Namibia Green Hydrogen Research Institute

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Context

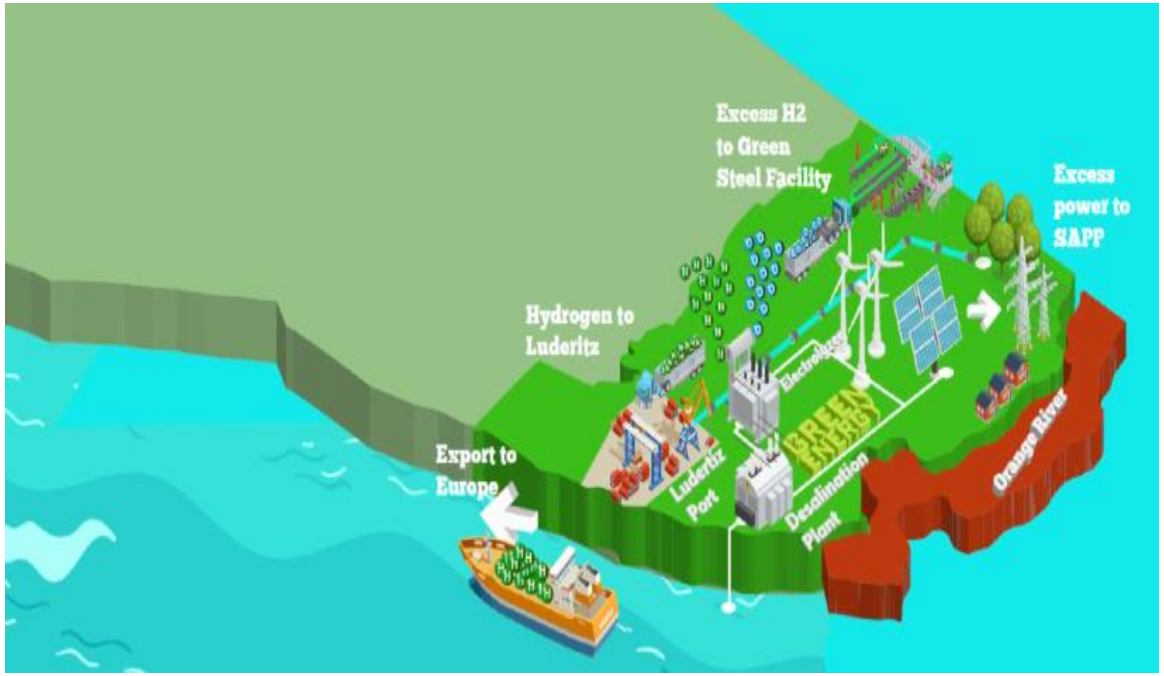
- Globally, decarbonization initiatives are considered key driving forces towards the use of low-carbon gases and fuels. Incorporating green hydrogen as an energy carrier can leverage the earth's existing, widespread, energy infrastructure to facilitate the transition to a low-carbon future.

