

Proposed South African Green Hydrogen (GH₂) Commercialisation Strategy

Summary of the Green Hydrogen Commercialisation Panel Report

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Preamble

- This Green Hydrogen Commercialisation Strategy (GHCS) builds on the strong foundation of the work undertaken by the Department of Science and Innovation (DSI) with respect to its HySA programme and the recent development and publication of the Hydrogen Society Road Map (HSRM)
- In June 2021 the Minister of Trade, Industry and Competition established the Green Hydrogen (GH₂) Commercialisation Panel
- The Panel consists of private and public sector champions in the potential green hydrogen value chain and is currently being co-ordinated by the Industrial Development Corporation of South Africa (IDC)
- The objective of the Panel is to specifically focus on the development of a South African Green Hydrogen Commercialisation Strategy and Action Plan
- The objective of this document is to present the proposed Green Hydrogen Commercialisation Strategy (GHCS) and Action Plan for South Africa.



GH₂ Commercialisation Summary (1/4) – Strategic Elements

The successful implementation of the commercialisation strategy will depend on the execution of the six key elements :

1 PRIORITISE EXPORTS	2 STIMULATE DOMESTIC MARKET	3 SUPPORT LOCALISATION	4 SECURE FINANCING	5 PROACTIVE SOCIO ECONOMIC DEVELOPMENT
Target exports of green hydrogen and green chemicals by leveraging on South Africa's proprietary Fischer Tropsch technology and utilising financing support mechanisms including grants, concessional debt and contract for difference / price subsidies to improve the financial viability of these projects	In parallel to the export strategy, develop projects along the value chain to stimulate demand for green hydrogen in South Africa. "Low hanging fruit" opportunities to be prioritised to provide confidence in the domestic market. Examples include green steel, hydrogen valley mobility programme and sustainable aviation fuel projects.	Develop local industrial capability to produce fuel cells, electrolyser, ammonia cracking and balance of plant equipment and components by leveraging on South Africa's PGM resources. Together with demand stimulation this will drive longer term GH ₂ price reduction allowing penetration in various sectors.	"Crowd in" and secure funding from various sources and in various forms including grants, concessional debt and contract for differences.	Maximise development impact (incl. skills and economic development and social inclusion). Ensure gender equality, BBBEE and community participation. Maximise job creation and alternative options for potential job losses.

6 **ROLE OF GOVERNMENT IN POLICY AND REGULATORY SUPPORT**

Position GH₂ as a key early contributor to decarbonization and a just transition in the country programme of work being collated by the JET-IP Task Team ensuring a fair proportion of climate finance is sourced to enable development of this industry.

Prioritize the execution of the green hydrogen commercialisation strategy and the development of a national GH₂ infrastructure plan

Drive the required policy and regulatory changes required to sustain long term growth of the new hydrogen industry.

Mobilise and coordinate the Government support required to support the development of this new industry for South Africa.

GH₂ Commercialisation Summary (2/4) – Government Actions

Summary of immediate actions to be taken by government



Presidency

- 1.1 Prioritise an in-depth analysis of required GH₂ regulatory framework.
- 1.2 Develop a programme to implement the required regulatory changes – i) Prepare a Regulatory Development Timeline; ii) Develop regulatory objectives for how the GH₂ industry should be regulated. iii) Develop a set of Regulations specifically aimed at creating enabling environment for GH₂
- 1.3 Fast track project regulatory approvals with support from the ISA office
- 1.4 Prioritise support of project applications to the H₂ Global organization



Presidency and DIRCO

- 2.1 Advocate for policies at EU level to support GH₂ development in RSA: namely
 - a) Extension of the time allowed to use hard to abate CO₂ for the production of Sustainable fuels with GH₂. The current EU directives allow use of CO₂ till 2036
 - b) Modify the current rules for emission allocation to product to allow for “flexible” allocation (and use of existing facilities)
 - c) Support global advocacy for unavoidable carbon for steel and Fischer Tropsch for a transition period.
- 2.2 Facilitate bilateral government to government agreements relating to off take of GH₂ derivatives



DMRE

- 3.1 Clarify the power planning regime for GH₂ power requirements and specifically differentiate between GH₂ grid tied projects and non-grid tied projects. With regards to specifically GH₂ grid tied projects, the IRP should align to the GHCS and make the necessary allocation for both wind and PV technology to enable the development of the new GH₂ industry.
- 3.2 Utilise section 19(1), subsection (f) of the National Energy Act to introduce incentives to promote the production, consumption, investment, research and development of renewable energy and green hydrogen.

GH₂ Commercialisation Summary (3/4) – Government Actions

Summary of immediate actions to be taken by government



DTIC

- 4.1 Attract investment into establishing equipment manufacturing facilities specifically for electrolyzers, fuel cells, ammonia crackers and balance of plant components along the hydrogen value chain in the country for both internal demand and export, with significant incentives (tax breaks, infrastructure support)
- 4.2 Develop and introduce GH₂ Standards and specifications.
- 4.3 Design and introduce a Guarantees of Origin system to install investor confidence in key import nodes. Engage with zaRECs Pty Ltd to explore expansion of current renewable energy certificate system to include GH₂.
- 4.4 Import duties: Exempt imported GH₂ equipment under Schedule 7 of the Customs and Excise Duties Act



National Treasury

- 5.1 Incentivize expedited private sector project investment, with specific focus on early export projects e.g. green methanol, aviation fuel, green ammonia and support local demand stimulation and localisation projects including mobility applications, green steel and equipment manufacturing.
- 5.2 Develop focused tax incentives on investment in GH₂ projects
- 5.2 Explicit Carbon Pricing: Phased approach to increase carbon tax rate or carbon fuel levy under the Carbon Tax Act and Customs and Excise Act
- 5.3 Implicit Carbon Pricing: Phased approach to remove fossil-fuel subsidies and reallocation of subsidies to GH₂ development.
- 5.4 Special Economic Zone and REDz incentives: Reduced corporate tax rate from 28% to 15%; accelerated depreciation allowance of 10% for buildings; VAT and customs relief; employment tax Incentives under SEZ Act.
- 5.5 Tax allowances: Apply Incomes Tax Act provisions to GH₂ (Sections 12L, 12B(1)(h), 12I, 12K, 11D, 11A, 12C, 13(1))



GH₂ Commercialisation Summary (4/4) – Government Actions

Summary of immediate actions to be taken by government



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

DSI

- 6.1 Drive innovation, RD&I and skills development
- 6.2 Together with dtic, support commercialisation of innovative products, processes and services that will reduce costs and enhance competitiveness of SA component production
- 6.3 Assist with management of patents and licenses, both local and foreign
- 6.4 Co-ordinate research on critical mineral value chains
- 6.5 Research and insights into chemical value chains to support sustainability and global competitiveness



higher education
& training
Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

DHET

- 7.1 Align to the identified skills and action plan in this commercialisation strategy
- 7.2 Co-create technical training courses to develop future skills requirement to support GH₂ and associated value chains
- 7.3 Focus on systems and design thinking to under-pin inter-related nature of GH₂ development
- 7.4 Co-ordinate funding and support for university programmes
- 7.5 Support and coordinate skills development in industry
- 7.6 Bring SETA funding at industry level
- 7.7 Funding support for GH₂ PhD projects, programmes and scholarships

GH₂ Commercialisation Summary (3/3) – Action Plan

1	2	3	4	5	6
Export Markets	Domestic Markets	Investment & Finance	Economic & Social Economic Development	Local industrial capability and participation	Just Transition
- Strategically position South Africa as a preferred and reliable provider to key markets, leveraging trade relationships and government support. - Secure global market and off-take with national procurement programmes such as H₂ Global. - Expedite export pilot projects to position South Africa as a serious global player and achieve early market entry. - Progress international strategy working with export promotion agencies.	- Introduce supportive policies and regulatory framework for GH₂ to aid price parity to increase domestic GH₂ demand. - Support demonstration projects in hydrogen mobility applications, specifically focused on Heavy Duty Fuel Cell Vehicles. - Demonstrate feasibility of GH₂ applications in industry including non-ferrous metals, green steel, cement and petrochemical industries for short term pilot projects and long-term commercialisation.	- Secure strong inflow of foreign direct investment and outflow of GH₂ exports by means of comprehensive incentive packages including tax incentives, grant schemes and reduced import surcharges on technology options. - Establish a regulatory and market framework to drive investment - Support a key set of “catalytic” infrastructure projects that frames the national GH₂ strategy, enabling private sector players while meeting Government’s objectives for inclusive economic growth. - Define government role's for financial investment and support for pilot projects to expedite and enable private sector investment.	- GH₂ can significantly contribute to achievement of South Africa’s revised Nationally Determined Contribution targets. - Focus on hard-to-decarbonise industrial sectors by aligning sectoral carbon budgets with GH₂ mitigation potential and financial support required for a just transition - Ensure integration of RE through a robust GH₂ sector and regulatory framework. - Extension of the HySA programme to support further R&D for innovation as a means of developing South Africa’s competitive advantage and supporting identified “deep dive” studies.	- Integrate the potential for industrialization of the RE manufacturing supply chain aligning to the masterplans for renewable energy, steel and automotive sectors as well as other relevant initiatives. - Create partnerships and joint ventures to secure investment in the local manufacturing of equipment and components in the GH₂ value chain including fuel cells, electrolyzers, ammonia cracker and balance of plant equipment. - Implement projects to develop skills and support localised industrialisation for key parts of the GH₂ value chain. - Invest and implement research and development programmes.	- Quantify the macro economic and socio economic impact and sustainability of GH₂ applications in industrial sectors to advise a socio-economic and just transition plan. - Develop GH₂ Socio-economic plan to enhance local content inclusion of SMME’s and entrepreneurs and empower previously disadvantaged groups. - Analyse and plan for a Just Transition, ensuring appropriate public and social dialogue and understanding. - Ensure appropriate training and skills development programmes as part of the Just Transition plan.

