



Seoul — Daejeon, South Korea
14-16 July 2026



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REPUBLIC OF SOUTH AFRICA



Green hydrogen mini-value chain at HySA Infrastructure NWU

Phillimon Modisha

HySA Infrastructure CoC

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<http://www.hysainfrastructure.org/>

Background



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2008-2014

2014-2019

2019-2023

2023-

Technology Catch-up

Extensive Research & Development

Technology Demonstrations

Commercialization

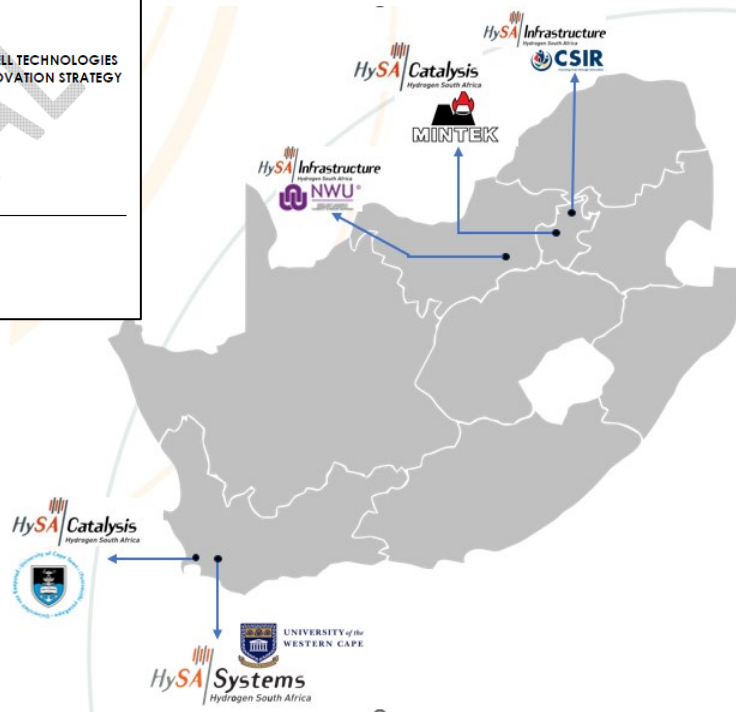


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NATIONAL HYDROGEN AND FUEL CELL TECHNOLOGIES
RESEARCH, DEVELOPMENT AND INNOVATION STRATEGY

May 2007

Private Bag 1004
PRETORIA
0001
www.dst.gov.za

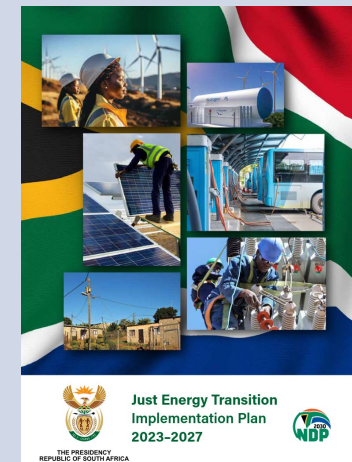
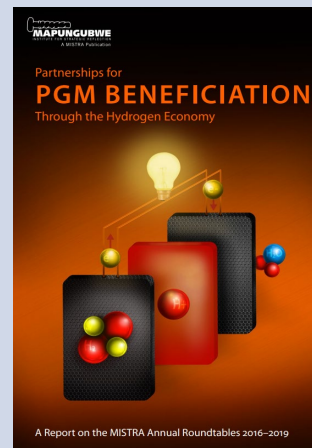
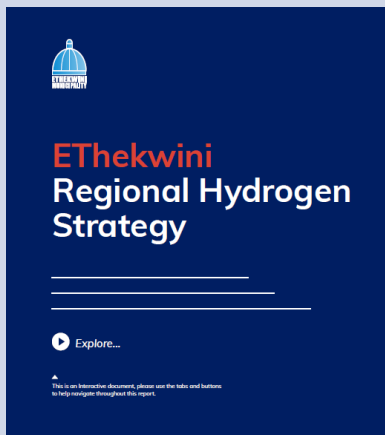
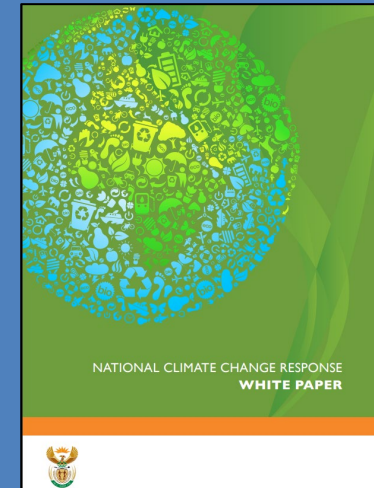
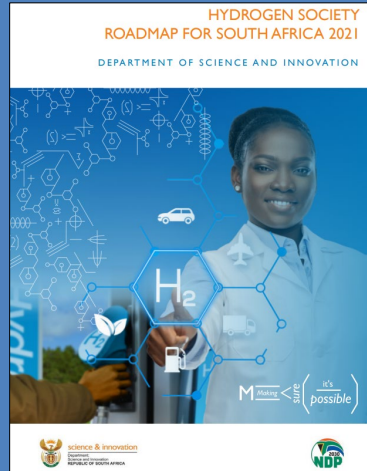


Policy Landscape: Various SA Government Stakeholders



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Identified South African Hydrogen Hubs



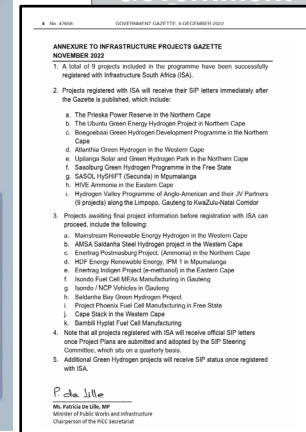
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Ministry of Public Works and Infrastructure



