, Li | 17.76 | [illegible] | 453.32 | [illegible] | 13636 | [illegible] | 2.425 | [illegible] |

23



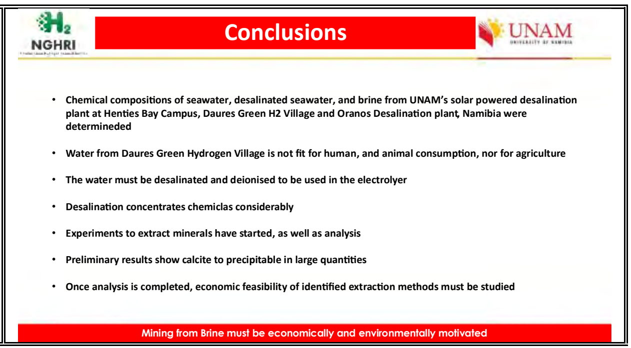

| Sample | | Precipitation conditions | Results |
|---|---|---|---|
| 3 | 100 mL of Daures borehole 6 | Base: $Na_2CO_3$ pH 10 Temperature: 90°C | 0.8739g of $Na_2CO_3$ was used and 0.1626g precipitate was obtained |
| 4 | 100 mL of Daures borehole 6 | Base: NaOH pH 10 Temperature: 50°C | 0.0035g of NaOH was used and 0.0153g precipitate was obtained |
| 5 | 100 mL of Daures borehole 6 | Base: $Na_2CO_3$ pH 10 Temperature: 50°C | 0.1953g of $Na_2CO_3$ was used and 0.1417g precipitate was obtained |

24




| Sample | | Precipitation conditions | Results |
|---|---|---|---|
| 1 | 100 mL of RO-Permit | Base: $Na_2CO_3$ pH 10 Temperature: 90°C | 0.0031g of $Na_2CO_3$ was used and 0.2765g precipitate was obtained (Not removable from the filter paper) |
| 2 | 100 mL of RO-Intake | Base: $Na_2CO_3$ pH 10 Temperature: 90°C | 0.5833g of the $Na_2CO_3$ was used and 0.617 precipitate was obtained |
| 3 | 100 mL of RO-Brine | Base: $Na_2CO_3$ pH 10 Temperature: 90°C | 1.7704g of $Na_2CO_3$ was used and 2.1964 precipitate was obtained |

25




26


27


28

# Preparation of coating solutions involving Cu(II) complexes from copper plates by electrochemical process and its application in fabrication of thin films as potential electrodes in water splitting

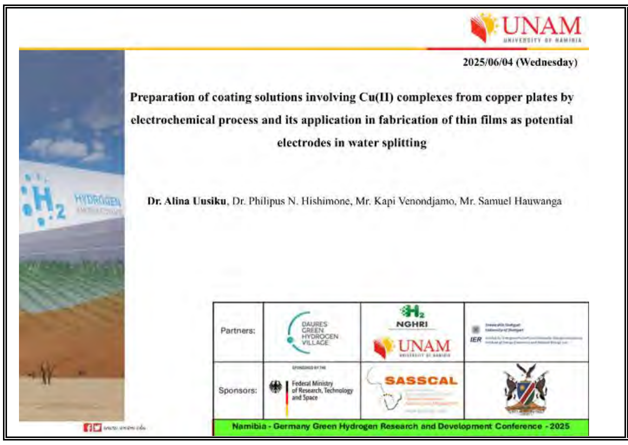
Alina Uusiku, Venondjamo G. Kapi, Rahman Ateeq, and Phillipus Hishimone

Namibia Green Hydrogen Research Institute (NGHRI), University of Namibia

E-mail: auusiku@unam.na

The Cu(II) complex species in aqueous precursor solution was novel synthesized by oxidation of anode copper metal electrode in electrolyte solution containing ethylenediamine–*N, N, N', N'*–tetraacetic acid (EDTA) and ammonia ($NH_3$) ligands at ambient temperature. Two types of coating precursor solutions were prepared by electrolysis of copper electrodes utilizing a single electrolytic cell. The presence of Cu(II) complex species of $[Cu(NH_3)_2(H_2edta)]$ and $[Cu(edta)]^{2-}$ in prepared precursor solutions were identified and confirmed by their UV – Vis spectra using UV- Vis Spectrophotometry. Cu based thin films were fabricated using Molecular Precursor Method (MPM) by heat treatment of sprayed films spray coated on substrate with precursor solutions. The films were spray coated at 180 °C in air and double heat treated at 350 °C for 50 minutes under $O_2$ gas in a furnace. X-ray diffraction patterns of the resultant films indicated the peaks assignable for $Cu_2O$ and CuO crystal phases. The field emission scanning indicated both the surface and cross-sectional morphologies which revealed agglomerated Cu based grains and thickness of the fabricated films, respectively. The fabricated films possess chemical application as candidates for electrodes in water splitting *via* electrolysis.

Dr. Alina Uusiku is a Researcher in the Namibian Green Hydrogen Research Institute (NGHRI) at University of Namibia (UNAM). She holds a Doctor of Philosophy in Engineering (Applied Chemistry and Chemical Engineering) from Kogakuin University, Tokyo, Japan. As well as a Post-Doctoral Certificate from RWTH Aachen University, Germany. She acquired a Master of Science, BSc in Chemistry and a Post Graduate Diploma in Higher Education from UNAM. Her research interests are on Teaching and Learning in Higher Education context, Quality assurance in Higher Education, Electrochemical Hydrogen production using Namibian raw material of copper electrodes, Fabrication and analysis of Membrane Electrode Assemblies (MEAs) for Proton Exchange Membrane (PEM) water electrolysis, Fabrication of functional nano materials with various energy requiring applications such as, conductive copper and copper based thin films and fabrication of *p*-type $Cu_2O$ photo catalysts.


UNAM
2025/06/04 (Wednesday)
Preparation of coating solutions involving Cu(II) complexes from copper plates by electrochemical process and its application in fabrication of thin films as potential electrodes in water splitting
Dr. Alina Uusiku, Dr. Philipus N. Hishimone, Mr. Kapi Venondjamo, Mr. Samuel Hauwanga
Partners:
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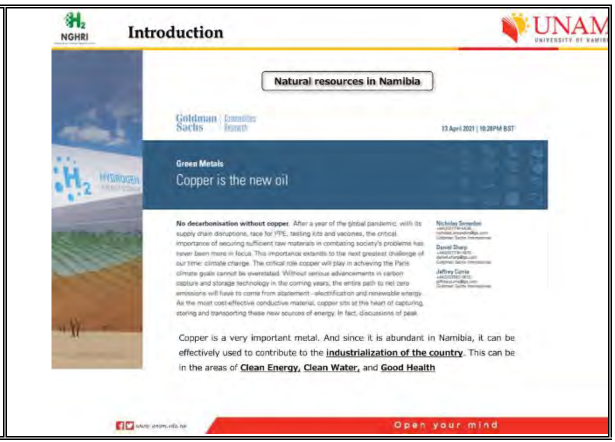
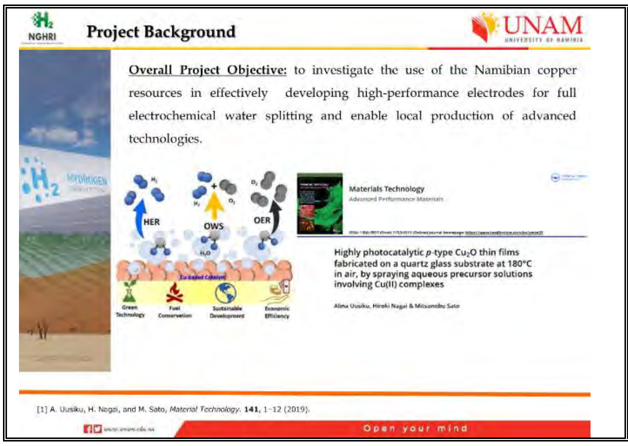
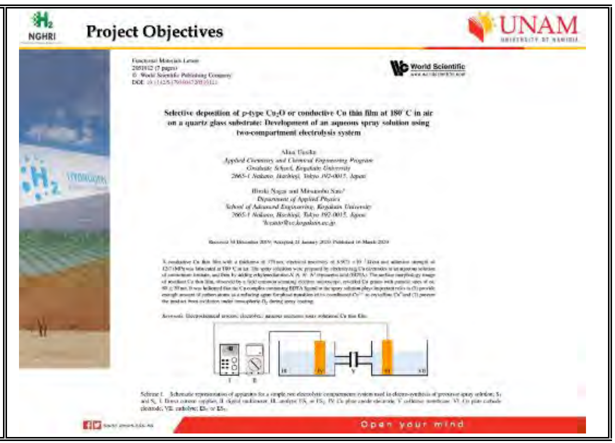
1


NGHRI
Introduction
UNAM
Natural resources in Namibia
Green Metals
Copper is the new oil
Copper is a very important metal. And since it is abundant in Namibia, it can be effectively used to contribute to the industrialization of the country. This can be in the areas of Clean Energy, Clean Water, and Good Health
Open your mind
2