Presentation Outline

- 1 **Opportunity Statement**
- 2 The need for a Commercialisation Strategy
- 3 Demand-driven commercialisation
- 4 Competitive Supply
- 5 Strategic choices
- 6 Key Enablers
- 7 Commercialisation Roadmap



The Opportunity presented by Green Hydrogen for South Africa

The GH₂ economy presents new economic, skills, employment and community opportunities for South Africa



Global Opportunity

Hydrogen will play a significant role in the transition to a net-zero energy system.

It will establish SA as a future energy market global trader, securing foreign direct investment, earning foreign income and creating economic growth and development

Import Markets for GH₂ to 2050 will be the EU (2050: 11-15 Mt GHpa); Japan (2050: 5 to 10 Mt GHpa); South Korea (2050: 1.0 to 1.2 Mt GHpa) and the United Kingdom (2050: 0.5 to 0.7 Mt GHpa).



Competitiveness

South Africa's natural endowments of Land, Wind, Solar, Oceans and Green Minerals and existing Petrochemical base can be leveraged.

Together with innovations in the hydrogen sector, a robust financial system, globally recognised renewable energy programme and inclusion of GH₂ as a key element of the Government's energy transition plans

South Africa's clear differentiators are proprietary Fischer Tropsch technology and resources of platinum group metals (PGMs)



Just Transition

The just energy transition focuses on the transition of South Africa's energy sector as the country navigates the shift away from coal towards cleaner sources of energy

The just energy transition requires that the transition is equitable to all communities and is better for our people and planet.

Transitioning away from fossil fuels will require the training and re-skilling of communities reliant on fossil fuel industry.



Decarbonisation

- GH₂ will be the global clean fuel of the future and critical to SA decarbonising our economy and ensuring the competitiveness and sustainability of our industries.
- In a global Net Zero environment, "dirty" economies will increasingly be financially penalised
- GH₂ can decarbonize much more than RE alone by replacing fossil fuel inputs in industrial processes

South Africa's Green Hydrogen Value Proposition

A unique combination of resources and capabilities will enable South African to compete in multiple areas.

South Africa will differentiate itself by using proprietary **Fisher Tropsch technology** to target the **sustainable aviation fuel** market and using **PGM resources to target fuel cell, electrolyser and ammonia cracker manufacturing**.

Global leader in **Platinum Group Metals Mining**
(Platinum, Iridium and Rhodium)



Multiple water sources (from mining, sea and fresh water)



Renewable Energy endowments and a rapidly developing Renewable sector



Established petrochemical sector & technology base including **proprietary Fisher Tropsch technology** critical for power to liquids



Geographic positioning



Relatively well developed infrastructure



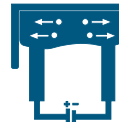
Export to EU, Japan, South Korea, UK



Decarbonization of local industry e.g. steel, petrochemicals, mining



Local and global sustainable mobility e.g. fuel cell buses, trucks and associated infrastructure



Manufacture of equipment and components e.g. fuel cells and electrolyser



Support the just energy transition that is equitable to all communities and is better for our people and planet.



Maximise development impact (incl. skills and economic development and social inclusion).
Ensure gender equality, BBBEE and community participation.

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A solid historical base supports accelerated commercialisation

1

2007

Development of the National Hydrogen and Fuel Cell Technology Strategy by the Department of Science and Innovation and approval by Cabinet

2

2008-2013

Demonstrator projects include an underground fuel cell powered mining locomotive, solar-to-hydrogen system, battery and fuel cell golf cart, fuel cell generator providing lights for the UWC Nature Reserve

3

2014-2016

Demonstrator projects include: fuel cells for power storage for homes and cellular phone tower base stations; a Hydrogen refueling station; and fuel cell powered forklift.

4

2017

Demonstrator projects include a Green Hydrogen fuel cell system with on-site production and storage and a Hydrogen in Mining test facility.

5

2018

Demonstration projects concluded for Hydrogen production, Liquid Organic Hydrogen Carriers and the use of PGM catalysts for the production of Hydrogen. HySA demonstrated a 2.5kW fuel cell system at Poelano Secondary School

6

2020

The DSI, Hydrogen SA and North West University initiate a process with the South African government to develop a Hydrogen Society Roadmap

7

JUNE 2021

Presidency announces that GH has been identified as the first of five 'Big Frontier' strategic investment opportunities

8

JULY 2021

The DTIC and IDC coordinated a joint approach to sector planning by establishing a Green Hydrogen Panel

9

SEPTEMBER 2021

Cabinet approves the Hydrogen Society Roadmap developed by the DSI

10

OCTOBER 2021

The drafting of the Green Hydrogen Commercialisation Strategy for South Africa was completed

11

NOVEMBER 2021

At COP 26 in Glasgow, Scotland, South Africa mobilizes funding support for the country's decarbonization

NCEDA releases GH Strategy at COP26

12

FEBRUARY 2022

The HSRM is released to the public marking a momentous milestone for South Africa's hydrogen industry development



Existing policies will be leveraged to support GH₂ industry development

1	National Development Plan	Advocates the transition to a low carbon and diversified energy system
2	White Paper on Renewable Energy Policy, 2003	Increased renewable energy contribution to the energy mix.
3	National Climate Change Response White Paper (2011)	Commitment to reduced emissions through a peak, plateau and decline trajectory.
4	Integrated Resource Plan (2019)	Increased contribution of renewable energy in the energy mix and potential longer term need for hydrogen for energy storage at large scale.
5	Beneficiation strategy for minerals industry of South Africa (2011)	Supports the development of technologies that locally beneficiate mineral resources for increased revenue earnings.
6	Green Transport Strategy for South Africa (2018)	Advocates for the deployment of electric vehicles including hydrogen fuel cell powered vehicles as a means for decarbonizing the transport sector.
7	National hydrogen and fuel cell strategy (HySA) 2008	Supports for the development of hydrogen and fuel cell technologies through the 15-year Hydrogen South Africa RDI programme
8	South African Economic Reconstruction and Recovery Plan	Supports the development of a new industry that will contribute towards job creation, economic growth and enhancing the role of SMEs.
9	South African Renewable Energy Master Plan (SAREM)	Supports the planning of renewable energy capacity required for GH ₂ production and for the localisation of equipment manufacturing in the renewable energy value chain

Commercialisation leverages the Hydrogen Society Roadmap

Hydrogen Society Roadmap

The strategy for Commercialisation, aligns with the objectives and outcomes of, and builds on the strong foundation of the Hydrogen Society Roadmap

Objectives

- Investment
- Reduced GHG emissions
- Just Labour transition
- Balance of payment
- Energy Security
- Reduced inequality and poverty

Outcomes

- Creation of export market for SA
- Decarbonisation of transport sectors
- Decarbonisation of energy-intensive industry
- Manufacturing sector for H2 products and excellence
- Green and enhanced power sector and buildings
- *Hydrogen generation storage and distribution linked to objectives, outcomes and levers of change



science & innovation

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GH₂ Commercialisation Strategy

Objectives

- Export Markets
- Domestic Markets (includes applications in hard to abate sectors and mobility)
- Local industrial capability (includes manufacturing of equipment)
- Investment and Finance
- Economic and socio-economic impact
- Affordability of a Just Transition
- Regulatory Environment

Enablers

- Skills development
- Financing
- Policy and Regulation
- Catalytic projects



the dtic

Department:
Trade, Industry and Competition
REPUBLIC OF SOUTH AFRICA



The roadmap for commercialisation provides detail and granularity differentiating between short and long term actions by public and private sectors

Specific actions identified in the following areas:

70

- Establish Targets and Policy Signals
- Mitigate Investment Risk
- Harmonize standards and remove barriers
- Strategic demonstration and deployment projects
- Promote RDI
- Skills development and public awareness
- Support demand creation
- **Development of a national commercialisation strategy**

Specific actions identified in the following areas:

257

- Skills and R&D
- Regulations and Policy
- Finance
- Technology Partners
- Raw Materials
- Masterplan
- Foundation for projects
- Hydrogen Hubs
- Additional project development
- Mobility projects
- Manufacturing projects
- Material handling projects
- Stationery and back up power projects
- Refueling and Distribution
- Production / Industrialisation / Manufacturing
- GH₂ Beneficiation and Export

The Commercialisation Strategy in Summary

Role of a commercialisation strategy ...