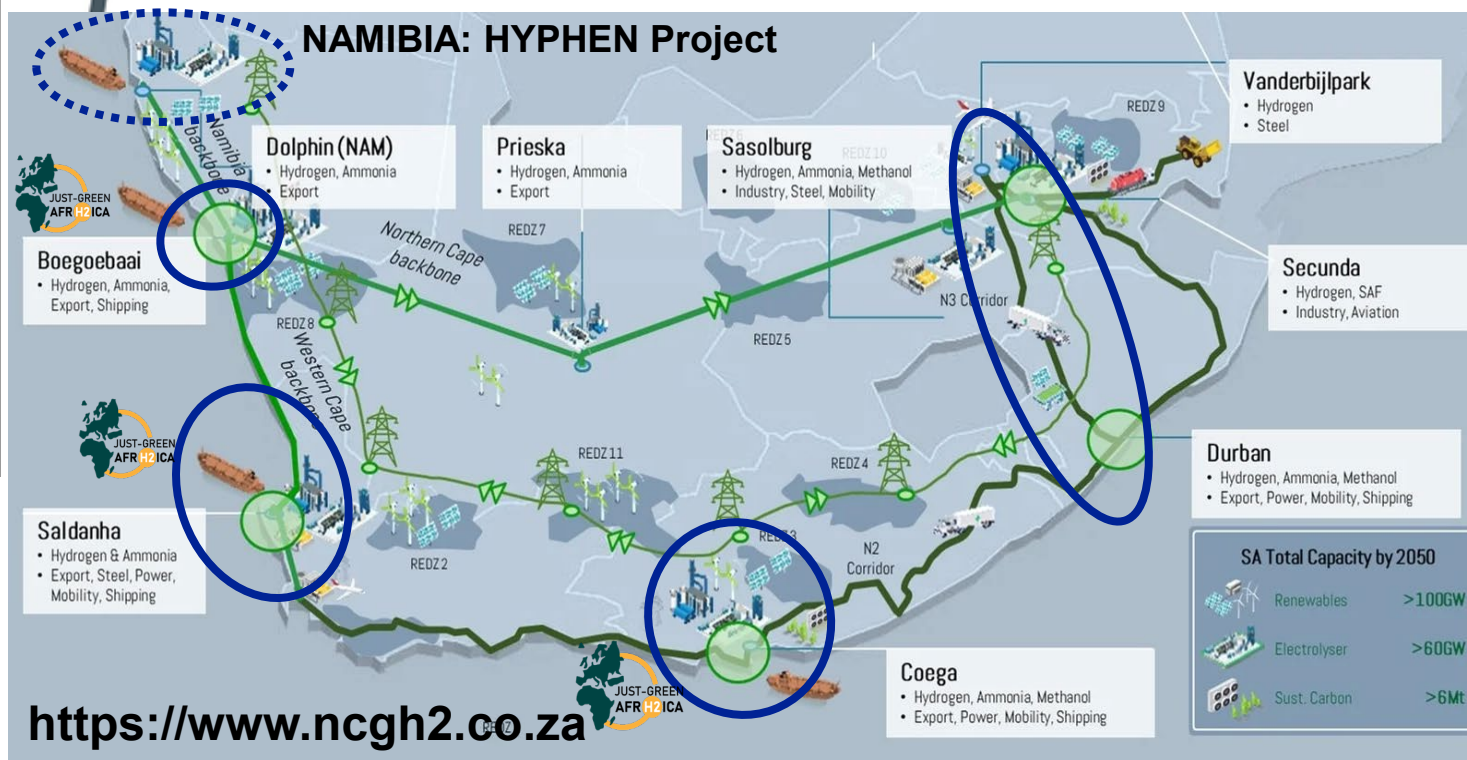
Government Gazette



No. 4755

The South African Government has officially designated Green Hydrogen Hubs, which have been registered as Strategic Integrated Projects.

NAMIBIA: HYPHEN Project



Current Infrastructure

- Ports, Roads (N1, N12, N2, N3), REDZ, Northern and Southern Ele. Transmission, pipelines

Planned infrastructure

- Desalination plants, Electrolysers, Ammonia plants, Refueling Stations, pipelines, CO₂ direct air capture

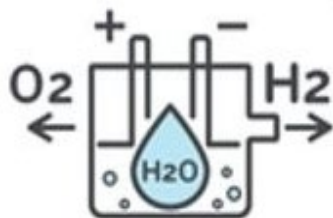
HySA Infrastructure Project Portfolio



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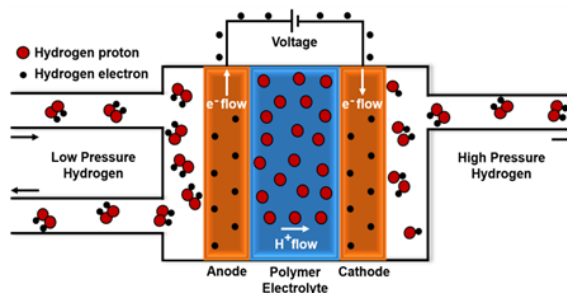
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PEMWE