NGHRI
Project Background
UNAM
Overall Project Objective: to investigate the use of the Namibian copper resources in effectively developing high-performance electrodes for full electrochemical water splitting and enable local production of advanced technologies.
HER
OWS
OER
Materials Technology
Highly photocatalytic p-type Cu2O thin films fabricated on a quartz glass substrate at 180°C in air, by spraying aqueous precursor solutions involving Cu(II) complexes
Alina Uusiku, Hiroki Nagai & Mitsunobu Sato
[1] A. Uusiku, H. Nagai, and M. Sato, Material Technology. 141, 1-12 (2019).
Open your mind
3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Project Objectives
UNAM
World Scientific
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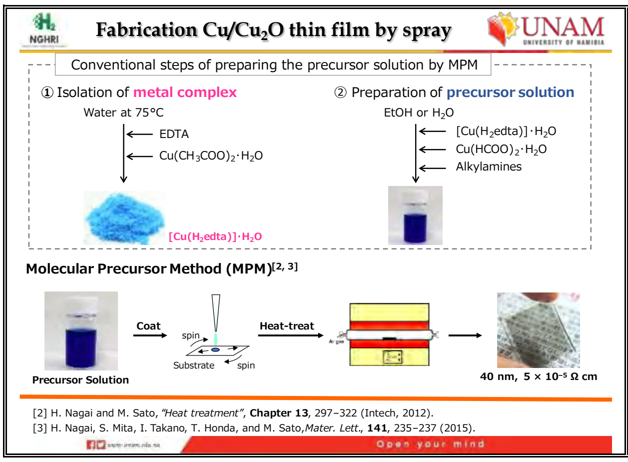
4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Fabrication Cu/Cu2O thin film by spray
UNAM
Conventional steps of preparing the precursor solution by MPM
① Isolation of metal complex
Water at 75°C
EDTA
Cu(CH3COO)2·H2O
[Cu(H2edta)]·H2O
② Preparation of precursor solution
EtOH or H2O
[Cu(H2edta)]·H2O
Cu(HCOO)2·H2O
Alkylamines
Molecular Precursor Method (MPM)[2, 3]
Coat
spin
Substrate
spin
Heat-treat
Precursor Solution
40 nm, 5 × 10-5 Ω cm
[2] H. Nagai and M. Sato, "Heat treatment", Chapter 13, 297–322 (Intech, 2012).
[3] H. Nagai, S. Mita, I. Takano, T. Honda, and M. Sato, Mater. Lett., 141, 235–237 (2015).
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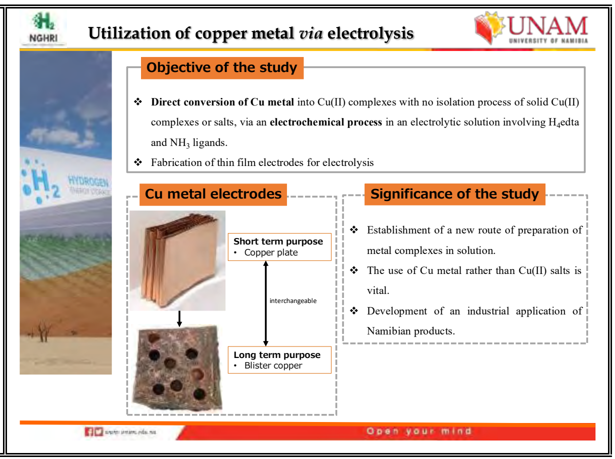
5


NGHRI
Utilization of copper metal via electrolysis
UNAM
Objective of the study
Direct conversion of Cu metal into Cu(II) complexes with no isolation process of solid Cu(II) complexes or salts, via an electrochemical process in an electrolytic solution involving H4edta and NH3 ligands.
Fabrication of thin film electrodes for electrolysis
Cu metal electrodes
Short term purpose
Copper plate
interchangeable
Long term purpose
Blister copper
Significance of the study
Establishment of a new route of preparation of metal complexes in solution.
The use of Cu metal rather than Cu(II) salts is vital.
Development of an industrial application of Namibian products.
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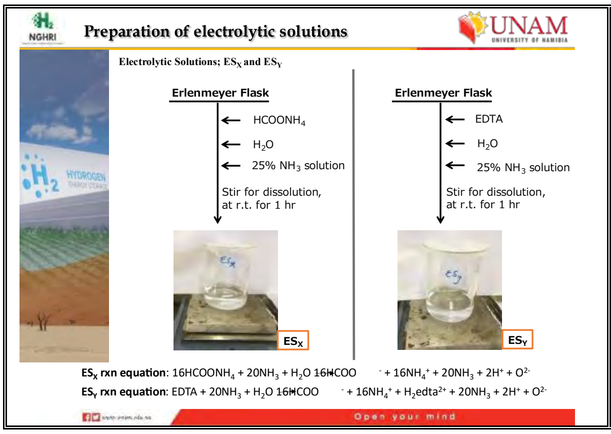
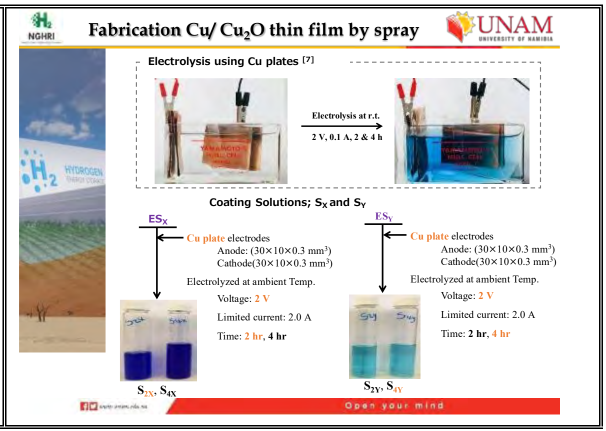
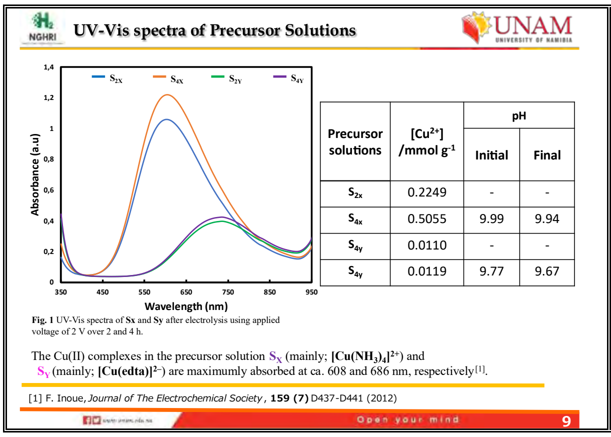
6




7

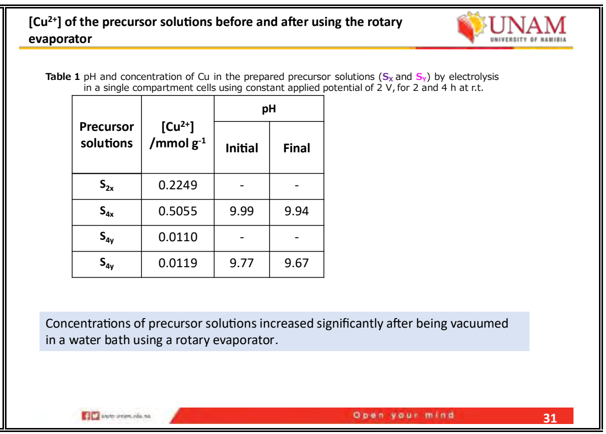



8



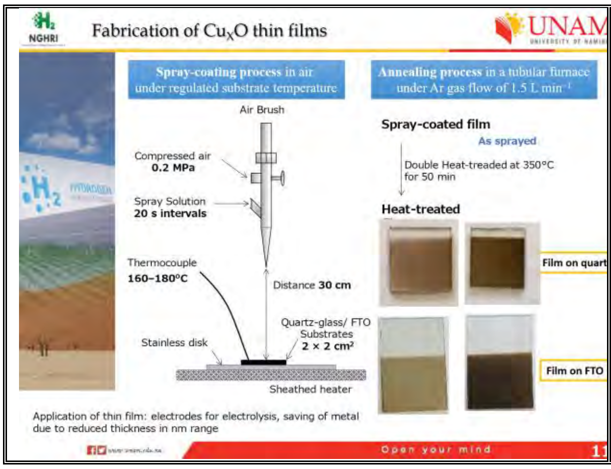

| Precursor solutions | [Cu$^{2+}$] /mmol g$^{-1}$ | pH | |
|---|---|---|---|
| | | Initial | Final |
| $S_{2x}$ | 0.2249 | - | - |
| $S_{4x}$ | 0.5055 | 9.99 | 9.94 |
| $S_{4y}$ | 0.0110 | - | - |
| $S_{4y}$ | 0.0119 | 9.77 | 9.67 |

9

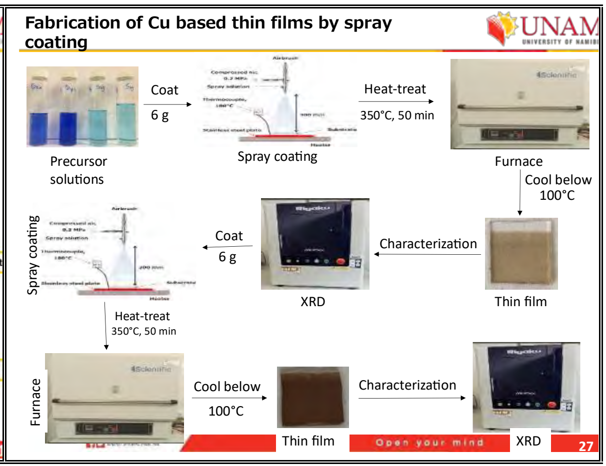



| Precursor solutions | [Cu$^{2+}$] /mmol g$^{-1}$ | pH | |
|---|---|---|---|
| | | Initial | Final |
| $S_{2x}$ | 0.2249 | - | - |
| $S_{4x}$ | 0.5055 | 9.99 | 9.94 |
| $S_{4y}$ | 0.0110 | - | - |
| $S_{4y}$ | 0.0119 | 9.77 | 9.67 |

10




11

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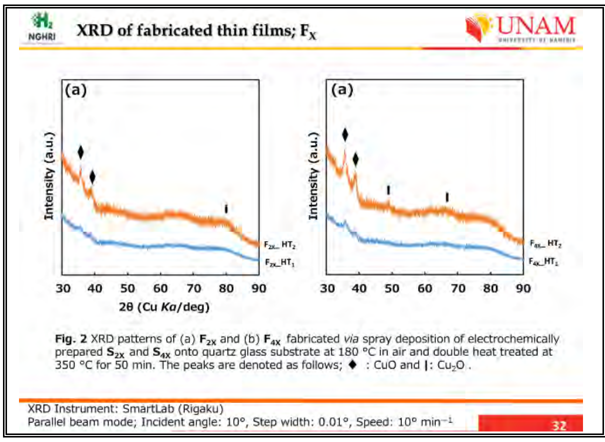