- National coordination / shared vision
- Provide policy certainty
- Encourage investors
- Guide decision makers (government, private)
- Ensure proactive industry development



... to achieve Strategic Objectives

- Secure early positioning for global export market share & competitive trade position;
- Establish domestic markets in mobility applications and hard to abate sectors;
- Secure foreign direct investment and low-cost green finance;
- Maximise Economic and Socio-Economic development benefits;
- Create an enabling policy and regulatory environment to sustain the long term growth;
- Support Local industrial capability and participation and
- Ensure a Just Transition

Vision

Developing a globally competitive, inclusive and low carbon economy by harnessing South Africa's entrepreneurial spirit, industrial capability, strong financial sector and natural endowments

Strategic Pillars

1	2	3	4	5	6
EXPORT MARKET	DOMESTIC MARKET	INVESTMENTS & FINANCE	ECONOMIC DEVELOPMENT	LOCALISATION	JUST TRANSITION
Secure global market share and competitive trade position	Decarbonise SA economy; energy security and reliability	Mobilise foreign direct investment, domestic funding and low-cost green finance	Maximise development impact (incl. skills and economic development and social inclusion)	Establish local production facilities for both fuel cell, electrolyzers and ammonia cracker equipment / components	Maximise job creation and alternative options for potential job losses
Global exports potential ranges between 4 to 8 mtpa	Domestic market for GH ₂ has the potential to range between 2 to 6 mtpa	Secure grants and concessional debt from e.g. KfW and contract for difference from H2 Global	Ensure gender equality, BBBEE and community participation		Realise opportunities to create 650,000 new jobs across the value chain
7					
POLICY & REGULATORY					

Clear enabling environment with stimulating policies.

Additional actions to be taken by government

1. Strategy	1.1 Position GH ₂ as a key early contributor to decarbonisation and a just transition in the country programme of work being collated by the Climate Deal Task Team ensuring a fair proportion of climate finance is sourced to enable development of this industry.	1.2. Expedite International GH ₂ National Strategy with international partners (finance, technical, off-take)	1.3. Set up a single GH ₂ governance mechanism to coordinate public sector and support private sector investment.	1.4. Prioritise the development of a national Infrastructure Plan, including undertake land/ corridor appraisal assessments for dedicated renewables and electrolysis.	1.5. Design and introduce a Guarantees of Origin system to install investor confidence in key import nodes.
2. Industrialisation	2.1. Conduct a detailed PGM potential market study, Including local CCM/MEA manufacturing opportunities.	2.2 . Establish relationships with OEMs to attract anchor partnership for investment in SA (electrolysers).	2.3. Develop clear sector coupling plans and techno economic planning of sector impact and transition costs	2.4. Invest in R&D opportunities to advance localisation of specialised skills.	
3. Projects	3.1 Incentivize expedited private sector project investment, with specific focus on early export projects e.g. green methanol, aviation fuel, green ammonia	3.2. Support local demand stimulation and localisation projects including mobility applications, green steel and equipment manufacturing.	3.3 Support development of both coastal and inland port development for green hydrogen	3.4. Develop GH ₂ standards and specifications for mobility, production, refueling, storage, transportation and end-use applications based on international best practice standards.	
4. Finance	4.1. Apply for GH ₂ funding from International green funds and South Africa investment support to meet GH ₂ production of 200 ktpa by 2025/2026.	4.2. Structure/ support green financing instruments and innovative funding with private sector for GH ₂	3. Build up investment fund to prioritize and enable government investment into initial projects.		
5. Skills & R&D	5.1. Develop GH ₂ Socio-economic plan to enhance local content inclusion of SMME's and entrepreneurs.	5.2. Engage with training partners and tertiary institutions on GH ₂ training			

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Demand-driven Commercialisation: Market focus

A range of local and export use cases can anchor demand for GH₂ in South Africa

	Application Hydrogen and derived product use	Application Key Configuration				Long-term competitiveness Considered in demand scenario		Potential end-users in SA (non-exhaustive)
Industry	Ammonia production	H ₂	NH ₃	MeOH	C _x H _y	Feedstock	✓ For own demand and export	
	Methanol production	H ₂	NH ₃	MeOH	C _x H _y	Feedstock	✓ For own demand and export	
	Refineries	H ₂	NH ₃	MeOH	C _x H _y	Feedstock	✓ Potential decarb. of PetroSA	
	Steel	H ₂	NH ₃	MeOH	C _x H _y	FC/Comb.	✓ For local steel industry	
	High-Temp Process	H ₂	NH ₃	MeOH	C _x H _y	Combustion	✓ For local glass industry	
Mobility	Light Road	H ₂	NH ₃	MeOH	C _x H _y	FC	✗ BEV assumed dominant alternative	
	Heavy Road	H ₂	NH ₃	MeOH	C _x H _y	FC	✓ FCEV in commercial and public transport HDV as dominant tech	
	Off-highway	H ₂	NH ₃	MeOH	C _x H _y	FC	✓ FCEV in commercial HDV as dominant tech	
	Rail	H ₂	NH ₃	MeOH	C _x H _y	FC	? Potentially relevant (e.g., to replace diesel gen. where grid power unavailable)	
	Shipping (Ocean)	H ₂	NH ₃	MeOH	C _x H _y	FC/Comb.	✓ Ammonia for long-distance maritime shipping fuel demand	
	Aviation (International)	H ₂	NH ₃	MeOH	C _x H _y	Combustion	✓ Green kerosene to meet aviation fuel demand	
Power & Heat	H ₂ adapted turbines	H ₂	NH ₃	MeOH	C _x H _y	FC/Comb.	? As part of last mile decarbonisation of power	
	Backup power	H ₂	NH ₃	MeOH	C _x H _y	FC/Comb.	✗ Assumed negligible	
	Long/mid storage	H ₂	NH ₃	MeOH	C _x H _y	FC/Comb.	? As part of last mile decarbonisation of power	
	Grid blending (heat)	H ₂	NH ₃	MeOH	C _x H _y	Combustion	✗ Assumed negligible	

1. Indicative example of long-term (2050) cost competitiveness of presented green techs but relevant to all categories, P2G power to gas, P2L power to liquid | Source: BCG
 2. Efficiency improvements not included here,

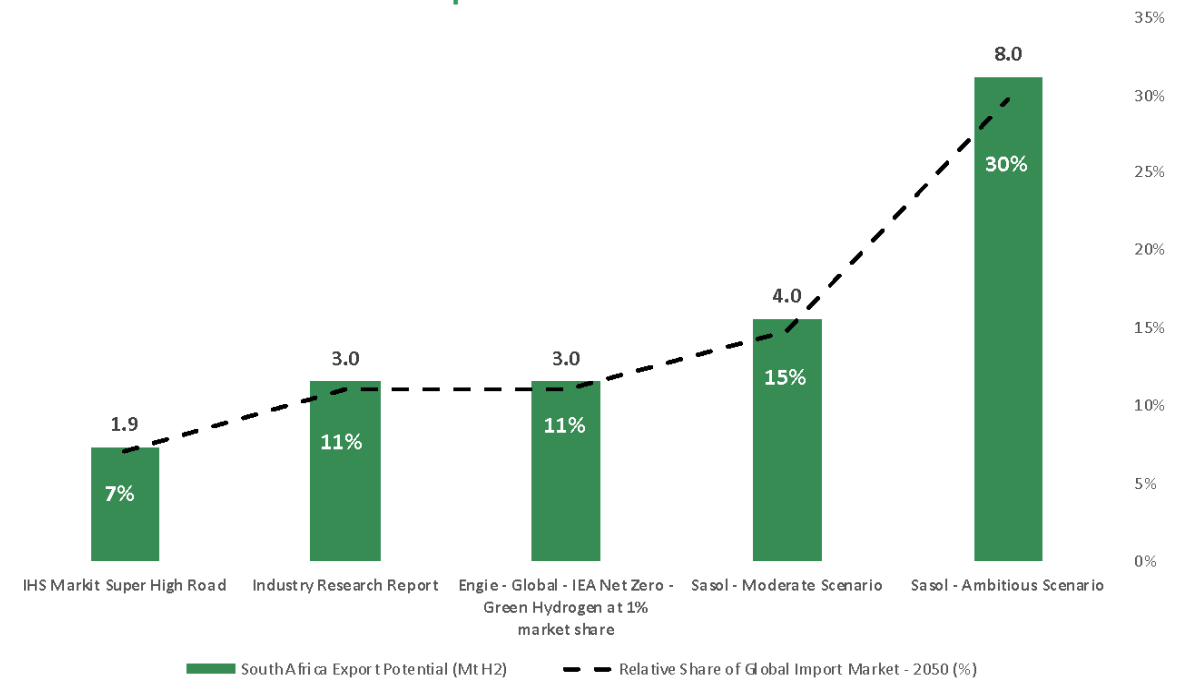
Demand-driven Commercialisation: Exports

South Africa will have to secure a long term global market share and competitive trade position against competition from other exporters. Export potential is estimated at 2mtpa by 2040 with upside to be as high as 8mtpa in longer term.