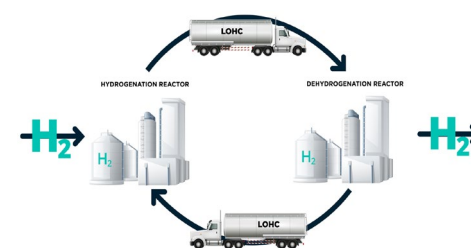
TRL 5

EHC



TRL 5

LOHC



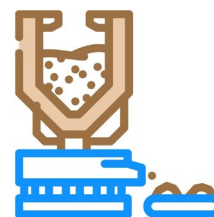
TRL 5

Hydrogen Refueling Stations



TRL 6

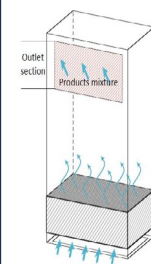
DRI-H2



Ammonia



PAR





PEMWE Development



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Raw material processing



CCM manufacturing



Components machining



Backplates, GDLs, PTLs, gaskets, etc



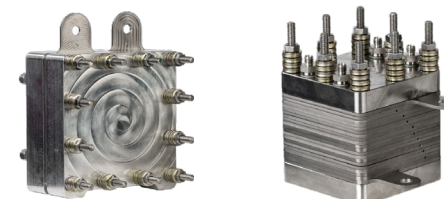
Electrolyser performance testing



System Specifications

- Fully automated and programmable testing procedure
- Electrochemical Impedance Spectroscopy (EIS)
- Cell temperatures up to: 100°C
- A maximum cell current of: 250A
- Active cell area: 25 & 100cm²
- Back-pressure control of up to 6 bar
- Ability to measure H₂ % in O₂ and O₂ % in H₂
- Water conductivity
- Mass flow rate (Oxygen + Hydrogen)

Cell/Stack assembly





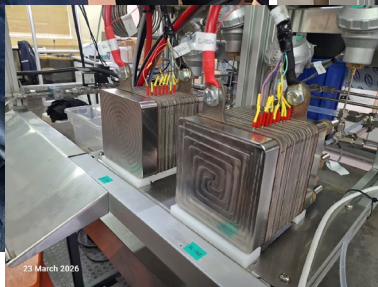
SASOL RT: System Commissioning onsite



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- Fully automated 2kW PEM electrolyser system
- Voltage monitoring in each cell
- Gas sensors
- PSA system



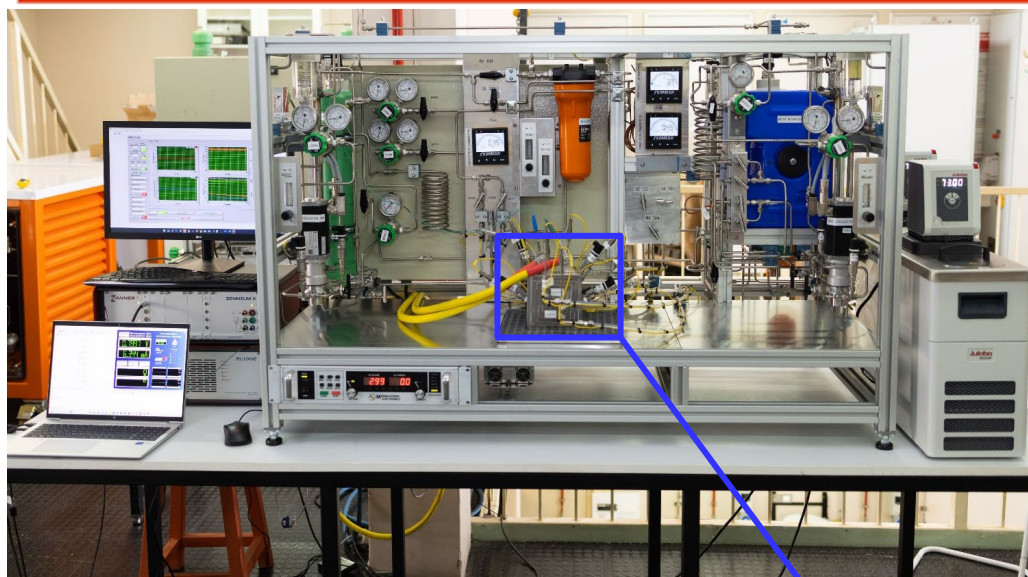
1 March 2026

Electrolyser Test Station



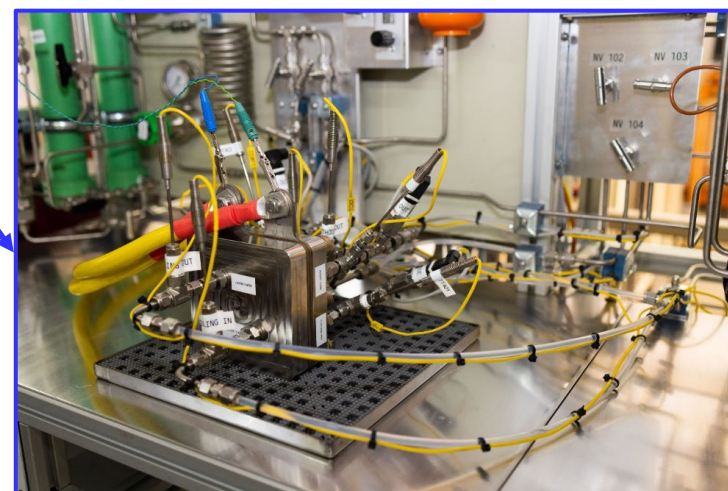
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Customized Testing Hardware

- Pol curves and EIS measurements
- Voltage: 0-100V
- Temperature control: $<90^{\circ}\text{C}$
- H_2 & O_2 pressure: 0-10 bar
- Water flow rate: 0-114 L/h
- Water conductivity: $0,06\mu\text{S}$
- Binary analyzer: H_2/O_2 and O_2/H_2

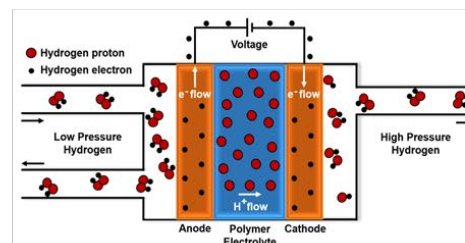


Electrochemical Hydrogen Compression and Separation



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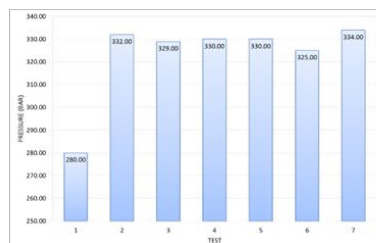
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- No moving parts
- H₂ gas purification by separation
- Noise less