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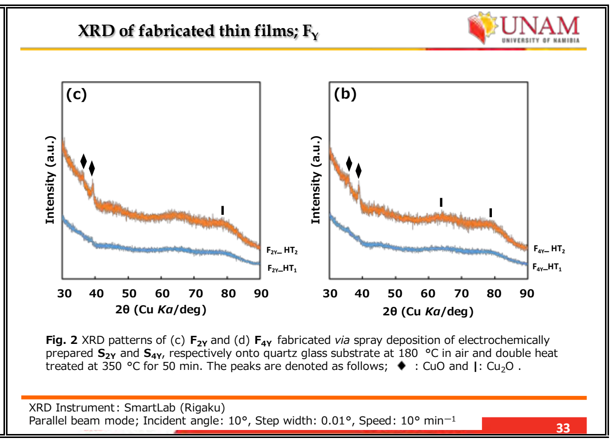


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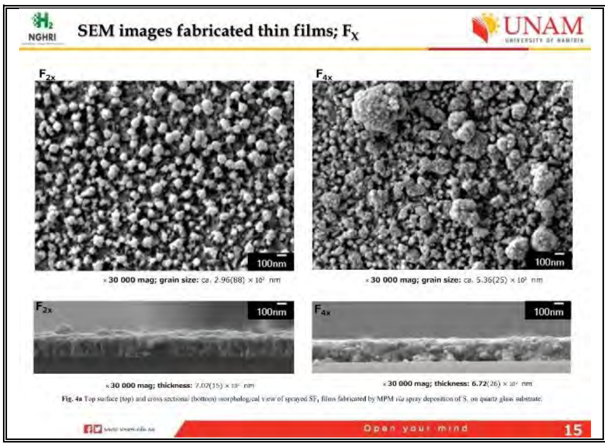


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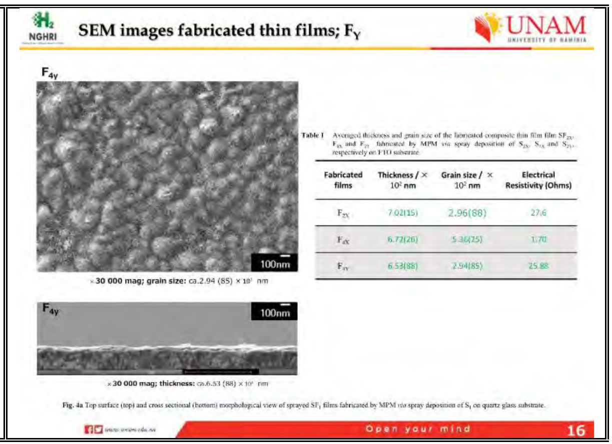


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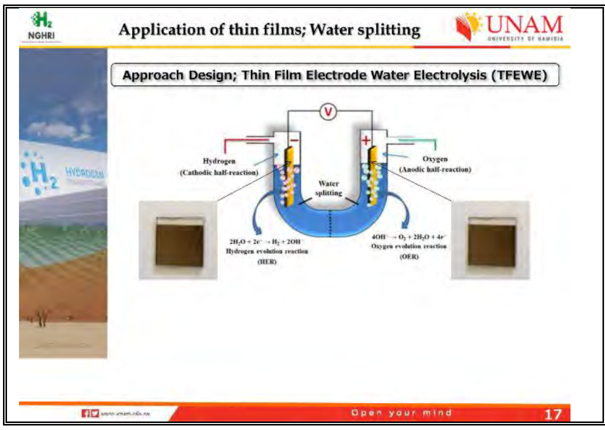


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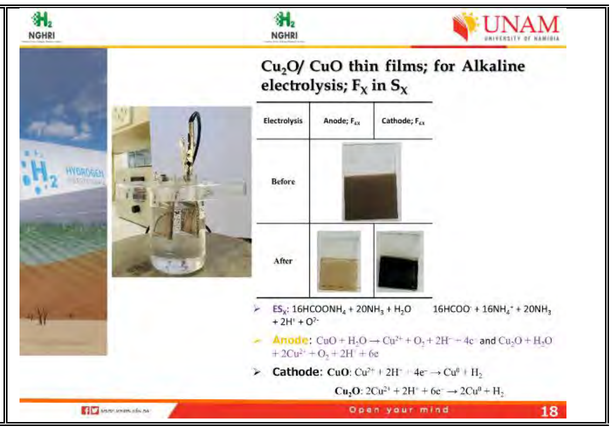


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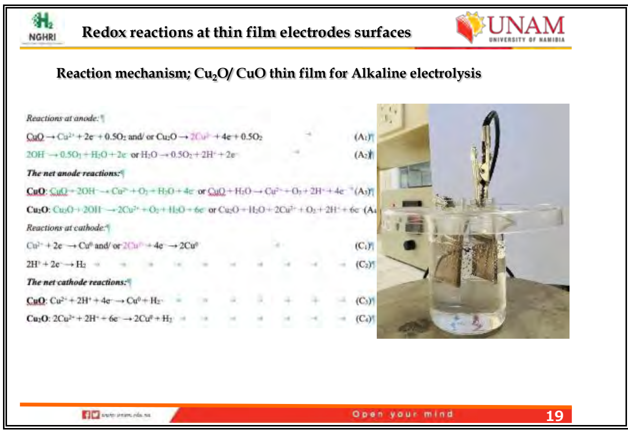
NGHRI
Redox reactions at thin film electrodes surfaces
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Reaction mechanism; $Cu_2O$/ CuO thin film for Alkaline electrolysis
Reactions at anode:
$CuO \rightarrow Cu^{2+} + 2e^- + 0.5O_2$ and/ or $Cu_2O \rightarrow 2Cu^{2+} + 4e^- + 0.5O_2$ (A1)
$2OH^- \rightarrow 0.5O_2 + H_2O + 2e^-$ or $H_2O \rightarrow 0.5O_2 + 2H^+ + 2e^-$ (A2)
The net anode reactions:
CuO: $CuO + 2OH^- \rightarrow Cu^{2+} + O_2 + H_2O + 4e^-$ or $CuO + H_2O \rightarrow Cu^{2+} + O_2 + 2H^+ + 4e^-$ (A3)
$Cu_2O$: $Cu_2O + 2OH^- \rightarrow 2Cu^{2+} + O_2 + H_2O + 6e^-$ or $Cu_2O + H_2O + 2Cu^{2+} + O_2 + 2H^+ + 6e^-$
Reactions at cathode:
$Cu^{2+} + 2e^- \rightarrow Cu^0$ and/ or $2Cu^{2+} + 4e^- \rightarrow 2Cu^0$ (C1)
$2H^+ + 2e^- \rightarrow H_2$ (C2)
The net cathode reactions:
CuO: $Cu^{2+} + 2H^+ + 4e^- \rightarrow Cu^0 + H_2$ (C3)
$Cu_2O$: $2Cu^{2+} + 2H^+ + 6e^- \rightarrow 2Cu^0 + H_2$ (C4)
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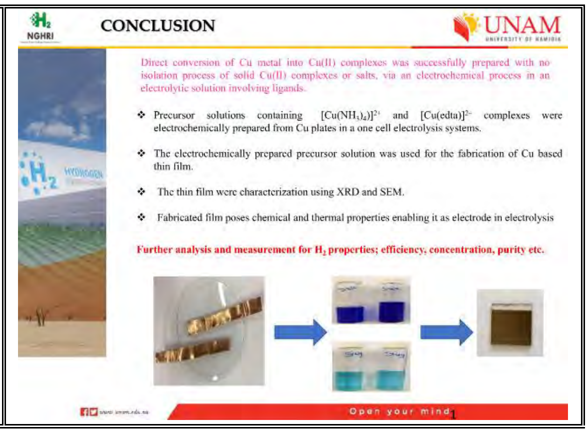
19

19


NGHRI
CONCLUSION
UNAM
UNIVERSITY OF NAMIBIA
Direct conversion of Cu metal into Cu(II) complexes was successfully prepared with no isolation process of solid Cu(II) complexes or salts, via an electrochemical process in an electrolytic solution involving ligands.
Precursor solutions containing $[Cu(NH_3)_4]^{2+}$ and $[Cu(edta)]^{2-}$ complexes were electrochemically prepared from Cu plates in a one cell electrolysis systems.
The electrochemically prepared precursor solution was used for the fabrication of Cu based thin film.
The thin film were characterization using XRD and SEM.
Fabricated film poses chemical and thermal properties enabling it as electrode in electrolysis
Further analysis and measurement for $H_2$ properties; efficiency, concentration, purity etc.
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20


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THANK YOU!
UNAM
UNIVERSITY OF NAMIBIA
Research Team
Collaborators
Partners:
DAURES GREEN HYDROGEN VILLAGE
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Universität Stuttgart
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21

# Balancing Societal and Ecological Resilience: A Critical Analysis of the Interface Between Conservation and Green Hydrogen Operations in Namibia

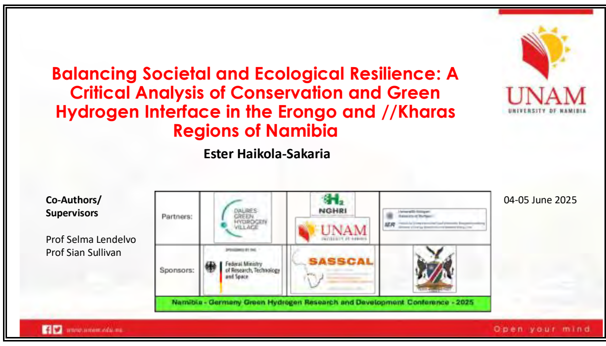
Esther Haikola[1], Selma Lendelvo[1], and Sian Sullivan[2]

