Unlocking South Africa’s Hydrogen Potential
Unlocking South Africa’s Hydrogen Potential – Key takeaways

**Hydrogen is critical to achieving global decarbonisation**

“As the world becomes more reliant on renewables as its primary source of energy, Hydrogen offers an unparalleled solution for the transport, storage and efficient utilisation of clean energy”

**The time is now**

“Hydrogen is receiving an unprecedented level of international traction as the cost of renewables decline and carbon emissions are increasingly penalised”

**SA has the competitive advantage to produce and export green energy**

“South Africa has world class renewable potential that can be leveraged to supply clean energy to the world and transform the domestic economy”

**Hydrogen means more than just Fuel Cells**

“Hydrogen has the ability to revolutionise the entire energy space. For South Africa, focussing on Fuel Cells alone is missing the bigger opportunity”

**Investing in Hydrogen is necessary to diversify the SA economy**

“As part of SA’s economic recovery plan, the country needs to develop new competitive industries in the global markets. Hydrogen can fulfil that role and in a complementary manner to other initiatives and sectors”

**Regulation is key for SA to successfully capitalise**

“Coherent government policy will be necessary to support the pace of hydrogen development and correctly incentivise the move towards fully Green hydrogen”
Hydrogen is critical to achieving global decarbonisation.

The time is now.

SA has the competitive advantage to produce and export green energy.

Hydrogen means more than just Fuel Cells.

Investing in Hydrogen is necessary to diversify the SA economy.

Regulation is key for SA to successfully capitalise.

### Global Electricity Generation PWh / year (2020 – 2050)

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar</th>
<th>Wind</th>
<th>Hydro</th>
<th>Coal-fired</th>
<th>Nuclear</th>
<th>Gas-fired</th>
<th>Geothermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key Insights**

- It is estimated that by 2050, renewables will account for 85% of Global Electricity production. Sectors such as transport, building heat and power and industrial processes will take longer.

- Despite this, it is expected that the Global Energy Mix will be 50% powered from renewable sources by 2050.

- As the world moves towards renewables as the primary energy vector, production will become increasingly geographically constrained, necessitating increased cross-border transportation and storage of green energy.

Source: DNV GL’s Energy Transition Outlook
The Global Energy Transition

Hydrogen is critical to achieving global decarbonisation. The time is now for countries to invest in hydrogen as a carrier of energy.

In the coming decades, hydrogen will play an ever-increasing role in the global energy mix as an efficient carrier of energy.

Hydrogen means more than just fuel cells. Regulation is key for South Africa to successfully capitalise on this opportunity.

South Africa has the competitive advantage to produce and export green energy. Investing in hydrogen is necessary to diversify the SA economy.

Hydrogen energy content

Hydrogen is critical to achieving global decarbonisation.

The time is now to produce and export green energy. Hydrogen means more than just Fuel Cells. Investing in Hydrogen is necessary to diversify the SA economy. Regulation is key for SA to successfully capitalise.

Compared to a high performing lithium-ion battery, Hydrogen carries approximately 160x the amount of energy per kg of weight.

Energy Content (MJ/kg)

- Hydrogen: 142.00
- Methane: 55.50
- Liquid Natural Gas: 55.00
- Kerosene: 46.30
- Gasoline: 45.80
- Diesel: 45.30
- Crude Oil: 41.90
- Anthracite Coal: 31.40
- Methanol: 31.10
- Ethanol: 19.90
- Lithium Ion Battery: 0.30 – 0.90

Source: C. Ronneau – Universitaires de Louvain
Hydrogen production methods

| Hydrogen is critical to achieving global decarbonisation | The time is now | SA has the competitive advantage to produce and export green energy | Hydrogen means more than just Fuel Cells | Investing in Hydrogen is necessary to diversify the SA economy | Regulation is key for SA to successfully capitalise |