- Currently, all eyes are on Namibia as potential Green Hydrogen producer

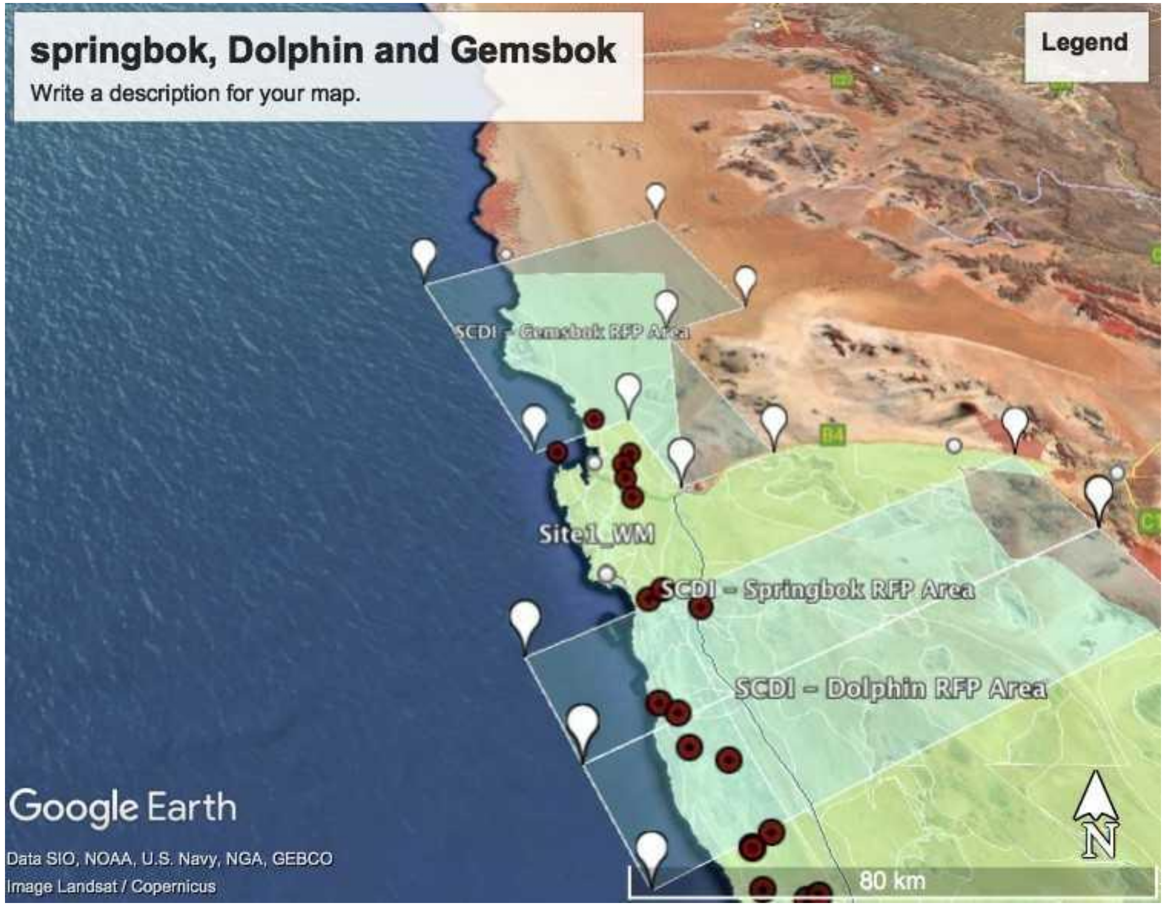
UNAM UNIVERSITY OF NAMIBIA

Southern Corridor Development: A hub of green hydrogen production and utilization

Potential commodities: Green Hydrogen, Green Ammonia, Green Zinc, Green steel, etc

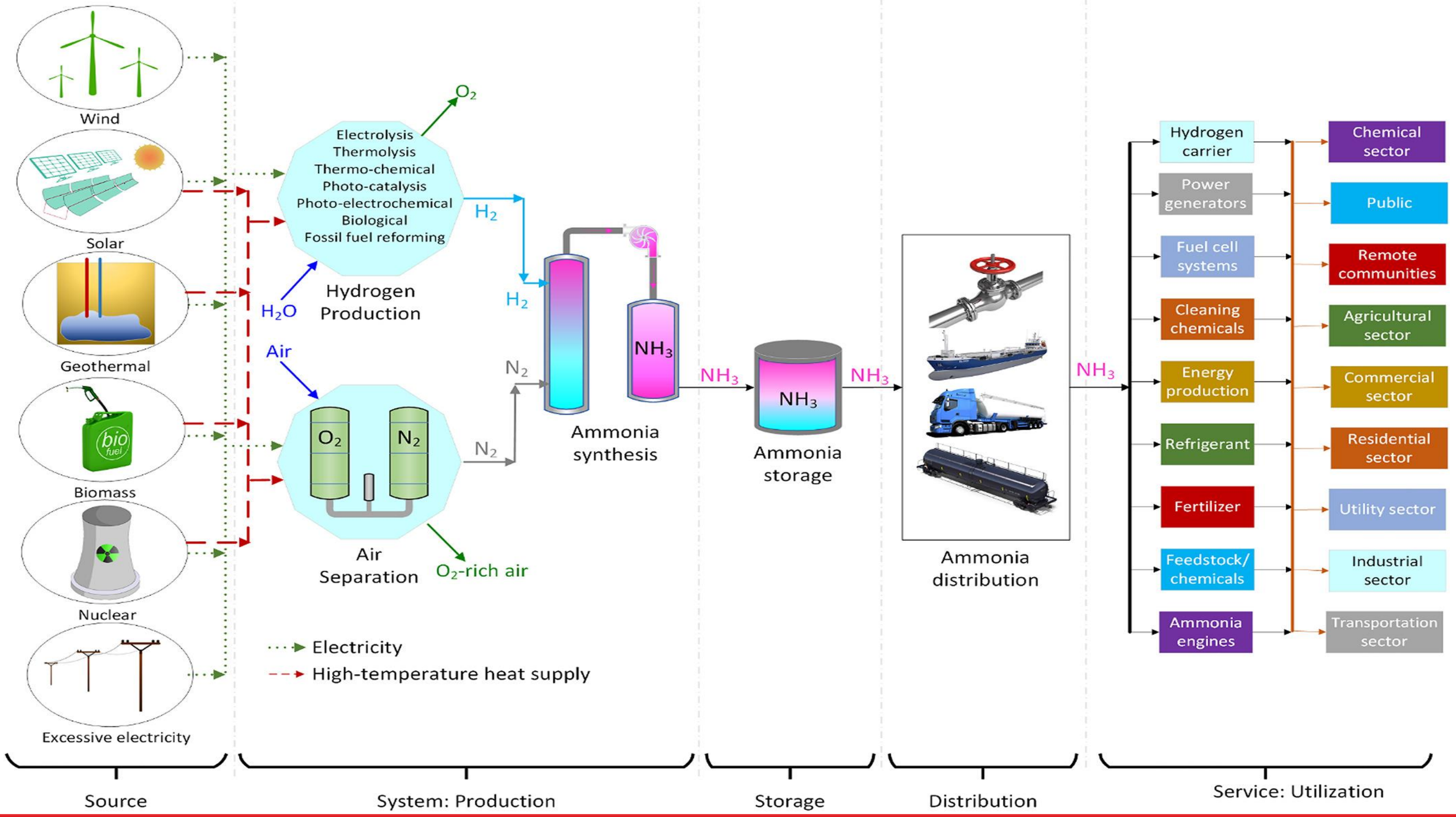


- **Dolphin** & **springbok** were availed for bidding,
- Awarded to Hyphen



Green Hydrogen Development in Namibia

Hydrogen Production and Valorization



Green Hydrogen Development in Namibia

The national Green Hydrogen initiative:

-> creates new industries and jobs
-> potential immense environmental, educational, economic & social impacts for Namibia
-> requires skills across different strata
-> requires R&D facilities and expertise
-> requires new businesses across the value chain

The University of Namibia (UNAM) positions itself as an academic partner to take a leading role:

-> vast and diverse specialisation areas,
-> multiple campuses,
-> high student numbers
-> a highly skilled and specialised academic complement,
-> a committed executive leadership.