[1]university of Namibia

[2]Bath SPA University, and Gobabeb Namib Research Institute

Most countries have been making investments in clean energy as a response to the problems brought on by climate change, and as a means of ensuring energy security to raise the standard of living of their citizens. Green hydrogen is a form of hydrogen that is produced using renewable energy sources, such as solar or wind power, through a process called electrolysis. It is considered a clean and sustainable energy source because it does not produce carbon emissions when used as fuel. Green hydrogen produced from renewable power and water is considered as one of the pivotal solutions to achieve net-zero emissions by 2050 worldwide. The Government of Namibia is pursuing the long-term goal of climate neutrality and to become a global net exporter and hub to produce Green Hydrogen and its derivatives. Green Hydrogen is sustainable in the long term, and the Namibian Government is to develop Green Hydrogen production capacities, promote a rapid market ramp-up and establish the corresponding value chains – both nationally and internationally. This will support local markets and local decarbonisation efforts, while generating employment for the Namibian people. As such, developing a Green Hydrogen industry will result in long-term pathways for economic recovery. One of the key Namibian Green Hydrogen Projects is the first large-scale green hydrogen project in the Tsau //Khaeb National Park, undertaken by Hyphen Hydrogen Energy (Hyphen). Objectives of the study are to identify key management strategies for landscape protection during implementation of Green Hydrogen initiatives in the conservation areas of Erongo and//Kharas regions; Map stakeholders' perceptions including opportunities, knowledge, attitudes and fears towards the GH operations in the Erongo and //Kharas region; and Analyse the benefit of sharing methods for inclusive participation and equitable benefit distribution among surrounding communities, members, and stakeholders adapted in the GH production projects in Erongo and//Kharas regions.

Hon. Esther Haikola-Sakaria has a Postgraduate Diploma in Education (Mathematics and Biology), Postgraduate Diploma in Monitoring and Evaluation, Bachelor of Sciences Honors Degree in Environmental Biology and Geography and a Master of Science in Biodiversity Management and Research. She is researched on Legal, Socio- Economic and Environmental Impacts of Green Hydrogen Production and Use at Daures Green Hydrogen Village, Namibia. Hon Haikola is a member of Parliament in the National Assembly of Namibia.


Balancing Societal and Ecological Resilience: A Critical Analysis of Conservation and Green Hydrogen Interface in the Erongo and //Kharas Regions of Namibia
Ester Haikola-Sakaria
UNAM
UNIVERSITY OF NAMIBIA
Co-Authors/ Supervisors
Prof Selma Lendelvo
Prof Sian Sullivan
Partners:
Sponsors:
SASSCAL
04-05 June 2025
Namibia - Germany Green Hydrogen Research and Development Conference - 2025
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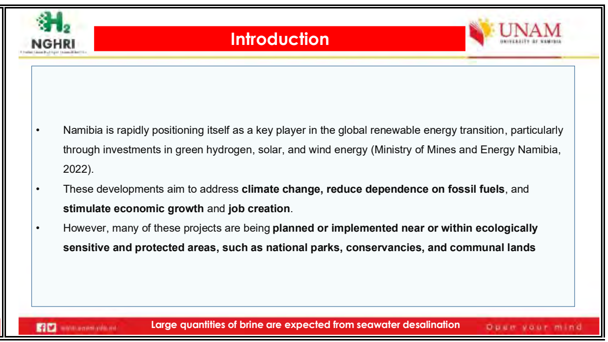
1


NGHRI
Introduction
UNAM
Namibia is rapidly positioning itself as a key player in the global renewable energy transition, particularly through investments in green hydrogen, solar, and wind energy (Ministry of Mines and Energy Namibia, 2022).
These developments aim to address climate change, reduce dependence on fossil fuels, and stimulate economic growth and job creation.
However, many of these projects are being planned or implemented near or within ecologically sensitive and protected areas, such as national parks, conservancies, and communal lands
Large quantities of brine are expected from seawater desalination
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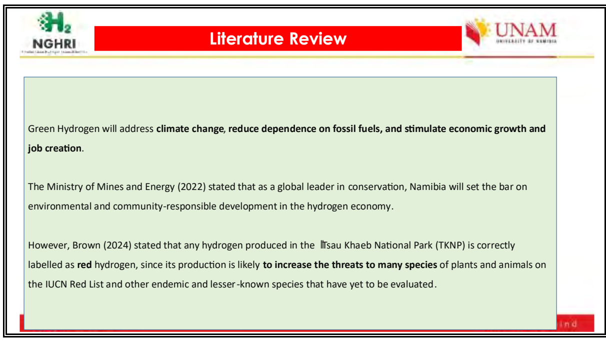
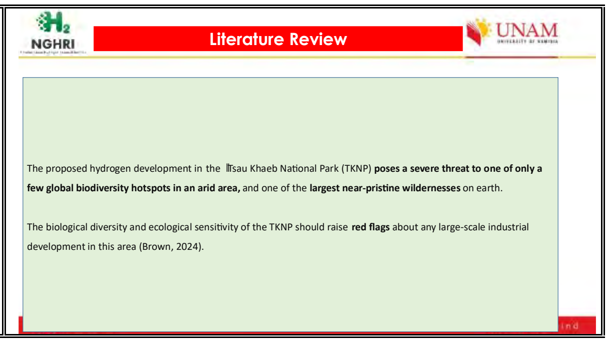
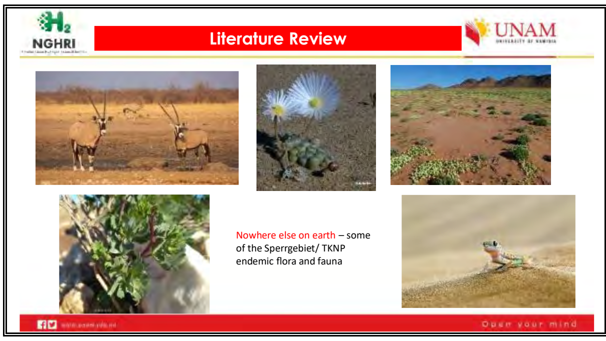
2


NGHRI
Literature Review
UNAM
Green Hydrogen will address climate change, reduce dependence on fossil fuels, and stimulate economic growth and job creation.
The Ministry of Mines and Energy (2022) stated that as a global leader in conservation, Namibia will set the bar on environmental and community-responsible development in the hydrogen economy.
However, Brown (2024) stated that any hydrogen produced in the ǁTsau Khaeb National Park (TKNP) is correctly labelled as red hydrogen, since its production is likely to increase the threats to many species of plants and animals on the IUCN Red List and other endemic and lesser-known species that have yet to be evaluated.

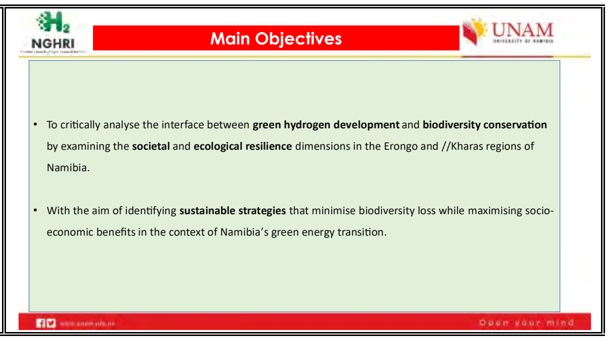
3


NGHRI
Literature Review
UNAM
The proposed hydrogen development in the ǁTsau Khaeb National Park (TKNP) poses a severe threat to one of only a few global biodiversity hotspots in an arid area, and one of the largest near-pristine wildernesses on earth.
The biological diversity and ecological sensitivity of the TKNP should raise red flags about any large-scale industrial development in this area (Brown, 2024).

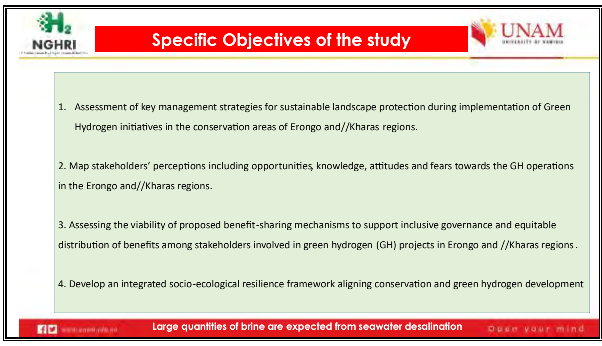
4


NGHRI
Literature Review
UNAM
Nowhere else on earth – some of the Sperrgebiet/ TKNP endemic flora and fauna
Open your mind

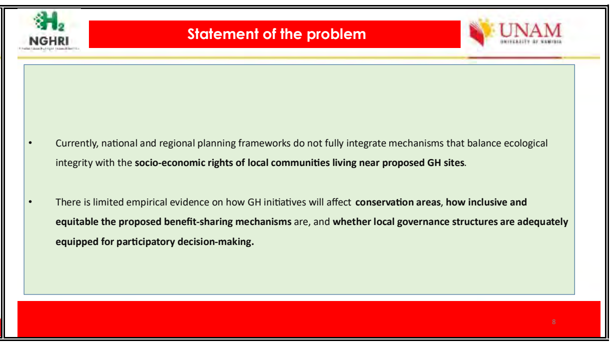
5


NGHRI
Main Objectives
UNAM
To critically analyse the interface between green hydrogen development and biodiversity conservation by examining the societal and ecological resilience dimensions in the Erongo and //Kharas regions of Namibia.
With the aim of identifying sustainable strategies that minimise biodiversity loss while maximising socio-economic benefits in the context of Namibia's green energy transition.
Open your mind

6


NGHRI
Specific Objectives of the study
UNAM
1. Assessment of key management strategies for sustainable landscape protection during implementation of Green Hydrogen initiatives in the conservation areas of Erongo and//Kharas regions.
2. Map stakeholders' perceptions including opportunities, knowledge, attitudes and fears towards the GH operations in the Erongo and//Kharas regions.
3. Assessing the viability of proposed benefit-sharing mechanisms to support inclusive governance and equitable distribution of benefits among stakeholders involved in green hydrogen (GH) projects in Erongo and //Kharas regions.
4. Develop an integrated socio-ecological resilience framework aligning conservation and green hydrogen development
Large quantities of brine are expected from seawater desalination
Open your mind

7


NGHRI
Statement of the problem
UNAM
Currently, national and regional planning frameworks do not fully integrate mechanisms that balance ecological integrity with the socio-economic rights of local communities living near proposed GH sites.
There is limited empirical evidence on how GH initiatives will affect conservation areas, how inclusive and equitable the proposed benefit-sharing mechanisms are, and whether local governance structures are adequately equipped for participatory decision-making.