<table>
<thead>
<tr>
<th>Grey Hydrogen</th>
<th>Blue Hydrogen</th>
<th>Green Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocarbon feedstock (coal, natural gas, oil) with all CO₂ from the production process emitted into the atmosphere</td>
<td>Same hydrocarbon feedstock as grey hydrogen with carbon capture and storage (CCUS) technology integrated</td>
<td>The electrolysis of water from a renewable power source (wind, solar, etc.) or through a bioreactor</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td><strong>Market Share</strong></td>
<td><strong>Outlook</strong></td>
</tr>
<tr>
<td></td>
<td>90%</td>
<td>6 - 7%</td>
</tr>
<tr>
<td></td>
<td>Decline as the world tightens carbon emissions and ‘blue’ and ‘green’ alternatives become less expensive</td>
<td>Positive outlook for the short to medium term as it is a viable ‘Green’ transition for existing Grey Hydrogen production sources</td>
</tr>
<tr>
<td>9kg - 20kg of carbon per 1kg Hydrogen</td>
<td>1kg – 2kg of carbon per 1kg Hydrogen</td>
<td>0kg of carbon per 1kg Hydrogen</td>
</tr>
</tbody>
</table>

Investing in Hydrogen is necessary to diversify the SA economy.
Hydrogen production methods

Hydrogen is critical to achieving global decarbonisation

The time is now

SA has the competitive advantage to produce and export green energy

Hydrogen means more than just Fuel Cells

Investing in Hydrogen is necessary to diversify the SA economy

Regulation is key for SA to successfully capitalise

Hydrogen production costs over time (US$/kg H₂)

- **2018**: Grey - 1.0–2.2, Blue - 1.6–3.0, Green - 2.3–3.8
- **2030**: Grey - 1.2–2.3, Blue - 1.5–2.8, Green - 1.4–1.8
- **2050**: Grey - 1.6–2.4, Blue - 1.5–2.7, Green - 0.7–0.9

Renewable landed cost of energy (US$/MWh)

- **2018**: Grey - 30–45
- **2030**: Grey - 18–26
- **2050**: Grey - 14–18

$95 billion hydrogen pipeline at beginning of 2020

Hydrogen is critical to achieving global decarbonisation

The time is now

SA has the competitive advantage to produce and export green energy

Hydrogen means more than just Fuel Cells

Investing in Hydrogen is necessary to diversify the SA economy

Regulation is key for SA to successfully capitalise

Source: Bloomberg Green, Strategy& analysis

Approximate CO₂ abatement of project at scale (Mt/year)

Production

Distribution

Storage

Mobility

Power Generation

Feedstock

Building heating

MAGNUM H2 POWER PLANT

NORTHERN LIGHTS

HYBRIT

H2 MOBILITY ENERGY NETWORK

HYNET & H21 HEATING

H2 FC TRAINS

H2 OBILITY

LH2 SUPPLY CHAIN

HYSECURE CAVERN

ENERGY FLEXIBILITY

HYNETHERLANDS

GREEN AMMONIA

GREEN H2 PROD FOR AMMONIA

H2 FC TRUCKS

H2 FC TRUCKS FLEET

H2 FC TRUCKS FLEET

TBC

TBC

TBC

TBC

TBC

Source: Bloomberg Green, Strategy& analysis
Rapid increase in national hydrogen strategies and funding

Hydrogen is critical to achieving global decarbonisation

The time is now

SA has the competitive advantage to produce and export green energy

Hydrogen means more than just Fuel Cells

Investing in Hydrogen is necessary to diversify the SA economy

Regulation is key for SA to successfully capitalise


In 2019, Saudi Arabia earmarked the NEOM region to be the leading global hub for renewable energy. In June 2020, it secured a ~€ 4.5 billion green ammonia production facility, producing 1.2mtpa

In 2019, New Zealand launched “a Vision for Hydrogen in New Zealand”, which sets out the role of Hydrogen in its commitment to be carbon neutral by 2050

In June 2020, the U.S. Department of Energy announced intentions to invest $100 million into two DOE National Laboratory-led consortia for fuel cell and hydrogen R&D.

The government released #mission2030 - Austrian Climate and Energy Strategy, which included boosting infrastructure for hydrogen and a flagship project centred on renewable hydrogen

In 2019, the Dutch government Climate Agreement included a substantial hydrogen development program to accommodate large-scale production and storage of renewable electricity with hydrogen technology

Launched a Industrial Decarbonization challenge, committing GBP 170 million towards deploying technologies like carbon capture and hydrogen networks in industrial clusters, supporting the Industrial Clusters Mission to establish the world’s first net zero industrial cluster by 2040

In June 2020, Germany announced a €9 billion stimulus package allocated to expand the role of green hydrogen to help end the country’s reliance on coal as the country revealed its Hydrogen strategy

JPY 26.3 billion (~€215 million) was approved to establish a hydrogen supply chain and offer subsidies toward public hydrogen station development for fuel-cell vehicles