UNAM: R&D, pilot projects, capacitating a specialized workforce, train small businesses

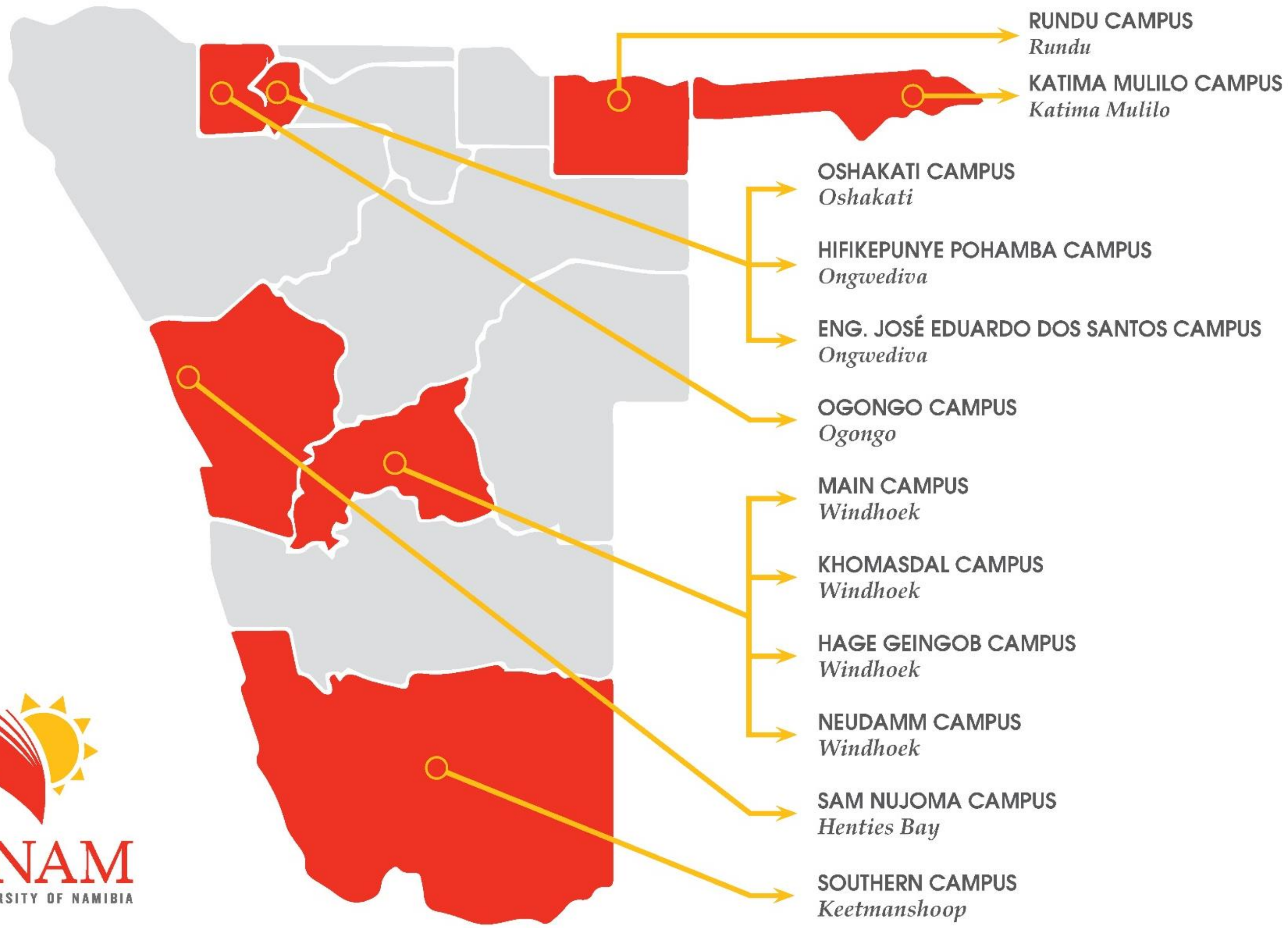
NUST has been invited to partner along with other national partners to make a truly national response.

Overview of UNAM

30,000	1600	2500	4	12	3
Students	Academic Staff	Total Staff	Faculties	Campuses	Research Centres

University of Namibia

Our 12 Campuses



Green Hydrogen Development in Namibia

UNAM has done some pilot research projects:

3 000 litres of drinkable water per hour

Energy resource: Technology: grid connected small wind systems. Towers: 12 m monopole galvanized. Sector: SMEs (small and medium enterprises), low-income housing. Size of turbines: 3 × 800 W; E230i wind turbine, 12/24/48Vdc

Green Hydrogen Development in Namibia

UNAM embarked on establishing a Namibia Green Hydrogen Research Institute in June 2021.