8

## Statement of the problem

- Without a **coherent framework** that aligns energy development with conservation and community resilience, GH operations risk intensify social inequalities, **undermining ecological stability**, and **weakening Namibia's sustainable development goals.**
- This gap underscores the **need for robust, context-specific research** that critically examines the interface between **GH development**, conservation, and inclusive governance.
- **This study seeks to fill that gap** and will serve as a crucial baseline upon which future research and policy development can build, especially as Namibia continues to expand its green energy ambitions within ecologically and socially sensitive areas.

9

## Significance of the study CONT..

- It is critical to understand not only the ecological implications, but also the governance, equity, and **socio-political dimensions of these developments.**
- The research offers timely insight into how GH activities intersect with conservation goals, particularly in ecologically sensitive regions like Erongo and //Kharas.
- By capturing and analyzing the **perceptions**, **knowledge**, and **concerns of diverse conservation** and **community stakeholders**, the study provides a platform for more inclusive and transparent decision-making in GH planning and implementation.

10

## Significance of the study

- It also highlights the conditions under which **benefit-sharing mechanisms** can support **equity**, **participation**, and **local legitimacy**—areas that are often neglected in high-level infrastructure and energy development strategies.
- Furthermore, the study generates empirical evidence that fills a current gap in **Namibia's policy and research landscape**.

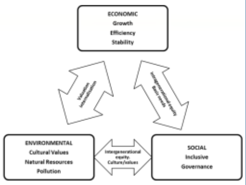
11

## Theoretical Framework

- The theoretical framework for this research explores the critical balance between **societal** and **ecological resilience** in Namibia, focusing on the interface between **conservation and GH operations**.
- **It integrates economic, social, and environmental sustainability**, using the triangular approach to assess th impacts of GH on job creation, energy security, and environmental protection(Burguillo & Del Rio, 2007).

12

## Theoretical Framework CONT..




**True sustainability lies at the intersection** of all three dimensions.
If one is prioritized without consideration for the others (e.g., economic growth at the expense of ecological health), **sustainability is compromised**.

In this study, this diagram justifies the need for a **balanced approach** — one that promotes **green economic growth** through hydrogen

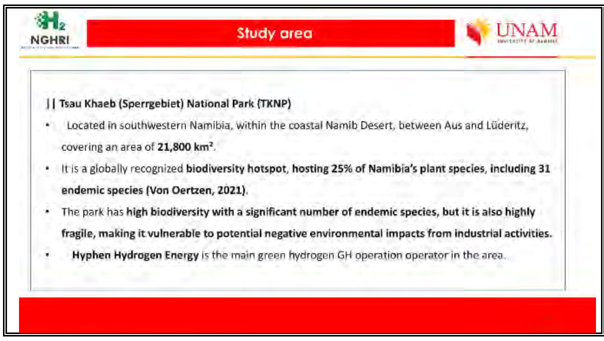
Fig.1 The dimension of sustainability and their interrelationships (Burguillo & Del Rio, 2007).

Open your mind

13

## RESEARCH METHODOLOGY

14

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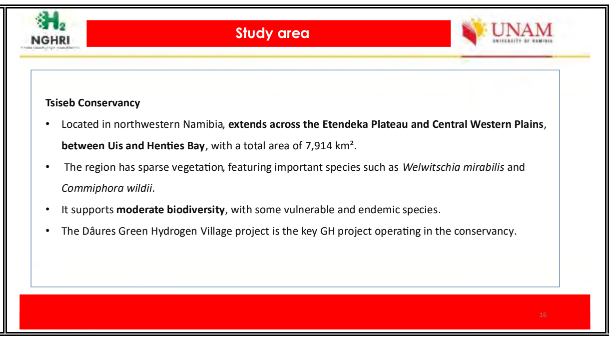


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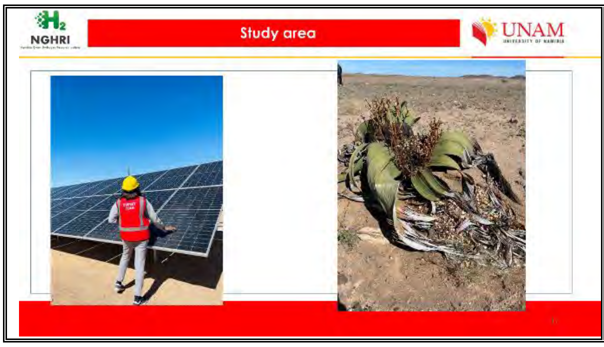


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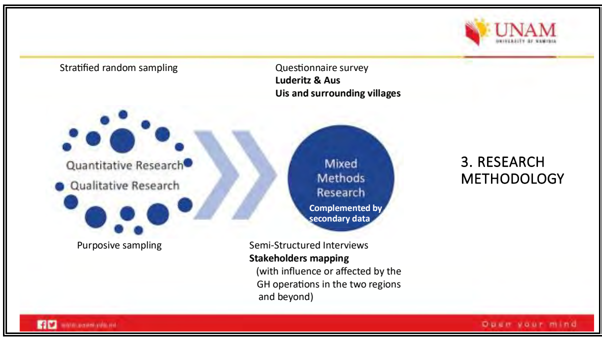


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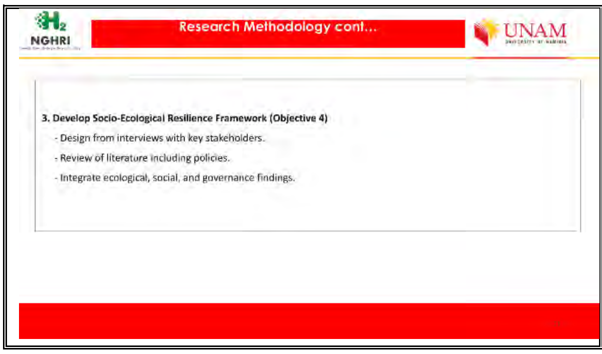


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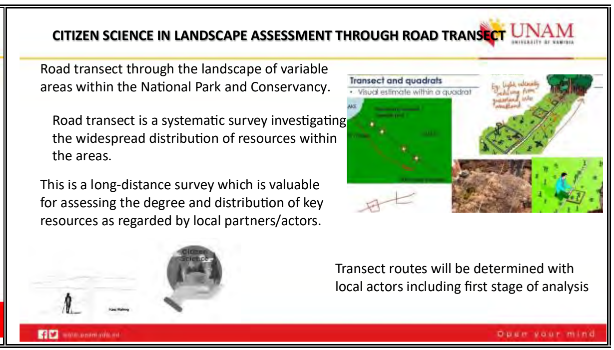


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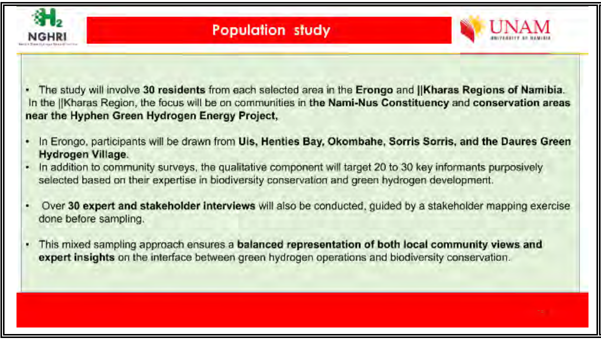
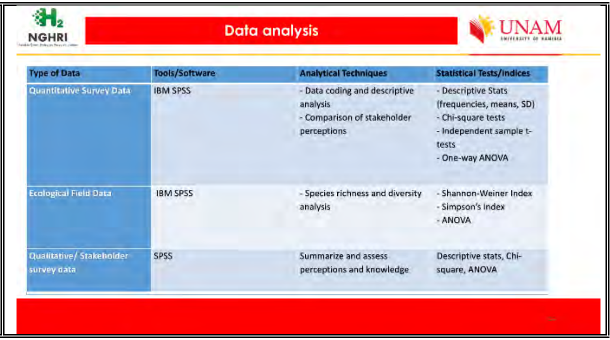
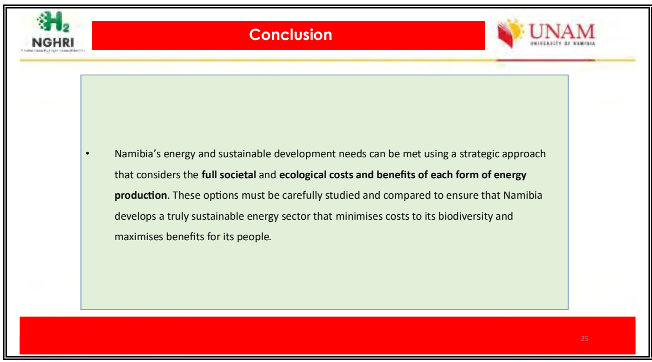

NGHRI
Population study
UNAM
The study will involve 30 residents from each selected area in the Erongo and ||Kharas Regions of Namibia. In the ||Kharas Region, the focus will be on communities in the Nami-Nus Constituency and conservation areas near the Hyphen Green Hydrogen Energy Project.
In Erongo, participants will be drawn from Uis, Henties Bay, Okombahe, Sorris Sorris, and the Daures Green Hydrogen Village.
In addition to community surveys, the qualitative component will target 20 to 30 key informants purposively selected based on their expertise in biodiversity conservation and green hydrogen development.
Over 30 expert and stakeholder interviews will also be conducted, guided by a stakeholder mapping exercise done before sampling.
This mixed sampling approach ensures a balanced representation of both local community views and expert insights on the interface between green hydrogen operations and biodiversity conservation.