In January 2019, the government announced its Hydrogen Economy Roadmap and Ulsan’s Future Energy Strategy, focussing on leading the hydrogen vehicles and fuel cell industry. Furthermore, the government announced it plans to build three hydrogen-powered cities by 2022

In 2018, the Government presented the Hydrogen Deployment Plan for Energy Transition to the key players in the sector. One of the objectives is to put 5000 hydrogen vehicles on the road by 2023 and to install 100 refuelling stations for those vehicles

Global renewable energy potential

**Hydrogen is critical to achieving global decarbonisation**

**The time is now**

Hydrogen means more than just Fuel Cells

Investing in Hydrogen is necessary to diversify the SA economy

Regulation is key for SA to successfully capitalise

---

**SA has the competitive advantage to produce and export green energy**

---

**Europe**
High-demand location. Renewables-constrained due to varying load curves & limited space availability. Will import Hydrogen

**Japan/Korea**
Strategy to scale up hydrogen consumption & technology development. Space and resource constraints. Will import hydrogen

**China**
Large investments in hydrogen economy. Potential to be self-sufficient

**Australia**
Investment in Green & blue hydrogen. Large-scale PV farms with favourable load profiles. Gearing for Green energy exports to Japan

**South Africa**
World class wind & solar resources. Limited domestic demand, high export potential

---

**United States**
Favourable PV and wind conditions. Good domestic demand

**Chile**
Favourable PV/wind conditions. Low domestic demand. Gearing for exports

---

**Source:** IEA, McKinsey

---

**Legend:**
- Optimal renewable and low-carbon resources
- Optimal low-carbon resources
- Average low-carbon resources
- Optimal renewable resources
- Average renewable resources
South Africa has world class renewables

Hydrogen is critical to achieving global decarbonisation
The time is now
SA has the competitive advantage to produce and export green energy
Hydrogen means more than just Fuel Cells
Investing in Hydrogen is necessary to diversify the SA economy
Regulation is key for SA to successfully capitalise

“South Africa has near perfect wind conditions across almost all of its 3000km coastline, along with pockets of high capacity onshore wind in the Western and Eastern Cape”

“South Africa’s solar in the Northern Cape has the potential to not only generate energy for the domestic economy but also to export this clean energy through the West Coast Ports”

“South Africa has world class renewables

Source: Global Solar Atlas, World Bank

Source: Global Wind Atlas 2020

Source: Global Solar Atlas, World Bank

Source: Global Wind Atlas 2020
SA is ideally positioned to be an exporter of green energy to the world.

Hydrogen is critical to achieving global decarbonisation.

The time is now.

SA has the competitive advantage to produce and export green energy.

Hydrogen means more than just Fuel Cells.

Investing in Hydrogen is necessary to diversify the SA economy.

Regulation is key for SA to successfully capitalise.

As the western world leads the way towards full decarbonisation, South Africa has the opportunity to leverage its world class renewable energy potential to supply green Hydrogen enabled chemicals, fuels and products to these high demand areas.
Four pillars of the Global Hydrogen Economy

Hydrogen is critical to achieving global decarbonisation. The time is now. SA has the competitive advantage to produce and export green energy. Investing in Hydrogen is necessary to diversify the SA economy. Regulation is key for SA to successfully capitalise.

Hydrogen means more than just Fuel Cells.

Transport
- Road – High efficiency, zero emission Fuel Cell Electric Vehicles
- Aviation – Liquid hydrogen drones, VLOTs and synthetic fuels
- Rail – Fuel Cell Electric Locomotives
- Shipping – Green Hydrogen based ammonia fuel

Building Heat and Power
- Off-grid / backup power systems
- Natural Gas Replacement / blending
- Combined heat and power systems (CHP)

Industrial Feedstock
- Industrial Heat – Zero emission efficient heat
- Feedstock – Moving carbon heavy feedstock to green ones
- Carbon Sequestering – capturing carbon (CC) using hydrogen
- Synthetic Fuels – CC from fossil fuels and air scrubbing

Energy Sector
- Renewable Energy Intermittence – Store of energy
- Efficient Energy Transport – Cross border
- Cost effective grid buffering and cross sector coupling
- Multi-use – Direct combustion and fuel cells
Six key benefits of South Africa investing in Hydrogen

Support South Africa’s Resource Sector
Increased demand for Hydrogen Fuel Cells will stimulate demand for South Africa’s PGMs and the massive increase in domestic Solar and Wind resources will help support the wider commodities sector.