Ideally, the Institute is envisaged as a distributed Science and Technology Park with
-> state-of-the-art infrastructure,
-> fully equipped laboratories,
-> experimental R&D stations,
-> private sector and government representative offices,
-> an entrepreneurship and startup incubation centre,
-> a training centre and wellness facilities.

Staffing:
-> 70 researchers across UNAM plus researchers from NUST
-> national and international specialists/experts,
-> visiting and exchange scholars,
-> postgraduate students and postdocs along with government and industry seconded experts
-> close collaboration with government Offices/Ministries/Agencies and private sector partners both in Namibia and internationally.
International and national academic and research institutes & private sector collaboration is being pursued.

Structure

Namibia Green Hydrogen Research Institute (NGHRI)

Centre for clean Hydrogen Production	Centre for Hydrogen Storage, New Materials and Delivery	Centre for Hydrogen Fuel Cell Technology for Mobility Applications	Centre for Hydrogen Energy Use, Economics, Law, Environment and Society	Centre for Hydrogen Capacity Building, Competence and Standards	Centre for Hydrogen Digital and Emerging Technologies

Formulation of enabling policies, end use and environmental sustainability options for widespread hydrogen energy usage

Collaboration with government and private sector partners. International academic and research institutes, identified as key for success

Hydrogen – Facts

- Atomic number (number of protons in the nucleus): 1
- Atomic symbol (on the Periodic Table of Elements): H
- Atomic weight (average mass of the atom): 1.00794
- Density: 0.00008988 grams per cubic centimeter
- Phase at room temperature: Gas
- Melting point: minus 434.7 degrees Fahrenheit (minus 259.34 degrees Celsius)
- Boiling point: minus 423.2 F (minus 252.87 C)
- Number of isotopes: 3 common isotopes, including 2 stable ones - Protium, Deuterium, Tritium
- Most common isotope: 1H, natural abundance 99.9885 percent

Hydrogen – Production methods

H2 Production Method	Description	Energy to produce 1kg of H2	CO2 emitted per kg of H2 produced	Cost to produce 1kg
Steam Methane Reform	High temperature steam (700-1,000°C) is combined with methane under 3-25 bar pressure in the presence of a catalyst to produce hydrogen and carbon dioxide in two chemical steps.		9 kg (Grey) If carbon is captured (Blue)	
Thermal and plasma pyrolysis	breaks up methane into hydrogen and carbon directly	10-12 kWh/kg	far fewer emissions than SMR	
Electrolysis of water		39 kWh – 48 kW/kg	Zero	~$5 to $6/kg

Low volume electrolyzer capital costs as high as $1,500/kW, and grid electricity prices of $0.05/kWh to $0.07/kWh

https://wernerantweiler.ca/blog.php?item=2020-09-28

Steam and methane generate carbon monoxide and hydrogen, and then a water-gas shift reaction combines carbon monoxide with more water to form carbon dioxide and hydrogen. A third step removes impurities from the gas stream, leaving pure hydrogen. Using low-cost natural gas is currently the most affordable option to make hydrogen, but it is not GHG neutral – CO_2 is created in the process, and natural gas is burn to provide the heat needed in the process

Hydrogen is an important structural element – it has a hand in nearly every single physiological function of living organisms due to its usefulness and abundance:

- In the task of digestion, hydrogen bonds with chlorine to form hydrochloric acid, which breaks down fat and protein in the stomach.
- In the task of aerobic respiration, the movement of free-floating hydrogen atoms helps stimulate the production of energy; this is similar to the way in which a water pump can create energy potential that can do work.

Hydrogen is an energy carrier with no carbon in it, so when you burn it, you only produce water

Energy for Hydrogen production

- **How much electricity is needed to make hydrogen?** A completely efficient electrolysis system would require 39 kWh of electricity to produce 1 kg of hydrogen. However, the devices commonly found in operation for this process are less efficient. A typical operational figure is about 48 kWh per kg of hydrogen

- One kilogram of hydrogen at room temperature occupies eleven cubic meters. Compressed to 700 bars, hydrogen achieves a density of 42 kg/m^3, and five kilograms of hydrogen (which suffice for propelling a car about 500 km, and can be stored in a 125 liter (L) tank).