- Global Market for GH₂ is forecast to be 300-320 Mt GH₂ by 2050 using the benchmark International Energy Agency's (IEA) Net Zero GH₂ Scenario to 2050.
- There is potential for 91% of this demand (279 Mt GH₂) to be met within the country or region of demand, with the balance of 9% (27 Mt GH₂) sourced through imports.
- Import Markets for GH₂ to 2050 will be the European Union (2030*: 10 mtpa); Japan (2050: 5 to 10 mtpa); South Korea (2050: 1.0 to 1.2 mtpa) and the United Kingdom (2050: 0.5 to 0.7 mtpa).
- **Export Potential:** South Africa is well positioned for global exports with estimates of the potential ranging between 1.9 to 8.0 Mt GHpa. Positioning on the Indian and Atlantic shipping routes could enable 8-10% market share of the global ammonia / methanol fuels market for shipping, equivalent to a further 0.8 to 1.0 Mt per year of GH₂.

* Based on the REPowerEU plan (18 May 2022), Europe has increased GH₂ demand projections planning to import 10mtpa by 2030 which was previously planned for 2050.

South Africa - Export Market Assessment Based on Share of Global Import Market

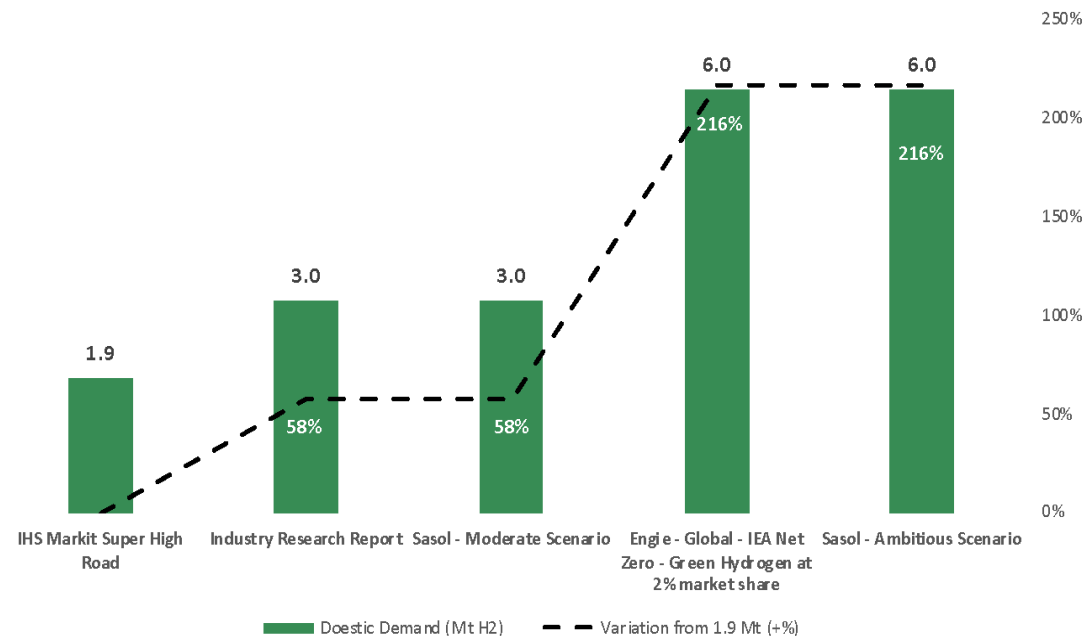


Demand-driven Commercialisation: Domestic Market

Domestic demand will accelerate as price parity gets closer to fossil fuels. Co-located production projects (eg. Mining sector) will have accelerated commercial value due to lower infrastructure and supply chain dependencies and hence lower cost. Domestic potential estimated at 2 - 3 mtpa by 2040 with upside as high as 6mtpa

- Domestic Market: The domestic market for GH₂ has the potential to range between 1.9 to 6.0 Mt GHpa.
- South Africa's potential to move higher on the range is price sensitive and will require specific co-ordination and intervention between the public and private sector to ensure higher efficiency at scale.
- Broader domestic penetration will take longer due to affordability but co-located projects have expedited commercial benefits due to lower infrastructure cost and dependencies
- **Affordability considerations:**
 - Considering GH₂ production cost at 2025 is estimated at \$6/kg, which will be 55% more expensive than Diesel (R17,28/l) and 111% more expensive than Eskom (R1.28/kwh) without considering transition costs for users and applications.
 - Accelerating price parity will be a combination of GH₂ cost and fossil fuel carbon taxes. Even if energy price parity is achieved (estimated by 2030) the total cost of transition must be considered per sector.

South Africa - South Africa - Domestic Market Assessment



Presentation Outline

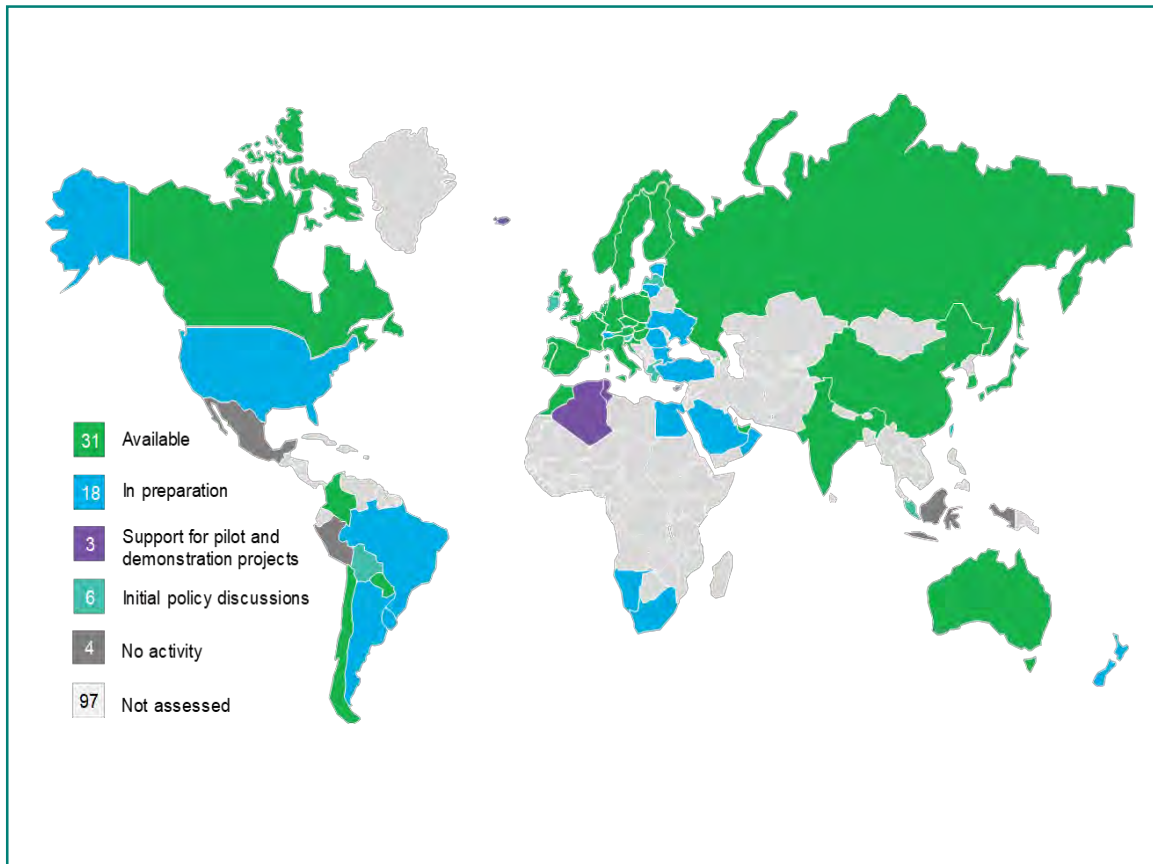
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Competitive Supply: Global developments

Globally countries and private companies are developing strategies for the commercialisation of the sector.