Decarbonise South Africa’s Energy and Industrial sectors
South Africa can not only help decarbonise its own power sector through large scale renewable investment, but through access to green hydrogen can decarbonise its other industrial sectors such as steel production and mining.

Strengthen Economy Through Sector Coupling
Hydrogen has the unique capability to be a carrier of energy across a multitude of different sectors. If the economy is able integrate Hydrogen technology across multiple sectors they can benefit from reduced value chain risk and benefit from cost reductions through economies of scale.

Support South Africa’s Resource Sector
Investing in Hydrogen is necessary to diversify the SA economy
SA has the competitive advantage to produce and export green energy
Hydrogen means more than just Fuel Cells
Regulation is key for SA to successfully capitalise

Diversify the SA Economy into a Green Energy Major
South Africa has the opportunity to leverage its world class renewable energy resources to produce and export green hydrogen and green hydrogen enabled fuels, chemicals and products. Generating large export revenue and attracting foreign investment.

Job Creation and Skills Development
Development of a new hydrogen export industry will create numerous jobs along the value chain and enhance the specialised skills pool in the country.

Reinforce Domestic Energy Supply
The large renewables investment needed to generate sufficient quantities of Hydrogen for export will bring the SA landed cost of energy down and a portion of this capacity can be used to support our domestic grid. Potentially at a lower cost to consumers.
Important regulatory questions remain

Hydrogen is critical to achieving global decarbonisation
The time is now
SA has the competitive advantage to produce and export green energy
Hydrogen means more than just Fuel Cells
Investing in Hydrogen can be a win for the entire economy
Regulation is key for SA to successfully capitalise

7 Point Policy Plan for South Africa

- Finalise the SA Hydrogen strategy and roadmap – where to play, how to start, how we support and incentivise (Currently under development)
- Clear Ministerial direction around which government department will champion Hydrogen (e.g. Energy or Trade and Industry)
- Assesses the need for regulation in enabling a competitive market (regulatory hurdles need to minimised and processes streamlined)
- Incentivise early investment and just transition from Grey, to Blue, to Green Hydrogen (e.g. sector specific SEZ’s, tax credits, policy certainty)
- Fast tracking of renewable energy licensing used for Hydrogen production
- Review and strategy for local content and local skills development
- Signing of collaboration agreements between hydrogen producers, off takers and technology players (similar to the Japan-Australia and Germany-Morocco MoUs signed in recent years)

Policy certainty and transparency
Political stability and accountability

Primary development platforms
Physical enablers

Secondary development platforms
Intensive economic growth sectors

Social and economic development

Policy
Energy ICT
Water and sanitation
Transport and logistics
Mining and minerals Services industry Agriculture
Manufacturing Trade and retail
Employment Poverty alleviation
Health and wellbeing Education GDP per capita
Environmental Sustainable growth Gender equality

Hydrogen can be a key enabler of economic growth

Clear policy is needed to stimulate investment and accelerate development

SA has the competitive advantage to produce and export green energy
Hydrogen means more than just Fuel Cells
Investing in Hydrogen can be a win for the entire economy
Regulation is key for SA to successfully capitalise

Strategy&
PwC South Africa Hydrogen Team

Jonathan Metcalfe
Africa South Market
Lead - Hydrogen
Strategy
+27 (0) 11 797 4000
jonathan.x.metcalfe@pwc.com

Le Riche Burger
Africa Energy, Utilities and Resources – Hydrogen SME
Strategy
+27 (0) 21 529 2620
le.riche.burger@pwc.com

James Mackay
Africa South Market
Lead - Energy
Strategy
+27 (0) 83 447 9734
james.mackay@pwc.com

Kalane Rampai
Africa Consulting Leader
PwC Africa
+27 (0)11 797 5395
kalane.rampai@pwc.com

Ricardo Rosa
Africa Advisory Clients and Market Leader
PwC Africa
+27 (0)11 797 5602
ricardo.rosa@pwc.com

Andries Rossouw
Africa Energy, Utilities and Resources Leader
PwC Africa
+27 (0)11 797 4060
andries.rossouw@pwc.com

Wayne Jansen
Africa South Market Lead - Energy, Utilities and Resources Strategy
+27 (0)11 059 7209
wayne.jansen@pwc.com

Simon Venables
Head of Origination, Sub-Saharan Africa
PwC Africa
+27 (0)11 797 5660
simon.venables@pwc.com
Thank you