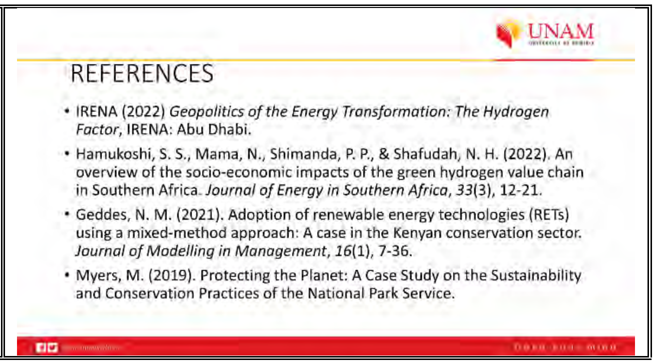
23


NGHRI
Data analysis
UNAM
Type of Data
Tools/Software
Analytical Techniques
Statistical Tests/Indices
Quantitative Survey Data
IBM SPSS
- Data coding and descriptive analysis
- Comparison of stakeholder perceptions
- Descriptive Stats (frequencies, means, SD)
- Chi-square tests
- Independent sample t-tests
- One-way ANOVA
Ecological Field Data
IBM SPSS
- Species richness and diversity analysis
- Shannon-Weiner Index
- Simpson's Index
- ANOVA
Qualitative/ Stakeholder survey data
SPSS
Summarize and assess perceptions and knowledge
Descriptive stats, Chi-square, ANOVA

24


NGHRI
Conclusion
UNAM
Namibia's energy and sustainable development needs can be met using a strategic approach that considers the full societal and ecological costs and benefits of each form of energy production. These options must be carefully studied and compared to ensure that Namibia develops a truly sustainable energy sector that minimises costs to its biodiversity and maximises benefits for its people.

25


UNAM
REFERENCES
IRENA (2022) Geopolitics of the Energy Transformation: The Hydrogen Factor, IRENA: Abu Dhabi.
Hamukoshi, S. S., Mama, N., Shimanda, P. P., & Shafudah, N. H. (2022). An overview of the socio-economic impacts of the green hydrogen value chain in Southern Africa. Journal of Energy in Southern Africa, 33(3), 12-21.
Geddes, N. M. (2021). Adoption of renewable energy technologies (RETs) using a mixed-method approach: A case in the Kenyan conservation sector. Journal of Modelling in Management, 16(1), 7-36.
Myers, M. (2019). Protecting the Planet: A Case Study on the Sustainability and Conservation Practices of the National Park Service.

26


NGHRI
THANK YOU
UNAM
Partners:
DAURES GREEN HYDROGEN VILLAGE
NGHRI
UNAM
IER
Sponsors:
Federal Ministry of Research, Technology and Space
SASSCAL
Namibia - Germany Green Hydrogen Research and Development Conference - 2025
Pioneering Green Hydrogen Flagship Projects in Namibia
Pioneering GH2 Research in Namibia
Open your mind

27

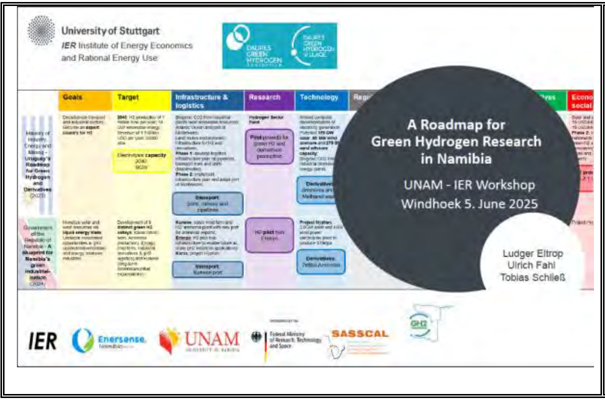
# Energy and Research Roadmap for Green Hydrogen – A Scientific approach

Ludger Eltrop, Tobias Schließ, and Ulrich Fahl

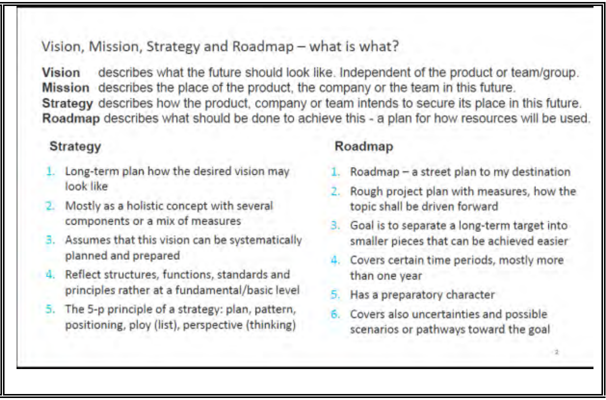
Institute of Energy Economics and Rational Energy Use – University of Stuttgart, Heßbrühlstr. 49 a, D-70569 Stuttgart, Germany

A scientific approach to an energy and research roadmap to develop the green hydrogen sector in Namibia and Germany is presented. In a common approach a team of scientist from Namibia and Germany has identified corner stones of research and education that is needed to develop the Green Hydrogen Sector in both countries. The roadmap approach investigates the requirements from government and the regulatory framework, from technology, economics and research. A main emphasis lies on the development of a curriculum for advanced studies and research to educate and qualify skilled people that can run a Green Hydrogen plant and support industries in Namibia to develop their competencies for creating added value in their own countries. Examples from research and education sector in Germany are presented.

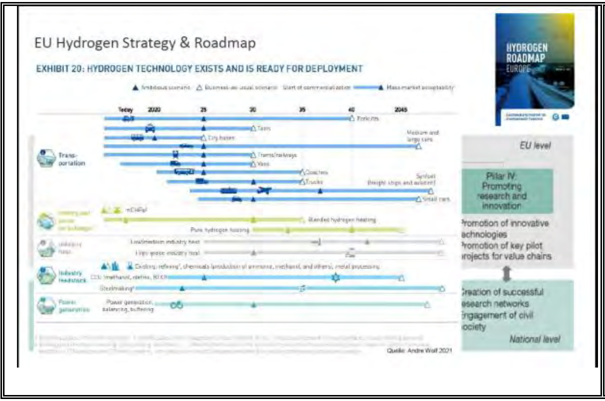
Dr. Ludger Eltrop is an environmental and systems engineer with a Diploma and PhD in natural science. He is today teaching and carrying out research in energy technology and energy economics at the University of Stuttgart. His specific field of expertise is in energy systems analysis with a special emphasis on renewable energies (bioenergy, solar, wind and geothermal energy) and integrating and sector coupling aspects (hydrogen, electrification, P2X). Since 1994 he was engaged in many consulting and research projects to industry companies and the public sector in Germany, Europe and especially also in developing and transition countries. Among others he was project manager of the EnerKey project, a collaborative German-South African project on sustainable energy infrastructure and of the Solar Mining project in Chile on integrating renewables in the mining sector. Today he is also in charge of the accompanying research project to the DAURES Green Hydrogen Village project in Namibia. Ludger Eltrop was a Visiting Professor at the University of Johannesburg twice between 2013 and 2018.


University of Stuttgart
IER Institute of Energy Economics and Rational Energy Use
A Roadmap for Green Hydrogen Research in Namibia
UNAM - IER Workshop
Windhoek 5. June 2025
Ludger Eltrop
Ulrich Fahl
Tobias Schließ
Goals
Target
Infrastructure & logistics
Research
Technology
IER
UNAM
SASSCAL

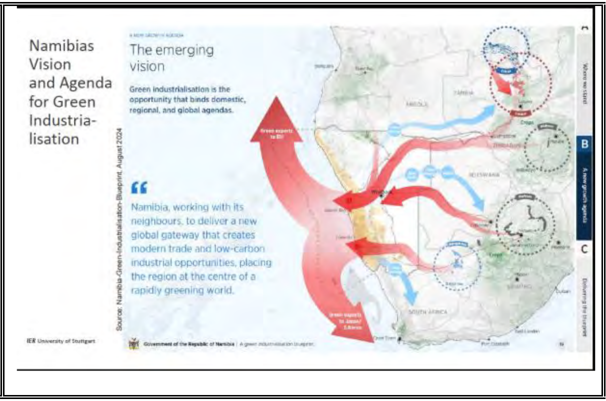
1


Vision, Mission, Strategy and Roadmap – what is what?
Vision describes what the future should look like. Independent of the product or team/group.
Mission describes the place of the product, the company or the team in this future.
Strategy describes how the product, company or team intends to secure its place in this future.
Roadmap describes what should be done to achieve this - a plan for how resources will be used.
Strategy
1. Long-term plan how the desired vision may look like
2. Mostly as a holistic concept with several components or a mix of measures
3. Assumes that this vision can be systematically planned and prepared
4. Reflect structures, functions, standards and principles rather at a fundamental/basic level
5. The 5-p principle of a strategy: plan, pattern, positioning, ploy (list), perspective (thinking)
Roadmap
1. Roadmap – a street plan to my destination
2. Rough project plan with measures, how the topic shall be driven forward
3. Goal is to separate a long-term target into smaller pieces that can be achieved easier
4. Covers certain time periods, mostly more than one year
5. Has a preparatory character
6. Covers also uncertainties and possible scenarios or pathways toward the goal

2


EU Hydrogen Strategy & Roadmap
EXHIBIT 20: HYDROGEN TECHNOLOGY EXISTS AND IS READY FOR DEPLOYMENT
HYDROGEN ROADMAP EUROPE
EU level
Pillar IV: Promoting research and innovation
Promotion of innovative technologies
Promotion of key pilot projects for value chains
Creation of successful research networks
Engagement of civil society
National level
Quelle: Andre Wolf 2021

3


Namibias Vision and Agenda for Green Industrialisation
The emerging vision
Green industrialisation is the opportunity that binds domestic, regional, and global agendas.
Namibia, working with its neighbours, to deliver a new global gateway that creates modern trade and low-carbon industrial opportunities, placing the region at the centre of a rapidly greening world.
Source: Namibia-Green-Industrialisation-Blueprint, August 2024
IER University of Stuttgart