Global hydrogen strategies

Source: Bloomberg NEF, 16 June 2022



- More than 30 countries have published a hydrogen strategy and over 200 hydrogen projects have been announced with governments committing to over \$70 billion in public funding
- Themes of strategies:
 - Early investment support to scale assets and infrastructure required to meet desired targets
 - Opportunities for sector-coupling.- optimising gas and electricity infrastructure to deliver low-cost GH₂
 - Seeding local market focus areas; including setting of national standards and priorities
 - Commercial model assessment inclusive of opportunities and the role of the state
 - Policy and detailed regulatory frameworks
 - Focus on Research and Development to improve technologies and identify initial projects
 - A social licence assessment – looking at the holistic impact of the new GH₂ market
 - International strategies on partnerships, including bi-lateral MOU's and agreements



Competitive Supply: South Africa's competitive advantages

South Africa is well positioned to produce GH₂ thanks to three structural competitive advantages



SA with large scale,
high quality RE potential

- **Power sector decarbonization alone requires ~150GW of solar PV and wind** installed capacity by 2050
- **Green H₂ opportunity will need additional ~100GW of RE capacity** (with 2-10GW by 2030)
- **REDZ¹ alone can hold 900+ GW** RE capacity with premium load factors
- **Average load factors in SA amongst the best in the world** and on par with major competitors like Chile, Saudi and Australia



Sufficient land and synergies
in solving for water security

- Just **1% of SA land area** (1.1MHa) would be sufficient to produce **10Mt of green H₂**
- **SA with vast land available**, with ~5.4 MHa in REDZ alone (areas not in competition with agriculture or settlements)
- **Reducing water requirement** (10Mt/yr. of green H₂ production is only 31% of current power sector use in coal-based generation), **and increasing water security** making financially viable desalination plants at the coast (desalinated water cost is a fraction of a premium commodity like GH₂ - ~\$0.01/kg H₂)

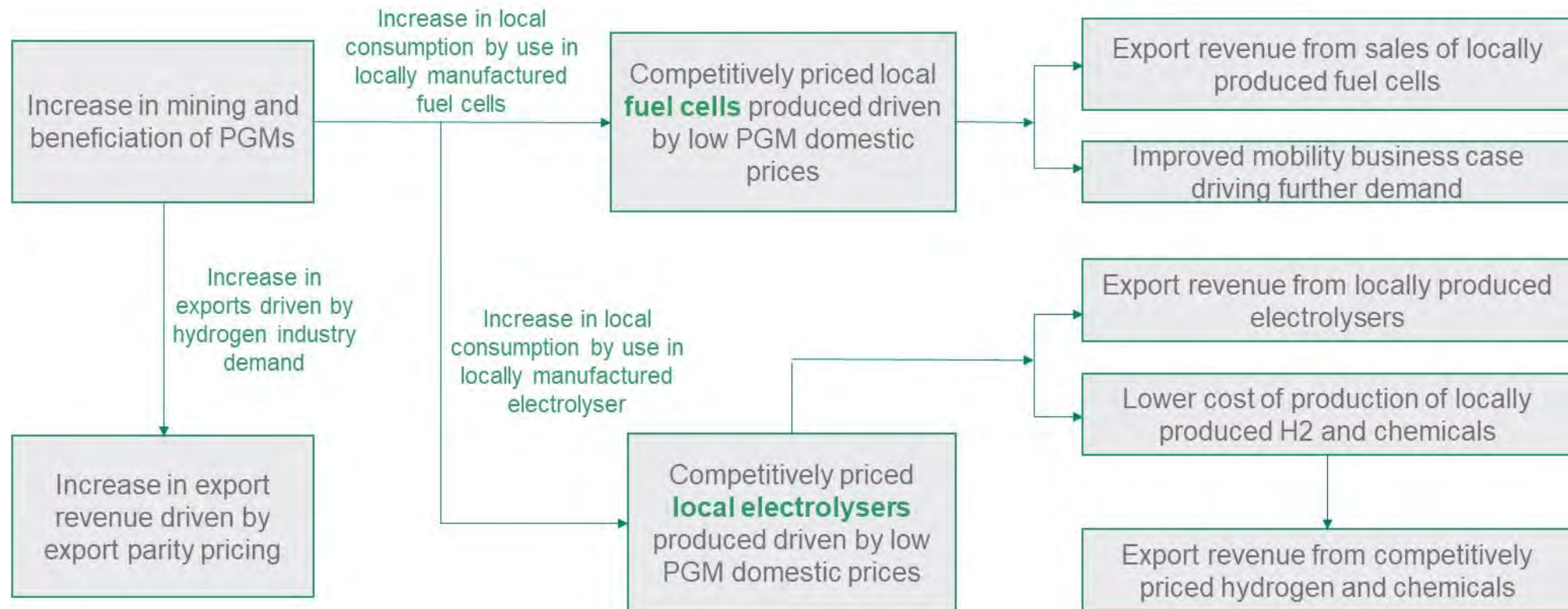


Unique expertise for
beneficiation into e-Fuels

- **Proprietary Fischer-Tropsch tech**—lacking in other countries (critical for Power-to-Liquid)
- **Existing assets and knowledge** (e.g., multiple Fischer Tropsch and steel facilities) allow for local beneficiation of green H₂ and enhances potential for large scale local demand
- **Opportunity to capture portion of global export market** for e.g., green ammonia/methanol/jetfuel

Competitive Supply: PGMs

Increase demand for PGMs driven by the global Hydrogen Industry will enable South Africa to take advantage of both export market and local consumption

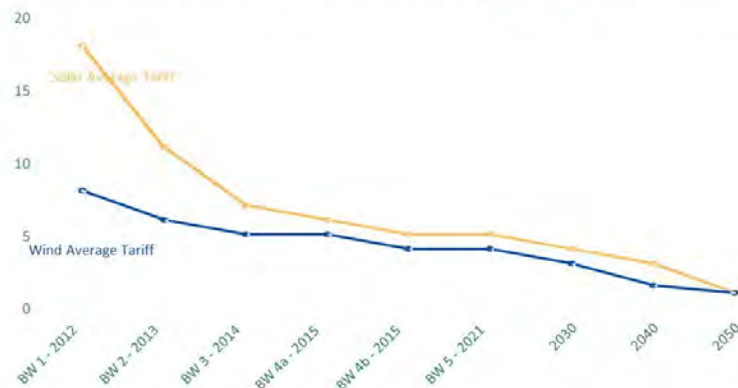


Competitive Supply: Cost of production drivers

Hydrogen is currently not cost competitive when compared with other sources of energy but it is globally anticipated that the cost will reduce to facilitate improved competitiveness

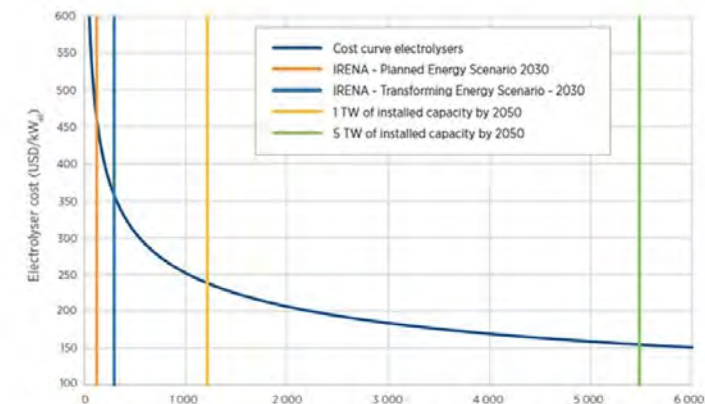
Renewable Energy Power Prices declined 67% for Solar and 49% for Wind since 2012

Renewable Energy Price - Bid Window (BW) 1 to 5 (US\$ cents)



Between 2011 and 2021, four Bidding Windows through competitive tenders resulted in more than US\$ 20 bn (R320 bn) of investment in renewable energy generation capacity,

Learning rates and investment in technology will see similar price declines for electrolyzers



Potential cost decrease for electrolyzers based on learning rates and costs achieved by deployment in IRENA scenarios 2030 to 2050.

Source: International Renewable Energy Agency (IRENA) Analysis

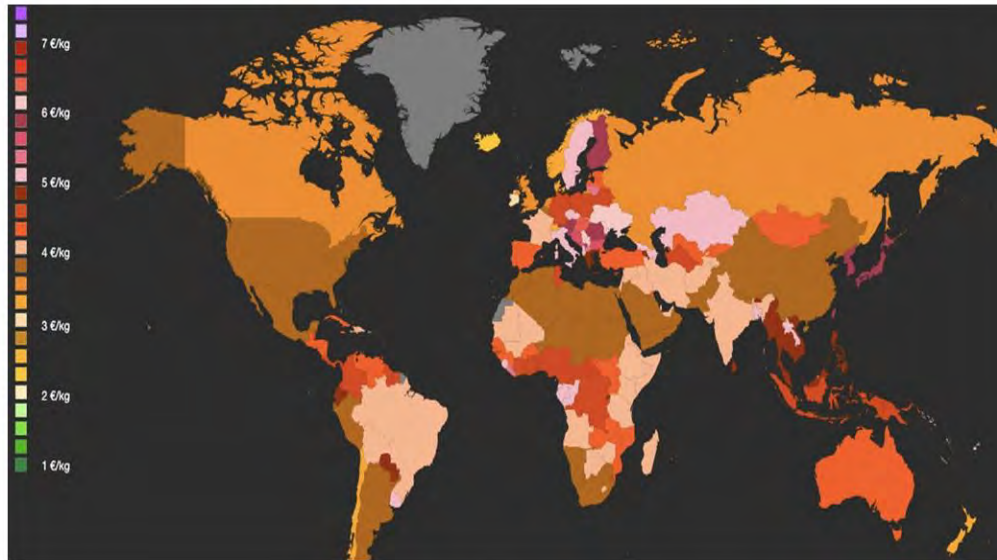
- A combination of cost reductions in electricity and electrolyzers, together with increased efficiency and operating lifetime, has the potential to deliver 80% reduction in hydrogen cost over time
- Targeting projects with scale will contribute to equipment cost reductions by aggregating demand