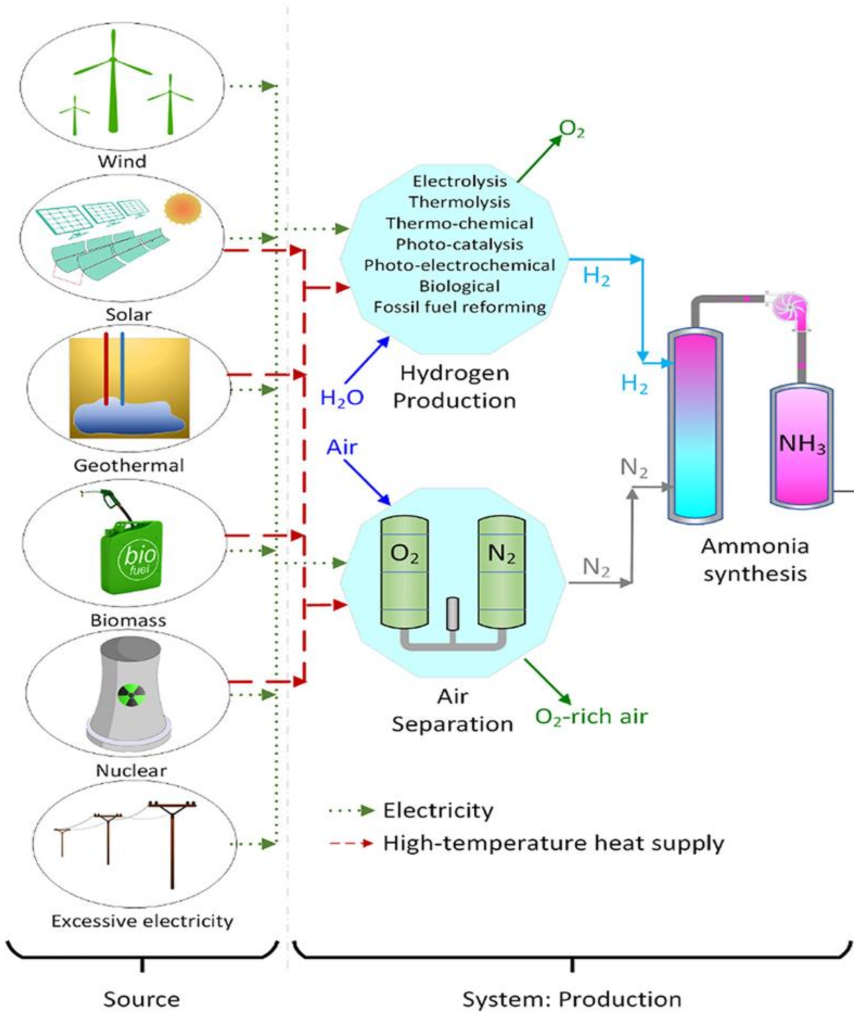
- The tank-to-wheel efficiency of fuel cells is reckoned to be only about 40–45 %. Toyota reports that its Fuel Cell Vehicle requires about 0.8kg of hydrogen per 100 km. A typical Battery Electric Vehicle consumes about 20-25 kWh per 100 km, depending on weight and other characteristics.

Some Identified Research Projects

1	GREEN HYDROGEN PRODUCTION TECHNOLOGIES AND THE HYDROGEN VALUE CHAIN
2	SEAWATER DESALINATION
3	SOLAR AND WIND POWER (for desalination of sea water)
4	ELECTROCHEMICAL WATER SPLITTING FOR HYDROGEN GENERATION (WATER ELECTROLYSIS)
5	CATALYSIS: ROUTE TOWARDS GREEN HYDROGEN
6	DEVELOPMENT OF HYDROGEN FUEL CELLS
7	COMBINING HYDROGEN STORAGE, AMMONIA AND LIQUID HYDROGEN ORGANIC CARRIER
8	NEW MATERIALS DEVELOPMENT
9	PHOTOVOLTAIC AND WIND ELECTRICITY GENERATION AND STORAGE IN HYDROGEN
10	WATER RESOURCE MANAGEMENT
11	REGULATORY FRAMEWORK, POLICY FORMULATION AND ETHICS
12	STRATEGIC ENVIRONMENTAL ASSESSMENT, AND ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENTS
13	SKILLING, RESKILLING AND UPSKILLING THE WORKFORCE FOR A GREEN HYDROGEN FUTURE
14	EMERGING TECHNOLOGIES AND DIGITAL SOLUTIONS

Centre for Green Hydrogen Production

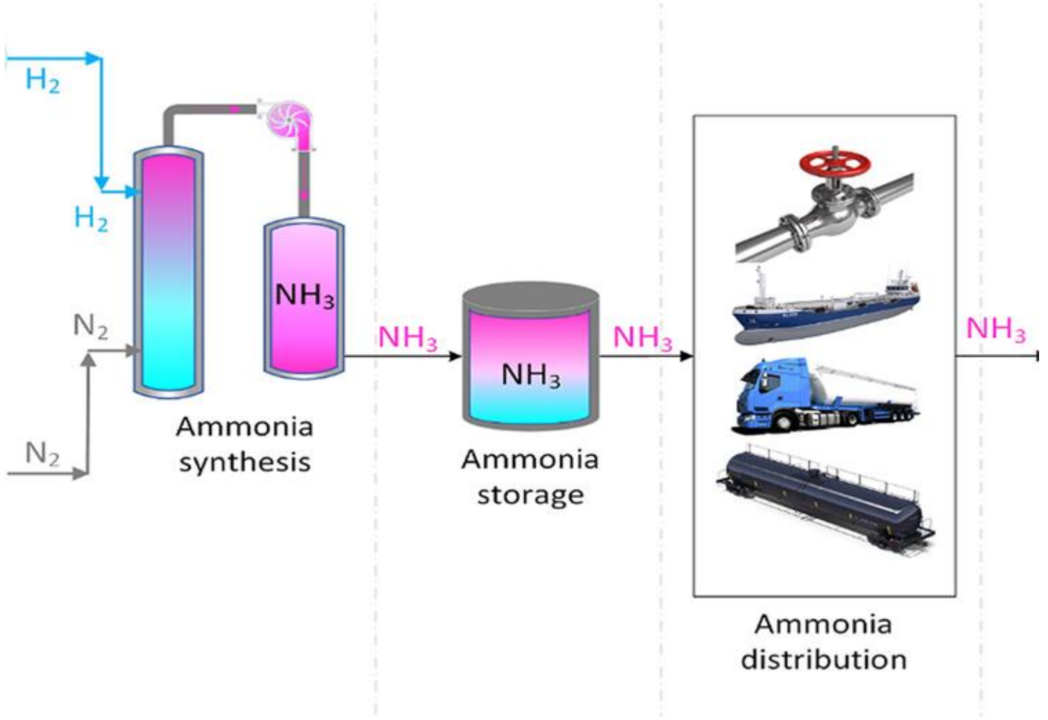
RESEARCH AREAS	• **Production of Green hydrogen from different feedstocks through a variety of processes** • **Green Energy Systems (Solar, Wind, Biomass)** • **Water sourcing and purification (desalination)** • **Electrolysis of water and gas collection (electrodes, catalysis, efficiency)** • **Safety of Hydrogen Production Processes**
MAIN OBJECTIVES	• To select the best hydrogen generation technology, with low or no GHG/carbon emissions depending on intended application. • To produce green hydrogen from hydrocarbons for large scale or smaller distributed production through incorporation of carbon capture and/or carbon sequestration in a cost-effective manner. • To gasify renewable agricultural or woody biomass to generate renewable hydrogen • To Produce hydrogen via electrolysis of water • To store renewable electricity from wind or solar energy, in hydrogen, so as to provide dispatchable lower-carbon energy to consumers, for use in remote and back-up power generation.