GEN1 EHC Compact

Current Density	0 – 1 Amp/cm ²
Compression Rate	0 – 3 085 mL _N /min
Rated Pressure	300 Bar(g)



HySA's EHC Stack

- Reached 330 Bar(g)
- Currently busy with new design focusing of reaching higher pressures





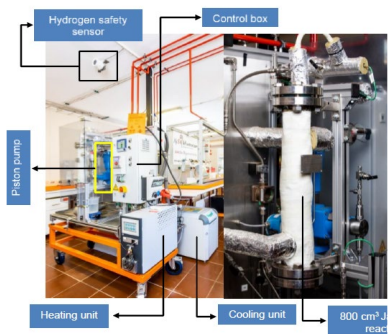
LOHC: Laboratory Testing Capabilities



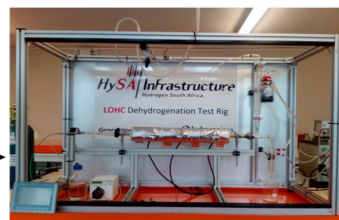
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Hydrogenation

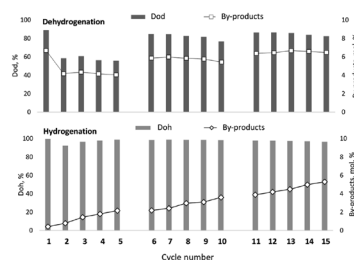
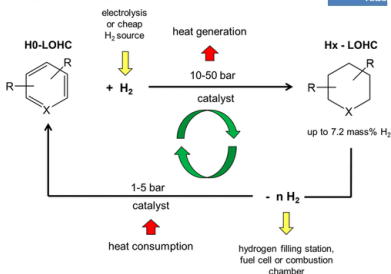


Dehydrogenation



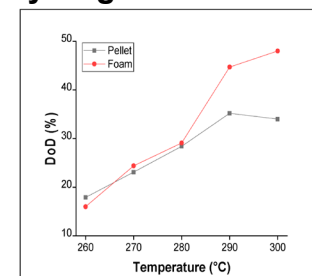
H18-DBT

H0-DBT

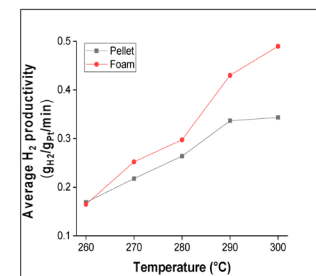


**Rapid hydrogenation
and dehydrogenation
for cycling stability**

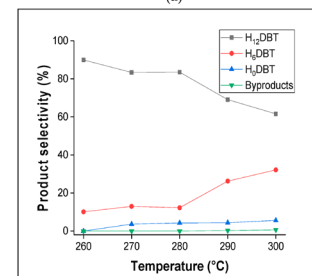
Comparison of foam and pellet based catalysts for dehydrogenation of H18-DBT



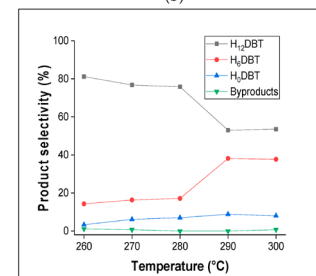
(a)



(b)

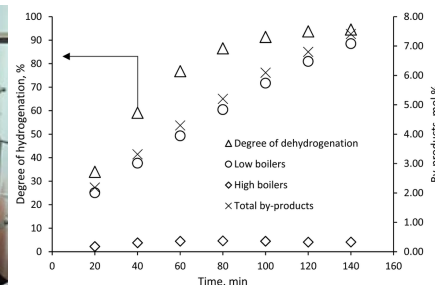


(c)



(d)

Batch setup for catalyst screening tests



Pressure swing (De)-hydrogenation reactor





LOHC Catalyst Preparation Capabilities



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Buchi rotary evaporator for heterogeneous catalyst preparation by wet-impregnation



Catalyst production capacity per batch:
150 g

Catalyst treatment furnace



**Pelletiser for catalyst preparation
Powder to pellets**



PGM Beneficiation

Raw platinum

Dissolved platinum

Platinum impregnation

Pt/Alumina Catalyst



Al₂O₃ pellets



- Pellet size: 0.85-38.1 mm
- Shape: Spherical
- Capacity: 0.006-0,02 m³/h

Analytical Equipment

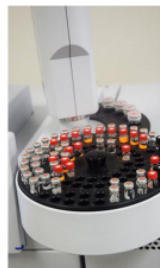


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LOHC Analysis

Scion GCSQMS



Agilent 5977C GC/MSD



Key Feature

- Selective Ion Mode, Peak area, Total Ion Content (TIC)

Function

- Degree of hydrogenation
- Quantify/qualify isomer fractions and by-products

Refractometer



Key feature

- Refractive index

Function

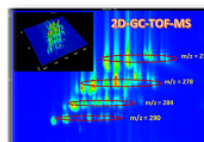
- Degree of hydrogenation

2D-GC-TOF-MS



Key feature

- 1st and 2nd dimension separation, TIC, 2D and 3D plots



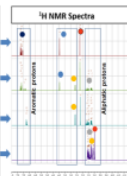
Function

- Degree of hydrogenation
- Quantify/qualify isomer fractions

NMR 400 MHz



HO-DET-HIS-DET	Proton Assignment
HO-DET	• Aromatic 7.3-7.5 • Methyl 2.20 • Methylphenyl 1.95
HO-DET	• Aromatic 7.3-7.5 • Methyl 2.20 • Methylphenyl 1.95 • Methylphenyl 1.95 • Methylphenyl 1.95
HIS-DET	• Aromatic 7.3-7.5 • Methyl 2.20 • Methylphenyl 1.95 • Methylphenyl 1.95 • Methylphenyl 1.95
HIS-DET	• Aromatic 7.3-7.5 • Methyl 2.20 • Methylphenyl 1.95 • Methylphenyl 1.95 • Methylphenyl 1.95