Competitive Supply: South Africa's long term cost of production

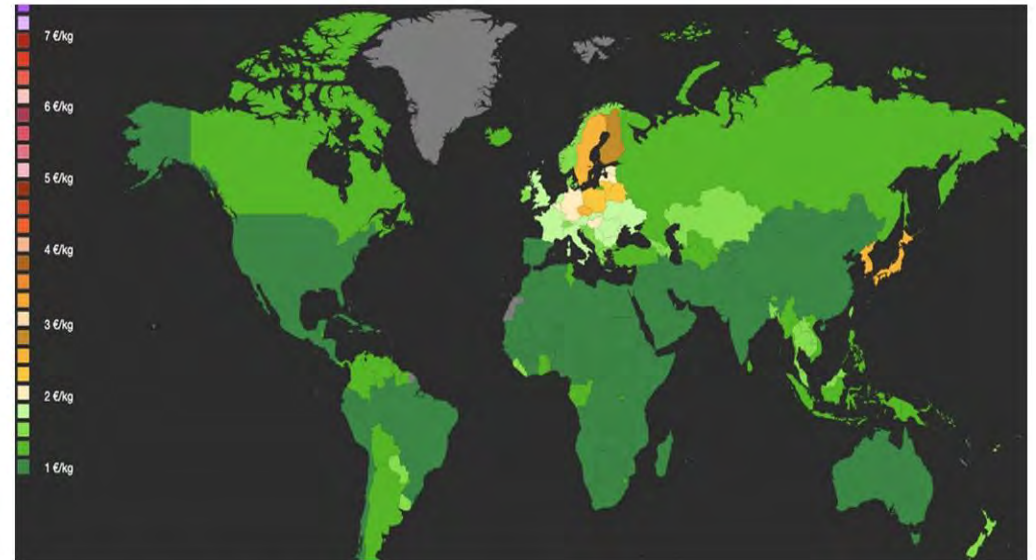
SA GH₂ could approach the \$1/kg GH₂ mark by 2050, equivalent to indigenous low cost energy, making South Africa **one of the competitive industrial economies**, however South Africa will differentiate itself by using proprietary Fisher Tropsch technology to target export of sustainable aviation fuel and will manufacture electrolyzers and fuel cells using PGMs available locally

Levelised Cost of Hydrogen (LCOH) comparable with the lowest cost producers in the world

Global Green Hydrogen Pricing - 2025*



Global Green Hydrogen Pricing - 2050*



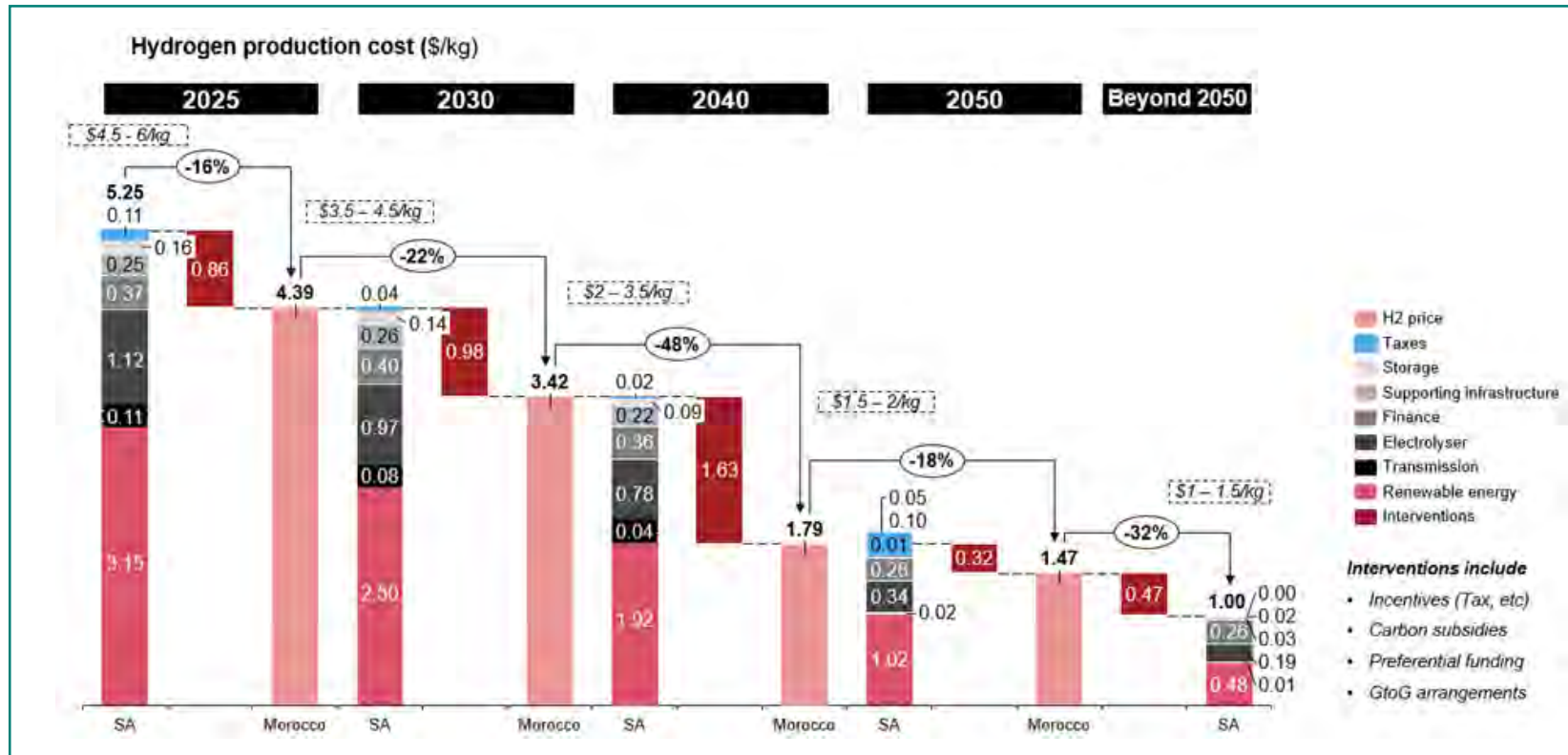
*PwC research (2021) | based on an analysis of various renewable energy sources and electricity generation / hydrogen equipment cost reductions worldwide

- Although far from the GH₂ importing markets in Europe and Asia, South Africa has the potential to make up the cost differential through greater efficiency and government support programmes.
- In 2025, the initial focus will be on the export of GH₂ at competitive prices as domestic use will not have reached commercial parity with local fuels. As GH₂ prices decline, a broader domestic transition will unfold.

Competitive Supply: Project Support Mechanisms

The cost reduction path can be influenced by a number of levers including taxes, supporting infrastructure, funding costs, electrolyser and transmission costs. Development of a detailed master plan and integrated value chain design will ensure our GH₂ development remains globally cost competitive

Measures to Improve Competitiveness and Possible Effects on Price (2030 - 2050)

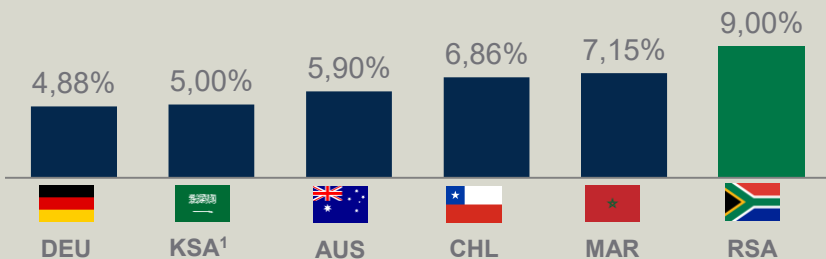


- South Africa will face significant competition for the European Union market from Morocco and Ukraine, who have already announced EU initiatives for GH₂, as well as Russia and Iceland. Namibia, due to its historical ties to Germany, will also compete with South Africa.
- Focusing on the hydrogen-supportive policies and creating a regulatory framework that encourages cost competitiveness will allow South Africa to play to win in the global GH₂ landscape.
- The graph indicates the different cost component levers that could facilitate improved competitiveness for South Africa, if compared to Morocco

Cost of capital as a means of comparative advantage

Cost of capital in South Africa is a key constraint that if addressed can provide a comparative advantage