Collaboration with government and private sector partners. International academic and research institutes, as well as with the private sector collaboration is already being pursued.

Centre for Storage, Delivery and New Materials

RESEARCH AREAS	• **Hydrogen Storage (Pressurized Gas, Ammonia, Liquefied, or solid state storage)** • **Liquid Hydrogen Organic Carrier (LOHC)** • **New materials for hydrogen transport and delivery mechanisms (tanks, pipelines)** • **Photolysis of water for H_2 production and Hydrogen storage materials** • **Safety of Hydrogen storage and Delivery Processes**
MAIN OBJECTIVES	• To design, develop, and test the hydrogen quality sampling apparatus to support fuel station certifications. • To test a free-piston expander for hydrogen cooling . • To improve cost and efficiency of hydrogen vehicle fueling infrastructure • To develop hydrogen storage and delivery infrastructure



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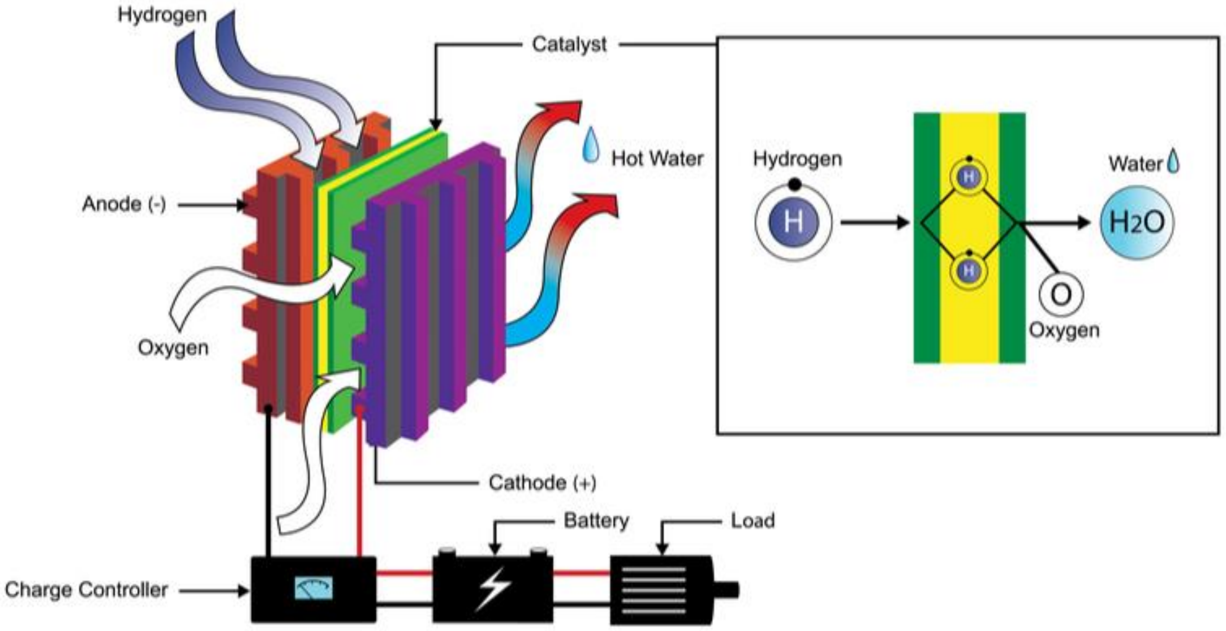
Centre for Hydrogen Fuel Cell Technology for Mobility Applications

RESEARCH AREAS	• **Hydrogen Fuel Cell Materials** • **Fuel cell vehicles**
MAIN OBJECTIVES	• To develop a hydrogen fuel cell prototype based on several materials, that can be tested in automobiles. • To develop, evaluate, and demonstrate technologies that further the use of hydrogen as a transportation fuel by delivering infrastructure, vehicle, engine, fuel. • To design and install hydrogen fueling facilities