Key feature

- Chemical shift (ppm)
- Number of protons

Function

- Degree of hydrogenation

Catalyst Characterization

BELCAT II



BELSORP MINI X



SHIMADZU EDX



- Catalyst Textural Properties
- Temperature Programmed Experiments
- Elemental Composition

Gas Analysis

GC SRI-8610C



Key feature

- Peak area, retention time

Function

- H₂ gas purity, quantification of gaseous impurities

Hidden Analytical HPR-20 MS



Key Feature

- Detect and quantify permanent gases, NH₃, chlorine, etc. in a fast response time (300 ms)

Function

- Online gas analysis

Scion 456



LOHC Demonstration units



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CREAMER MEDIA'S
ENGINEERING NEWS

<http://www.engineeringnews.co.za/article/chris-griffiths-2018-04-12>

Fuel cell dozer expected to make game-changing 2019 debut



JOHANNESBURG (miningweekly.com) – A fuel cell dozer that runs on hydrogen carried in liquid is expected to make a game-changing debut underground next year, Anglo American Platinum (Angplat) CEO **Chris Griffiths** said last night.

Speaking at the fortieth African Mining Network dinner, Griffiths said third generation development had already taken place on the dozer, which was powered by a liquid carrier of hydrogen, innovated to create market demand for platinum.

"This changes the game," he said in response to *Mining Weekly Online*.

A drum of the hydrogen-carrying, baby-oil-resembling liquid can fuel the dozer for several days.

"This is some really cool technology," he added.

It is poised to be taken underground for operation at a dip that has been very difficult to crack for mechanised trackless mining.

"We're ready to put that underground in about a year's time. The equipment's all working and now we're trying to put this all together so that it works as a system," he disclosed.

GREEN HYDROGEN

HYDROGEN STORAGE AT HYSA INFRASTRUCTURE

LOHC (liquid organic hydrogen carrier)

Hydrogen storage at ambient conditions
[57 kg H₂] / m³ LOHC
Non-flammable, non-toxic, low-cost, re-usable
Current system stores 1 MWh energy equivalent at NWU

1 MWh energy equivalent

HYSA INFRASTRUCTURE ON DEMAND ON-SITE PRODUCTION AND STORAGE

AngloAmerican and HySA Teams
demonstrated H₂ LOHC system for
low profile dozer



LOHC demonstration units



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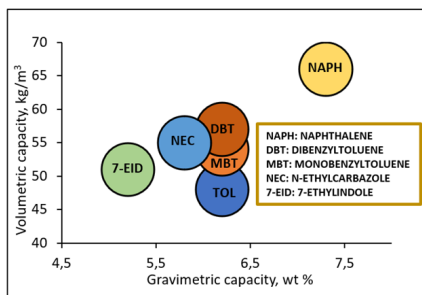


SPECIFICATIONS	HYDROGENATION PLANT
H ₂ CONSUMPTION RATE	4 Nm ³ /hr
HYDROGENATED LOHC PRODUCTION RATE	5 kg/hr
OPERATING PRESSURE	28 -30 bar
OPERATING TEMPERATURE	140 -180°C
REACTOR VOLUME: APPROX	50 Litres
REACTOR TYPE	Fixed-bed downflow

Hydrogenated LOHC



- High H₂ capacity: 6.2 wt% (equivalent to 57 kg-H₂/m³ - LOHC or 2.06 kWh/kg-LOHC)
- Degree of hydrogenation > 95%
- Non-flammable
- Compatible with existing infrastructure for fuels



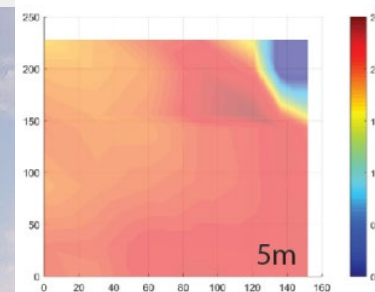


Ventilation Tests: Hydrogen in mining



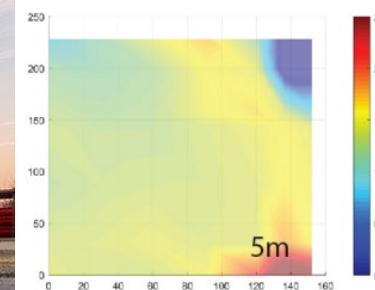
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Experimental

- 50 bar
- 0.8mm orifice
- with ventilation



Experimental

- 20 bar
- 0.8mm orifice
- with ventilation

Specifications

- 5 x 3 x 50 meter ventilation tunnel
- 55kW (50m³/sec) controlled custom ventilation fan
- On-site hydrogen production and storage
- Hydrogen release lines into the tunnel @ 350 bar and 200 bar
- Hydrogen sensors
- Remote site office



Refuelling Capabilities



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Specifications

- 6 Nm³/hr PEM electrolyser with 15 bar discharge
- 500-litre potable water supply tank on the roof
- 350 bar on-board hydrogen storage
- 350 bar SEA hydrogen dispenser
- 63 A 3phase electrical connection
- Deionizer water purification system