Cost of capital comparison¹

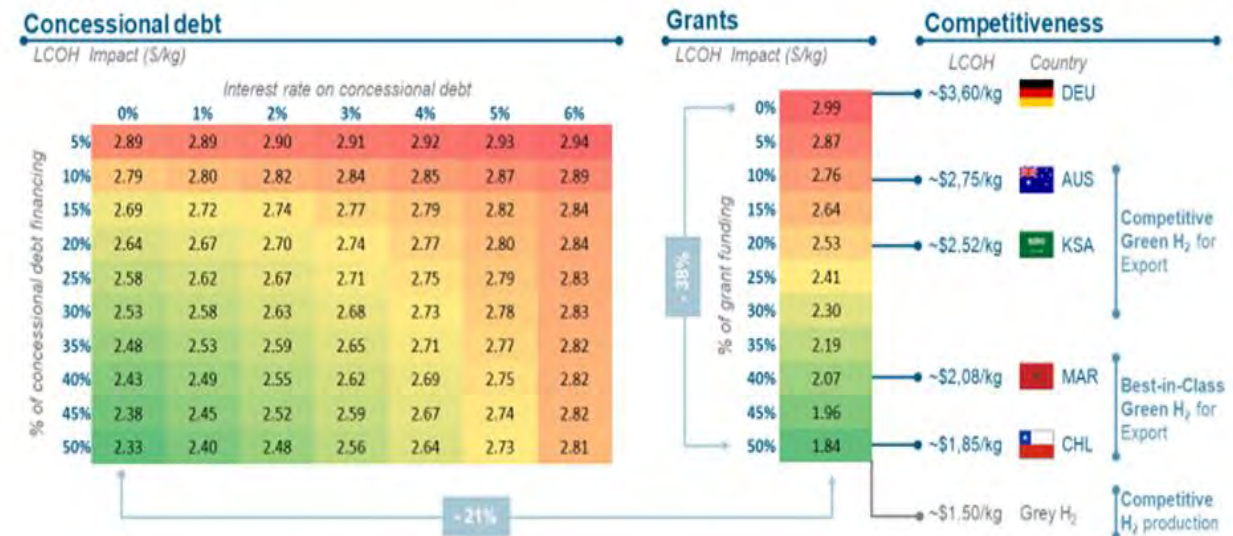


¹ Based on a bottom up calculation from first principles using a mixture of debt and equity. German and KSA assumed highly leveraged and the remaining countries medium leverage.

Three financing instruments are needed to improve the financial viability of projects:

- Grants: Decreases total capital burden of a project to produce H₂
- Concessional debt: Varies project WACC which acts as a discount rate
- Contract-for-Difference: Price difference between green hydrogen / chemicals and conventional grey hydrogen / chemicals will be subsidized

Analysis shows grants have a greater impact than concessional debt with both able to improve a project's competitiveness to be in line with Australia and Saudi Arabia. However, a significant portion of grants compared to the total capital stack is required to achieve competitiveness compared to countries with best-in-class load factors for example Chile and Morocco. Expectations are that initial off takes to Europe can attract premium prices and these off takers will be looking for a diversity of supply



Typical project funding support requirements

Analysis for a typical 200MW build with a CAPEX requirement of \$440m indicates that grant, concessional debt and contract for difference (e.g. H2 Global) will be required for each project

To ensure a minimum level of competitiveness for a single project requires blended funding. However, to be competitive with best-in-class green export for a typical 200MW installation, a \$440m project will require increased grant funding availability (\$110m – \$130m). Therefore, additional financing is required if a portfolio of projects is to be supported and made globally competitive.

Short term grant funding projections*

Based on South Africa's targeted production volumes it is estimated that between \$250m to \$3.25bn in grant funding will be needed to become a best in class GH₂ exporter

2025 – \$ 1bn total capex required and \$250m*** in grants

2030** – \$ 13 bn total capex required and \$3.25bn*** in grants

*this assumes a typical \$440m projects needs at least 25% grant component in addition to concessional debt and contract for difference

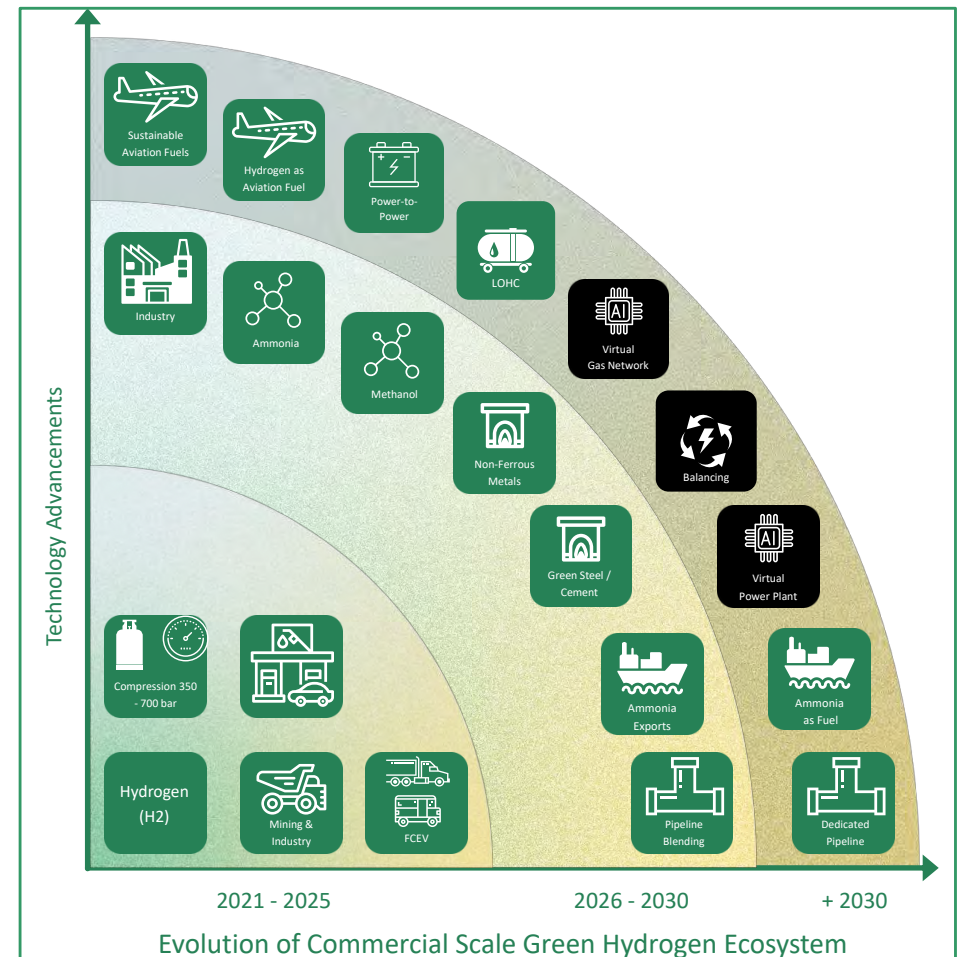
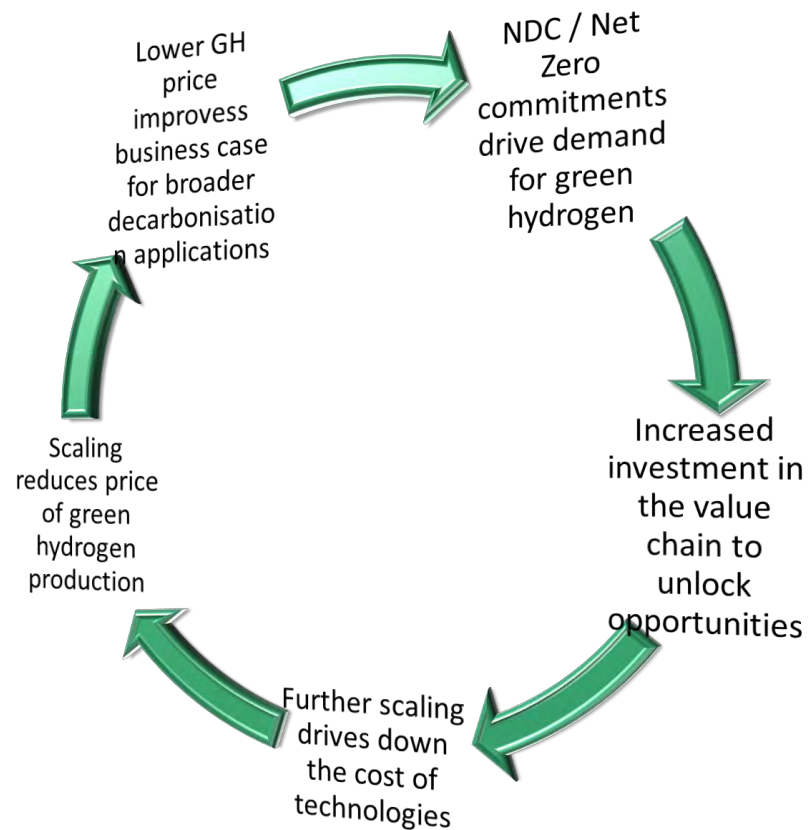
** - beyond 2030, cost of production is expected to decrease, lowering the need for grants. Projects would need to be globally competitive without grants.