4


Namibias Green Hydrogen and Green Industry Strategy
3 Valleys Feasibility
Vision for Namibia's three green valleys
Namibia
Green Hydrogen and Derivatives Strategy
A blueprint for Namibia's green industrialisation
Localizing Green Industries in Namibia
IER University of Stuttgart

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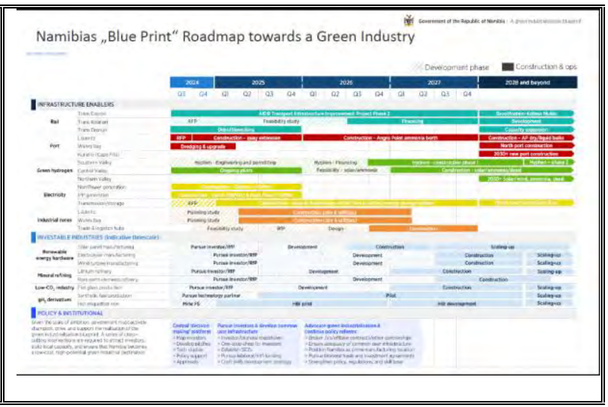
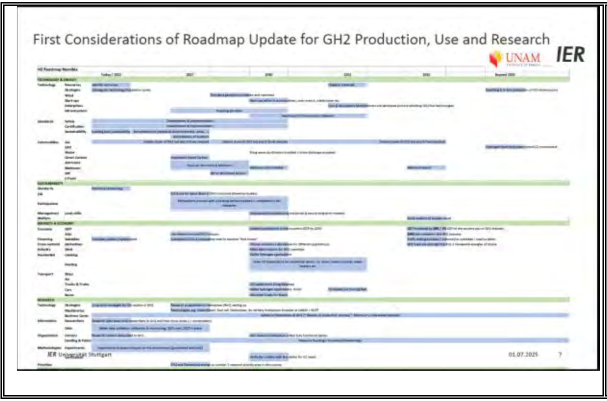

Namibias „Blue Print" Roadmap towards a Green Industry
Government of the Republic of Namibia
Development phase
Construction & ops
2024
2025
2026
2027
2028 and beyond
INFRASTRUCTURE ENABLERS
Rail
Port
Green hydrogen
Electricity
Industrial zones
INVESTABLE INDUSTRIES
POLICY & INSTITUTIONAL

6


First Considerations of Roadmap Update for GH2 Production, Use and Research
UNAM
IER
IER Universität Stuttgart
01.07.2025
7

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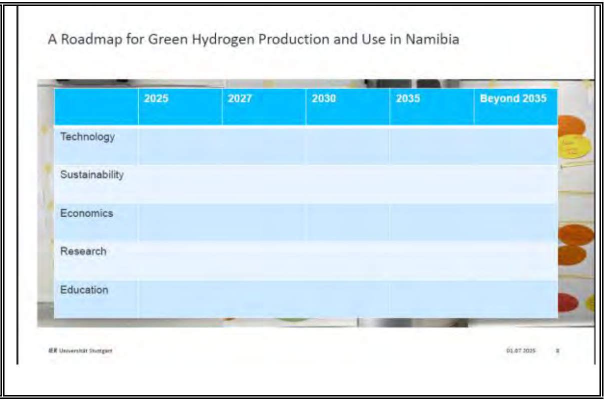
A Roadmap for Green Hydrogen Production and Use in Namibia
2025
2027
2030
2035
Beyond 2035
Technology
Sustainability
Economics
Research
Education
IER Universität Stuttgart
01.07.2025
8

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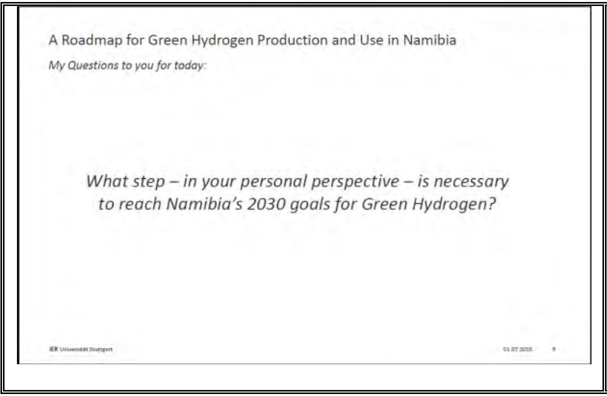
A Roadmap for Green Hydrogen Production and Use in Namibia
My Questions to you for today:
What step – in your personal perspective – is necessary
to reach Namibia's 2030 goals for Green Hydrogen?
IER Universität Stuttgart
01.07.2025
9

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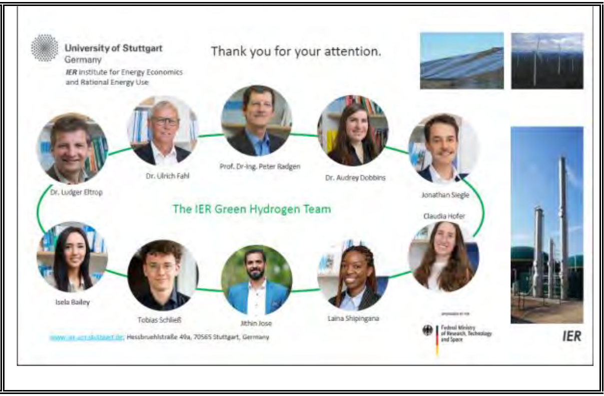

University of Stuttgart
Germany
IER Institute for Energy Economics
and Rational Energy Use
Thank you for your attention.
Dr. Ludger Eltrop
Dr. Ulrich Fahl
Prof. Dr-Ing. Peter Radgen
Dr. Audrey Dobbins
Jonathan Siegle
Claudia Hofer
The IER Green Hydrogen Team
Isela Bailey
Tobias Schließ
Jithin Jose
Laina Shipingana
Federal Ministry of Research, Technology and Space
IER

10

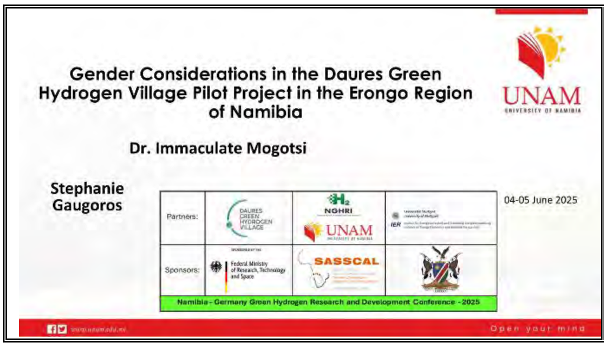
# Gender Considerations in the Daures Green Hydrogen Village Pilot Project in the Erongo Region of Namibia

Immaculate Mogotsi, and Stephanie Gaugoros

Senior Research Fellow, Multidisciplinary Research Services, University of Namibia, Namibia, imogotsi@unam.na

This study explores the social dimensions of the Daures Green Hydrogen Village project in Namibia, emphasizing community awareness, gender mainstreaming, and local empowerment. The research investigates the extent of community engagement with the project and assesses the inclusion of gender-sensitive strategies and empowerment initiatives, particularly among stakeholders such as the Tsiseb Conservancy and the Dâure Daman Traditional Authorities. The Daures Green Hydrogen Village introduces innovative sustainable energy solutions through green hydrogen and ammonia production, eco-tourism, and greenhouse horticulture. Employing a mixed-methods approach, including focus group discussions and key informant interviews, the study reveals that while community members are aware of the project's presence, largely through collaborative meetings with traditional authorities - they possess limited understanding of the green hydrogen concept. The research highlights both opportunities and challenges in achieving inclusive rural development and equitable socio-economic outcomes. It also examines the representation of women and marginalized groups in the planning and implementation phases. The findings aim to inform policy frameworks that reinforce gender mainstreaming as a cross-cutting theme, enhance community participation, and promote local ownership. Ultimately, the study contributes to the discourse on Namibia's green energy transition and its potential to drive inclusive and sustainable development in rural communities.

| | |
|---|---|
|  | Dr. Immaculate Mogotsi is a senior research fellow at the Multidisciplinary Research Services Centre at the University of Namibia focusing on Gender Training and Research. She holds a Bachelor of Arts Degree in Social Work and Community Development, a Master of Arts (MA) Degree in Women and Development Studies, and a PhD in Sociology. Her current academic work covers gender mainstreaming, prevention of sexual and gender-based violence, women's empowerment, sexual and reproductive health and rights, and feminist theorizing gender and sexuality, gender and climate change and decolonizing academia. Dr Mogotsi has been instrumental in the introduction of MA in Gender and Development at UNAM. She published in journals, wrote and co-edited books, and holds a track record of commissioned work. Among others she co-authored in the Sustainability Journal "Strengthening Gender Responsiveness of the Green Climate Fund Ecosystem-Based Adaptation Programme in Namibia". And in the Environment and Natural Resources Research. Canadian Centre of Science and Education she co-authored Forest resource management and utilization through a gendered lens in Namibia. Some of her policies and advocacy work entail Drafting of the National Drought Policy with the mandate for gender mainstreaming, GIZ; IREMA KUNENE Project: gender mainstreaming for GCF funded projects staff, key stakeholders and beneficiaries. Dr Mogotsi is also a member of the Environmental Investment Fund Steering Committee. |


Gender Considerations in the Daures Green Hydrogen Village Pilot Project in the Erongo Region of Namibia
Dr. Immaculate Mogotsi
Stephanie Gaugoros
04-05 June 2025
UNAM
Partners:
Sponsors:
NGHRI
UNAM
SASSCAL
Namibia - Germany Green Hydrogen Research and Development Conference - 2025