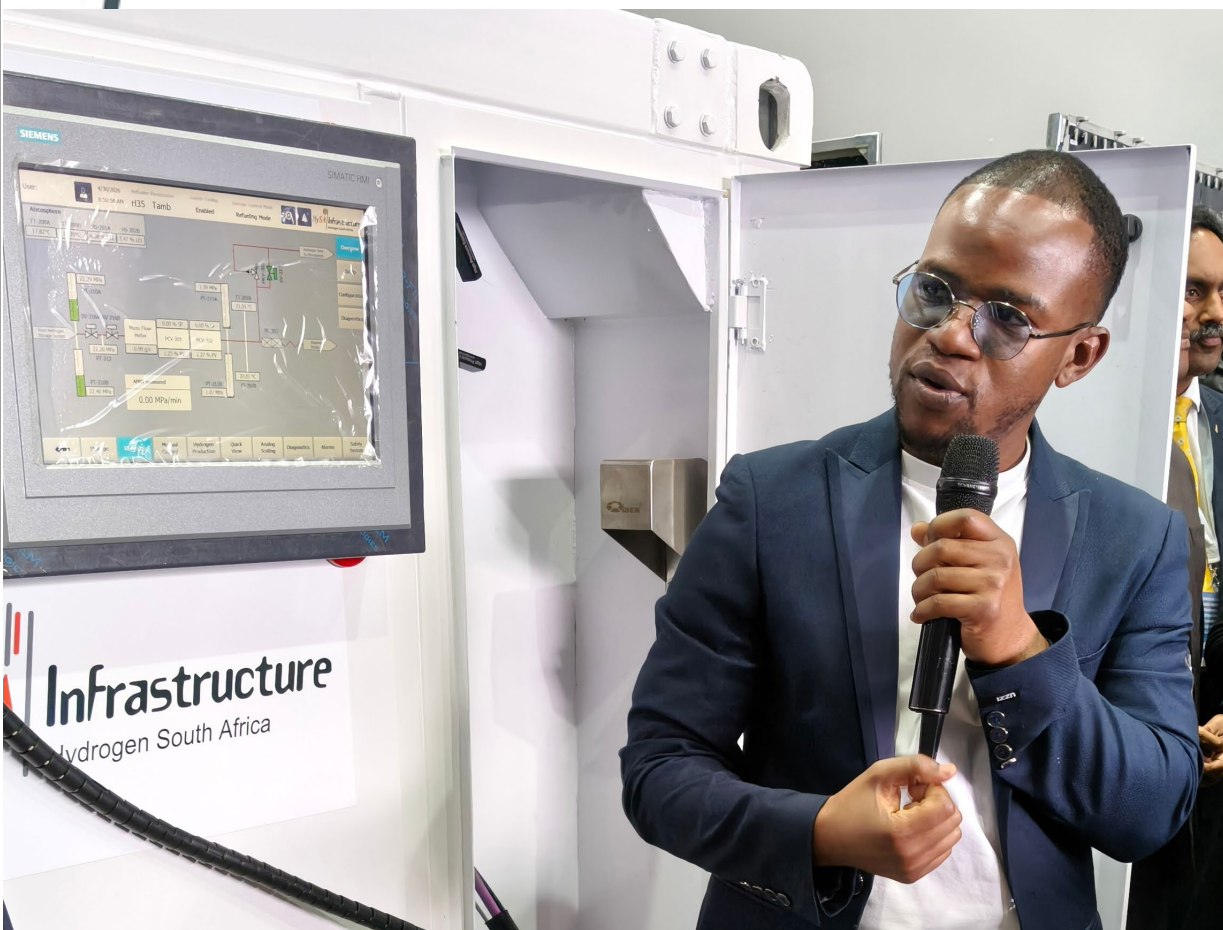


RPTTF Launch and Refueller handover



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Toyota Mirai Refuelling



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Ambient Refuelling Protocol



- Hydrogen Storage tanks

- Refuelling nozzle

- Power electronics

- Water deioniser

- PEM WE system

- Compressor

- Power electronics





DRI System Commissioning



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Decarbonising Steel Industry: H₂ DRI



Ammonia Synthesis



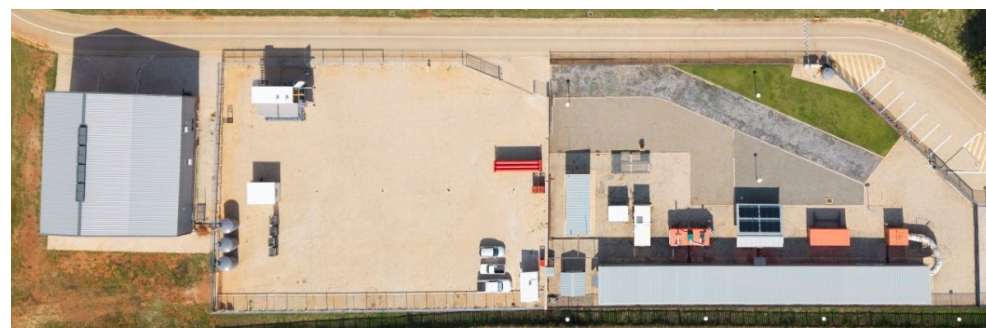
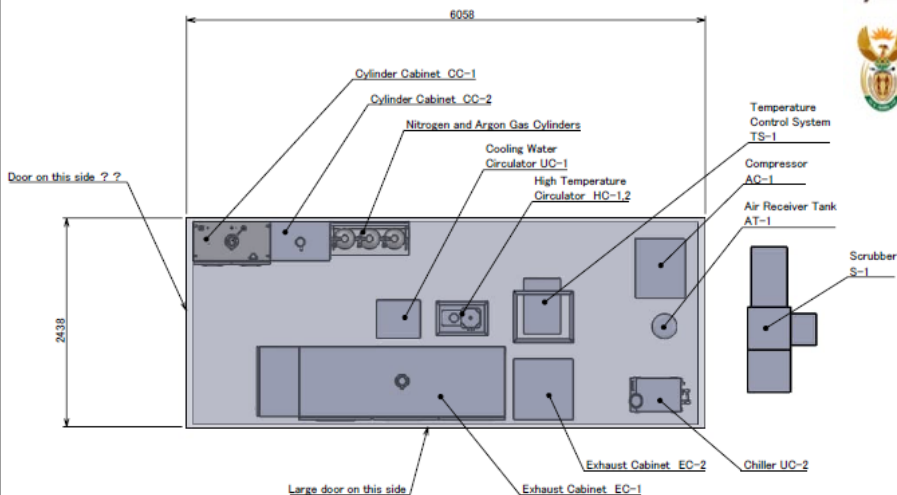
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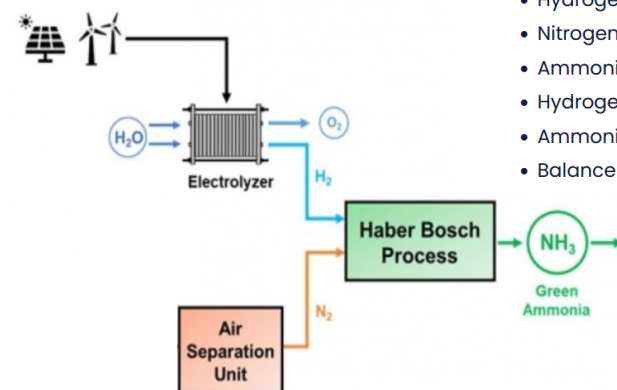
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SATREPS
Science and Technology Research Partnership
for Sustainable Development Program