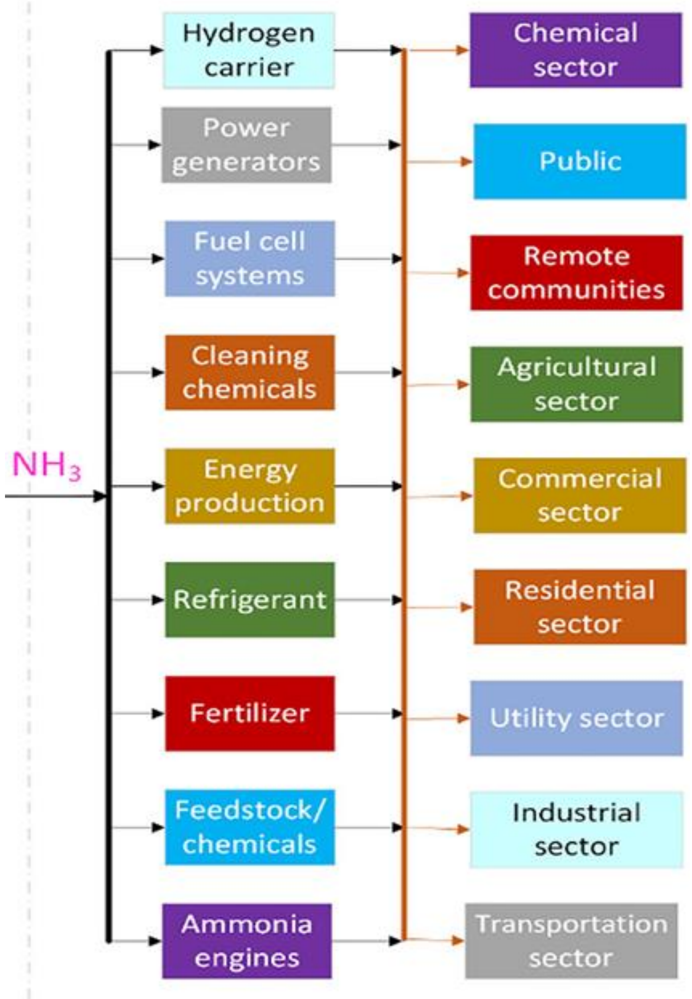
Hydrogen Fuel Cells



Collaboration with government and private sector partners. International academic and research institutes, identified as key for success

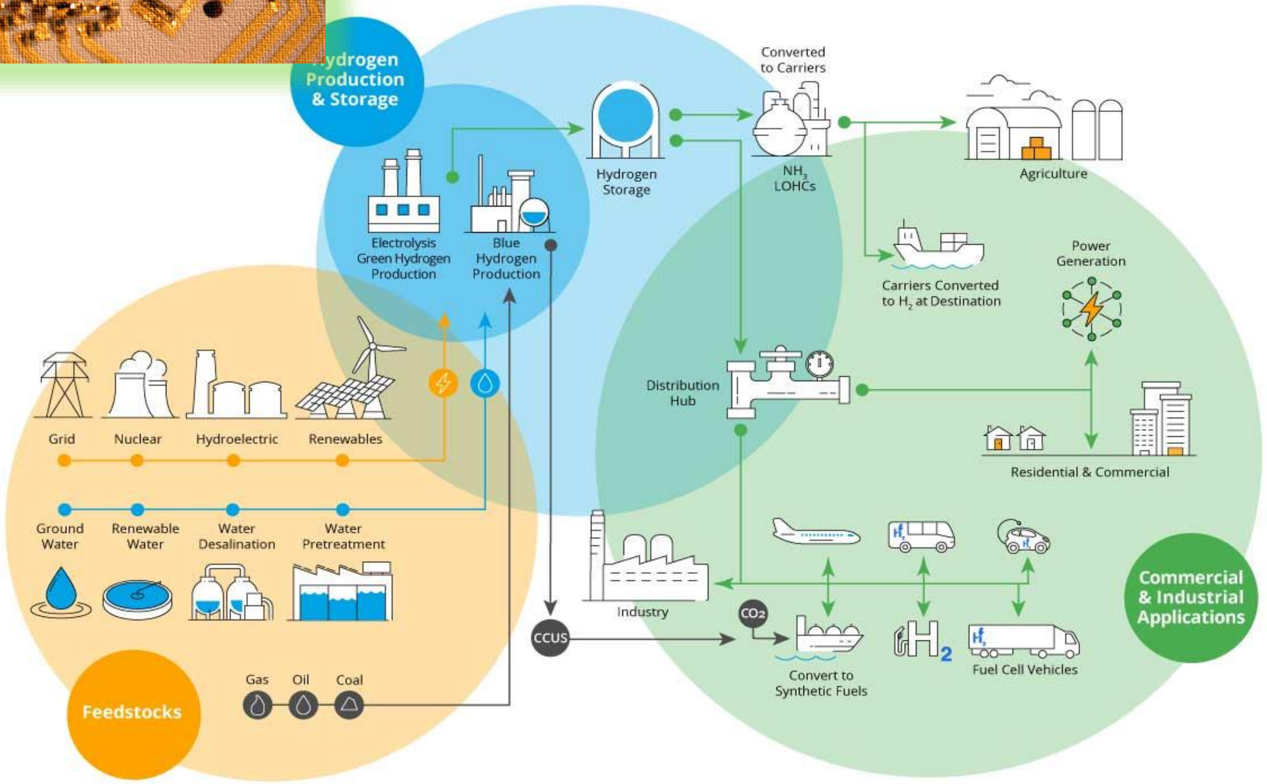
Centre for Hydrogen Energy Use, Economics, Law, Environment & Society