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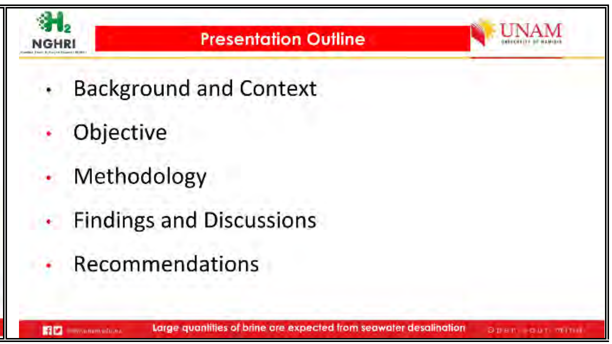
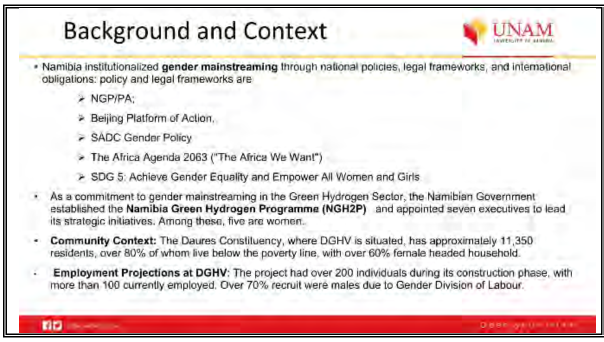

NGHRI
Presentation Outline
UNAM
Background and Context
Objective
Methodology
Findings and Discussions
Recommendations
Large quantities of brine are expected from seawater desalination

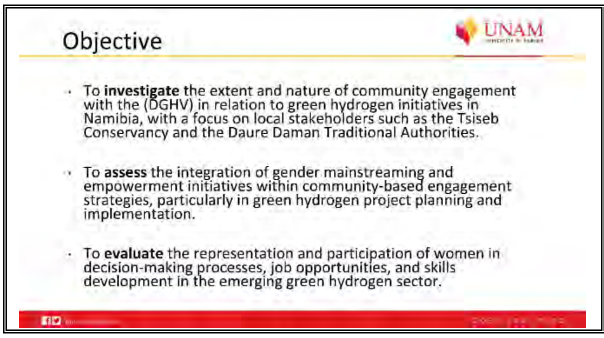
2


Background and Context
UNAM
Namibia institutionalized gender mainstreaming through national policies, legal frameworks, and international obligations: policy and legal frameworks are
NGP/PA;
Beijing Platform of Action,
SADC Gender Policy
The Africa Agenda 2063 ("The Africa We Want")
SDG 5: Achieve Gender Equality and Empower All Women and Girls
As a commitment to gender mainstreaming in the Green Hydrogen Sector, the Namibian Government established the Namibia Green Hydrogen Programme (NGH2P) and appointed seven executives to lead its strategic initiatives. Among these, five are women.
Community Context: The Daures Constituency, where DGHV is situated, has approximately 11,350 residents, over 80% of whom live below the poverty line, with over 60% female headed household.
Employment Projections at DGHV: The project had over 200 individuals during its construction phase, with more than 100 currently employed. Over 70% recruit were males due to Gender Division of Labour.

3


Background and Context
UNAM
Gender Representative Local Leadership: Both the Tsiseb Conservancy Management Committee and the Daure Daman Traditional Leadership have female representation.
Community Shareholding of TC and DDTA reflects a strong community involvement in strategic partnerships. The shareholding structure presents an opportunity for gender advocacy for women's inclusion in decision-making processes.
Gender Representation @ DGHV: Facilities such as greenhouses (50/50 gender representation), tourism and hospitality sector (majority female) (engineers-majority males).
Educational Opportunities: The DGHV has scholarship opportunities.
Number of scholarship beneficiaries from the Daures Constituency are estimated to be less than 5.
The scholarships provides an opportunity to address the underrepresentation of women in STEM, with women comprising only 23% of the workforce in engineering and technology fields in Namibia
Agricultural Initiatives: The DGHV focus on green agriculture, and conducted community awareness, distributes seedlings and agricultural produce to the community and sells to wholesales.

4


Objective
UNAM
To investigate the extent and nature of community engagement with the (DGHV) in relation to green hydrogen initiatives in Namibia, with a focus on local stakeholders such as the Tsiseb Conservancy and the Daure Daman Traditional Authorities.
To assess the integration of gender mainstreaming and empowerment initiatives within community-based engagement strategies, particularly in green hydrogen project planning and implementation.
To evaluate the representation and participation of women in decision-making processes, job opportunities, and skills development in the emerging green hydrogen sector.

5


Methodology
UNAM
Research Sites
Uis
Conservancies (Tsiseb and Sori-Soris)
DGHV
Research Methods
Mixed Method Approach
FGDs (Farmers Unions; Youth, Rangers, green scheme staff, Conservancy Management Committees)
KIIs (TA, Conservancy Managers; Agri Extension Officer, GH Liaison Officer, DGHV-Green scheme; Tourism & Engineers)

6

## Findings and Discussions

UNAM

All participants are:

- Aware of the Daures Green Hydrogen Village; ongoing community sensitization campaigns
- Uncertain about ongoing activities ( except TC and DDTA)
  - |Green Hydrogen & Ammonia Production
  - Eco-tourism Development
  - Greenhouse Horticulture (Veg distribution and seedlings)
  - Green Ammonia production
  - Desalination/Demineralization
  - Fuel Cell Technology
- Awareness levels equal across gender

7

## More Informed about the DGHV

UNAM

**Elderly (60+years)**

- More informed due to radio listenership.
- More likely to attend community meetings organized by DGHV.

**Youth, Rangers, Farmers Unions**

- Limited awareness about ongoing activities at the DGHV.
- Less exposure to communication channels

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## Cultural Norms Supporting Gender Equality

UNAM

- Daure Daman Traditional Authority have male and female senior council members.
- Daure Daman traditional values **encourage gender equality.**
- Both men and women reported **equal access** to employment opportunities
- **No cultural restrictions** identified that prevent women's participation

**Potential Hindrances to employment opportunities**

- Alcohol and drugs use among the youth (both genders)
- Teenage pregnancy and prostitution (male mine workers in Uis pose high risk)
- Lack of qualifications and experience (both genders)
- Distance and isolation DGHV is a challenge far from towns or services, and it **does not have facilities** (like schools, childcare, clinics, or playgrounds) to support **parents who have young children.**
- No confirmed discrimination based on gender in hiring or training opportunities.

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## Benefit Sharing: MOU: Enersense Energy Namibia, DDTA & TC

UNAM

- A Memorandum of Understanding (MoU) exists between three entities:
  - Enersense Energy Namibia
  - Daure Daman Traditional Authority (7%)
  - Tsiseb Conservancy (3%)

The MoU outlines the framework for community benefit and collaboration.

- This ensures **local ownership** and **stake in long-term gains.** **(lease period 20 +25 years)**
- Prioritizing job opportunities for people in the jurisdiction of the DDTA and surrounding communities
- This contributes to economic empowerment and skills development.
- Training programs in green hydrogen
- Empowering community members with agricultural and environmental skills
- Supporting sustainable livelihoods in parallel to industrial development

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## Community Empowerment Initiatives in partnership with DGHV

UNAM

**Food Security & Gardening Initiatives**

- DGHV supports gardens **backyard, school and community and community training on horticulture in** Omatjete, Okombahe, and Uis

**Green Ammonia for Local Cleaning Detergent Production**

- Build capacity of local community members in green ammonia production and the sustainable manufacturing of cleaning detergents, with a focus on strengthening value addition and supporting local Small and Medium Enterprises (SMEs).

**Community Awareness & Innovation**

- Conduct **awareness campaigns** in the constituency regarding the activities at the DGHV, with an Emphasis on capacity building.

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UNAM

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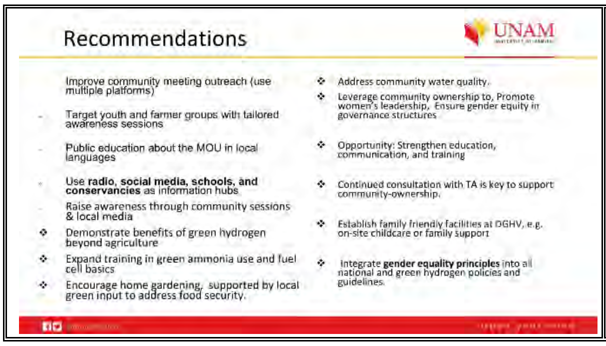

Recommendations
UNAM
Improve community meeting outreach (use multiple platforms)
Target youth and farmer groups with tailored awareness sessions
Public education about the MOU in local languages
Use **radio, social media, schools, and conservancies** as information hubs
Raise awareness through community sessions & local media
Demonstrate benefits of green hydrogen beyond agriculture
Expand training in green ammonia use and fuel cell basics
Encourage home gardening, supported by local green input to address food security.
Address community water quality.
Leverage community ownership to, Promote women's leadership, Ensure gender equity in governance structures
Opportunity: Strengthen education, communication, and training
Continued consultation with TA is key to support community-ownership.
Establish family friendly facilities at DGHV, e.g. on-site childcare or family support
Integrate **gender equality principles** into all national and green hydrogen policies and guidelines.


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Conclusion
UNAM
In conclusion this study proposes the need to empower women, engaging men, and ensuring no one is left behind.
This gender-sensitive approach is not only a matter of equity but a catalyst for long-term community resilience, ownership, and sustainability."
DGHV reflect a strong commitment to inclusive and sustainable community development through the shareholder arrangements with the Tsiseb Conservancy and the Daure Daman Traditional Authority.
The promotion of food security through gardening initiatives and horticulture training empowers both women and men to contribute to household nutrition and resilience.
Community awareness campaigns and capacity-building efforts provide a platform to mainstream gender by ensuring equal access to information and opportunities.
The training in green ammonia production and sustainable detergent manufacturing presents a unique opportunity to strengthen local SMEs, with an emphasis on male and female participation in enterprise development.
Integrating gender-sensitive approaches across all these initiatives is essential for achieving equitable outcomes and fostering long-term community ownership.


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