A Green Ammonia Plant consists of following units:

Renewables



- Hydrogen Production
- Nitrogen Production
- Ammonia Production
- Hydrogen Storage
- Ammonia Storage
- Balance of Plant (utilities and infrastructure)



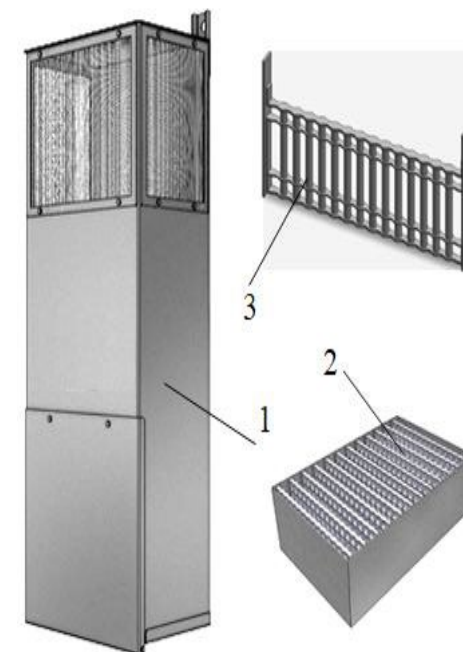
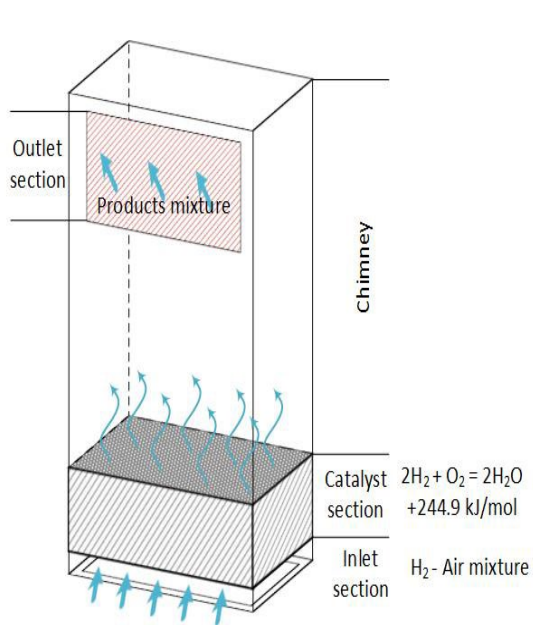
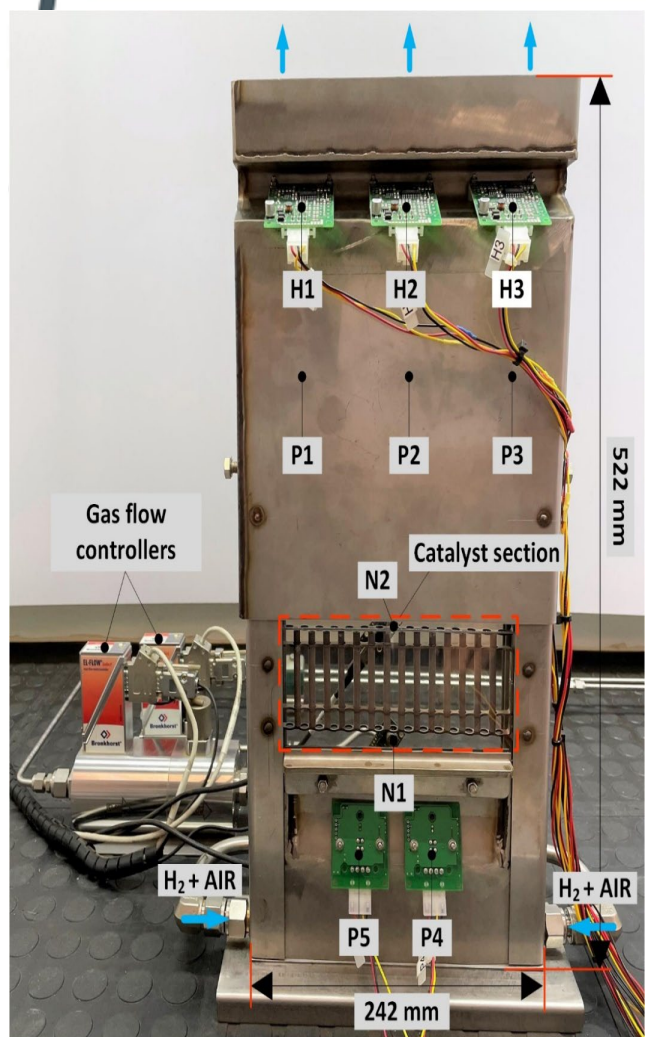
PAR Technology