RESEARCH AREAS	• Economics of Green Hydrogen • Legislative framework and policy Formulation • Environmental and Social Impact (cross-cutting) • End Use of the Products (construction of pilot projects) • Operation and Maintenance of pilot plants • Ammonia as a Fertilizer (Agricultural use)
MAIN OBJECTIVES	• To propose, supervise the establishment, operation and maintenance of Hydrogen based pilot plants. • To research, review and recommend the strengthening and enabling of the Green Hydrogen regulatory environment to function optimally within its eco-system. • To perform environmental impact assessments associated with the emission of excessive water vapour into the atmosphere • To develop the Environmental Management Plan (EMP) to indicate impacts and mitigation measures during construction, operation, and if needed decommissioning of proposed pilot plants • To examine the potential social impacts (positive and negative) • High temperature vapours/water produced in Hydrogen production processes • EIA of the residual brine, water and other by-products (wastes!) resulting from the H_2 production processes



Centre for Digital and Emerging Technologies

RESEARCH AREAS	• **Emerging technologies and digital solutions**
MAIN OBJECTIVES	To design and develop digital solutions and emerging technologies such as ➢ Big Data, ➢ Artificial Intelligence, ➢ Machine Learning, ➢ Robotics, ➢ Internet-of-Things, ➢ Augmented and Virtual Reality, ➢ Cybersecurity and ➢ mobile applications that are necessary for the Green Hydrogen value chain.



Centre for Hydrogen Capacity Building, Competence & Standards

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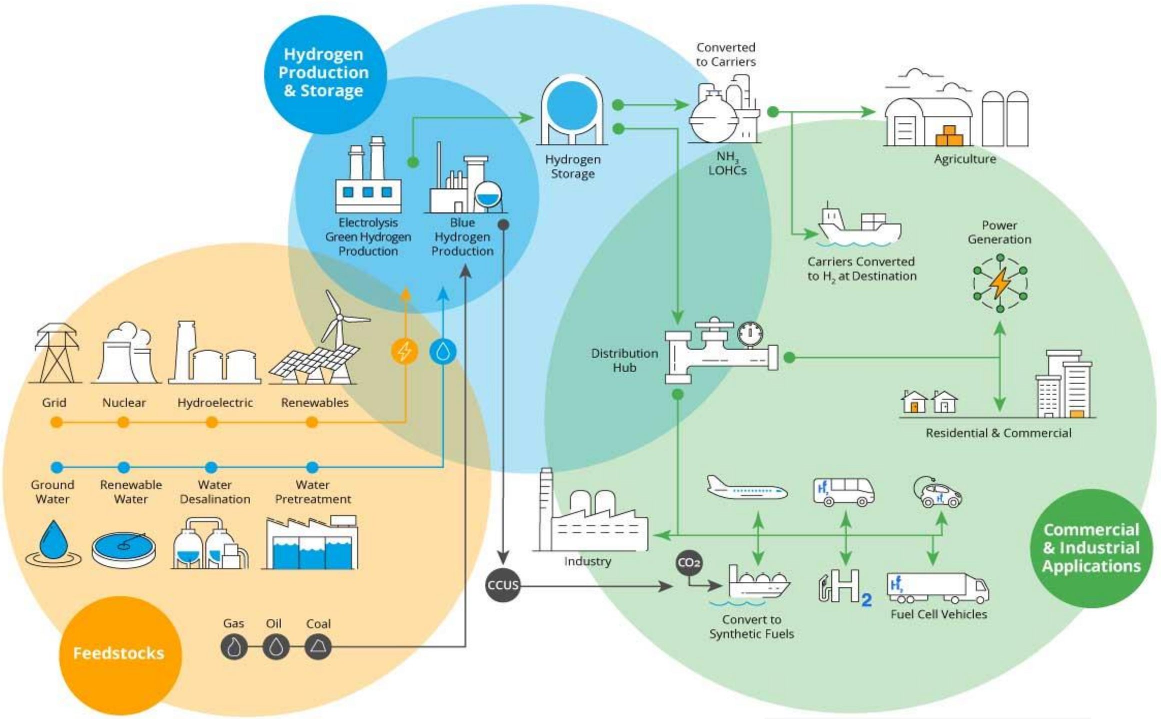
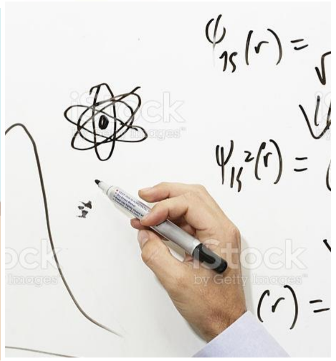
RESEARCH AREAS	• **Capacity Building: Development and design new and revised academic programmes** • **Short courses / capacity building workshops/ seminars**
MAIN OBJECTIVES	• To determine how the current, revised and proposed new degree programmes address the potential future needs of the country for the production and utilization of Green Hydrogen • To establish a Training and Certification Centre which will be attached to the National Green Hydrogen Research Institute to offer short courses and industry-based certifications in order to skill, reskill and upskill the workforce.





THANK YOU