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Hydrogen safety: Accidental hydrogen release in confined spaces



Innovation & Technology Funding Instruments



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Government and International Funding

R&D
TRL 1-6



- Intellectual Property
- Demonstration units
- Human Capital Development

Industry Co-funding



sasol



PD
TRL 7-9

Commercially Viable
Product Development

EU Funded Projects & Partners



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Consortium

Ended



Universidad
del Pais Vasco

Euskal Herriko
Unibertsitatea



EVONIK
POWER TO CREATE



hydr^ogenious
LOHC TECHNOLOGIES



EU Funded Projects & Partners



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Clean Hydrogen
Partnership

HORIZON-JTI-CLEANH2-2022-2

Started in 2023

unLOHCked Consortium



Universidad
del País Vasco

Euskal Herriko
Unibertsitatea



Heraeus

Precious Metals



NWU®

NORTH-WEST UNIVERSITY
NOORDWES-UNIVERSITEIT
YUNIBESITHI YA BOKONE-BOPHIRIMA



 **HYGEAR**



Centre National
de la Recherche
Scientifique



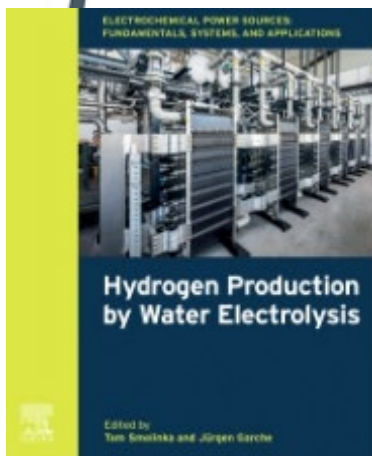
Research Outputs



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Book Chapters



Electrochemical Power Sources:
Fundamentals, Systems, and Applications

Hydrogen Production by Water Electrolysis

2022, Pages 455–486

Chapter 13 - Hydrogen storage

Henrietta W. Langmi ^a, Nicolaas Engelbrecht ^b, Phillimon M. Modisha ^b,
Dmitri Bessarabov ^b

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<https://doi.org/10.1016/B978-0-12-819424-9.00006-9>

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Abstract

This chapter presents an overview of the key hydrogen storage approaches being pursued. It discusses the recent status of hydrogen storage options and provides an outlook for the development of hydrogen storage technologies. It

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Industrial Arene Chemistry: Markets, Technologies,
Sustainable Processes and Cases Studies of
Aromatic Commodities

Editor(s): Jacques Mortier

First published: 10 March 2023

Print ISBN: 9783527347841 | Online ISBN: 9783527827992 | DOI: 10.1002/9783527827992

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About this book

Industrial Arene Chemistry

Explore the wide array of uses for aromatic hydrocarbons in this comprehensive reference

Aromatics are a class of compounds—normally but not exclusively organic—which tend to be produced as by-products of various industrial processes. Their importance as ... [Show all](#) ▾

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Chapter 35

Storage of Hydrogen in Reversible Aromatic Organic Liquids

Phillimon Modisha, Dmitri Bessarabov

Book Editor(s): Jacques Mortier

First published: 10 March 2023 | <https://doi.org/10.1002/9783527827992.ch35>

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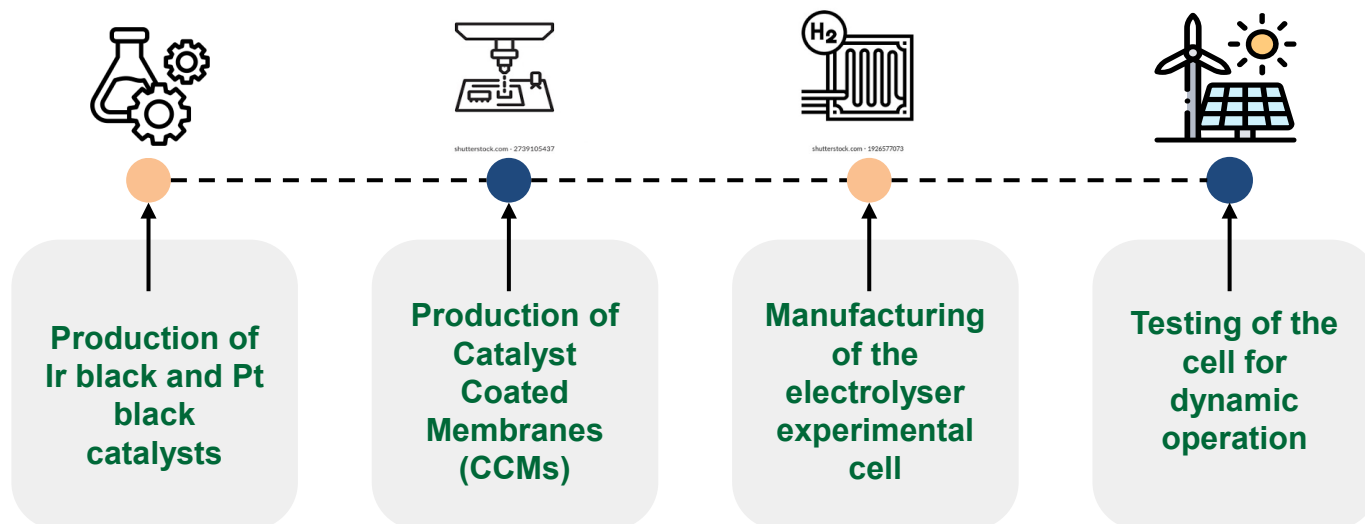
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