***If premium prices can be locked in, this will reduce the grant requirements

	Grants	Debt	Rate
 funding pool	~25	~200	
 Competitive Green H ₂ for Export	0	~65-220	0-5%
	~25	~25-65	0-6%
	~45	0	NA
 Best-in-Class Green H ₂ for Export	~110	~130	0%
	~130	~65-110	0-3%
	~180	0	NA
 Competitive H ₂ production	>220	NA	NA

Demand-driven Commercialisation: Value Chain Focus

Declining GH₂ prices will unlock opportunities across key sectors to decarbonise industry



Presentation Outline

- 1 Opportunity Statement
- 2 The need for a Commercialisation Plan
- 3 Demand-driven commercialisation
- 4 Competitive Supply
- 5 Strategic choices**
- 6 Key Enablers
- 7 Commercialisation Roadmap



Strategic Choices

In order to facilitate accelerated commercialisation certain strategic choices will have to be made including:

- i. Targeted volumes
- ii. Market focus and sequencing
- iii. Supply Location Archetypes
- iv. Spatial focus
- v. Localisation
- vi. Social inclusion & development impact
- vii. Maximisation of benefits and the minimisation of costs

Strategic Choices: (i) Projected Production Growth Path

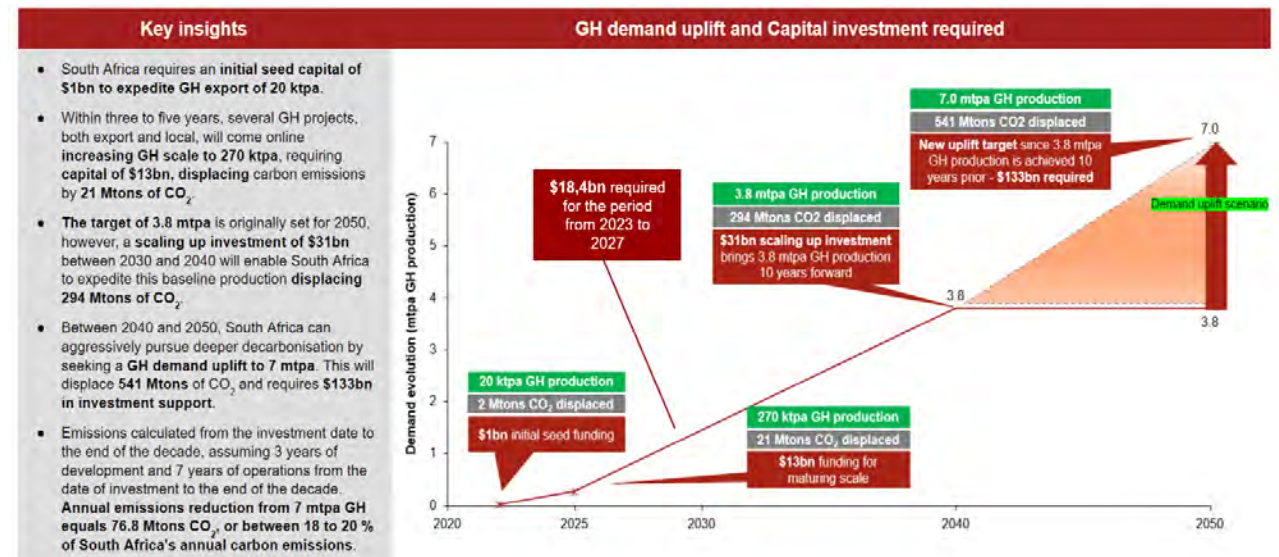
Long term growth aspirations could exceed 7mtpa of production by 2050

- \$1bn investment could expedite GH₂ export of 20 ktpa.
- Within three to five years, several GH₂ projects, both export and local, will come online increasing GH₂ scale to 270 ktpa, requiring capital of \$13bn, displacing carbon emissions by 21 Mtons of CO₂.
- The target of 3.8 mtpa by 2040 will require total investment of \$164 bn by 2040.
- Between 2040 and 2050, South Africa can aggressively pursue deeper decarbonisation by seeking a GH₂ demand uplift to 7 mtpa. This will displace 541 Mtons of CO₂ and increase investment support to \$133bn.
- Emissions calculated from the investment date to the end of the decade (assuming 3 years of development and 7 years of operations) could result in annual emissions reduction of between 18 to 20 % of South Africa's annual carbon emissions.

PRODUCTION TARGETS

YEAR	2025	2030	2040	2050
TARGET	20	1.0	3.8	7
UNITS	ktpa	mtpa	mtpa	mtpa

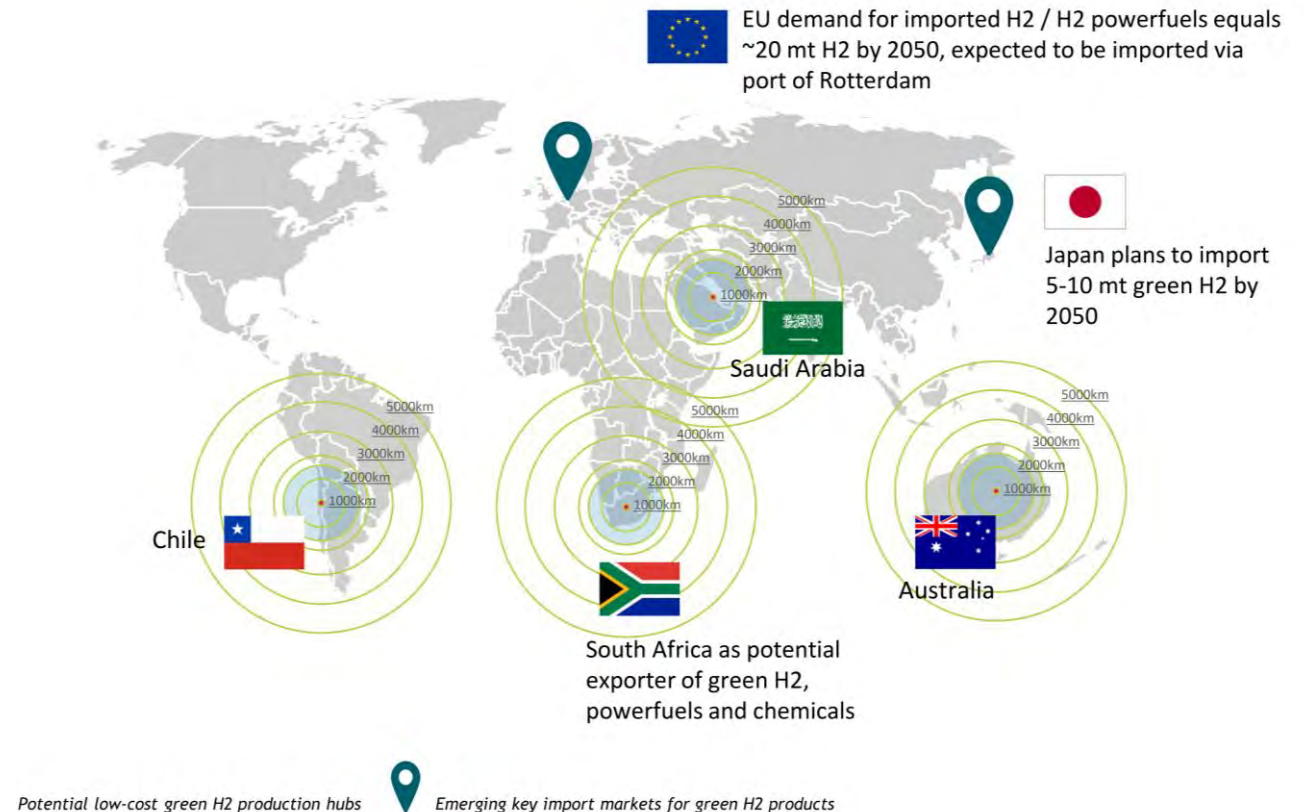
GH₂ demand uplift and Capital investment required



Strategic Choices: (ii) Market Focus - Exports

Significant additional GH₂ demand could arise from supply of GH₂ products to Europe and Japan where imports of 25-30mt GH₂ is expected by 2050

- **Import Markets** for GH₂ to 2050 will be the European Union (2050: 11-15 Mt GHpa); Japan (2050: 5 to 10 Mt GHpa); South Korea (2050: 1.0 to 1.2 Mt GHpa) and the United Kingdom (2050: 0.5 to 0.7 Mt GHpa).
- **Export Potential:** South Africa is well positioned for global exports with estimates of the potential ranging between 1.9 to 8.0 Mt GHpa. Positioning on the Indian and Atlantic shipping routes could enable 8-10% market share of the global ammonia / methanol fuels market for shipping, equivalent to a further 0.8 to 1.0 Mt per year of GH₂.



Source : NBI BUSA BCG, October 2021, "The green H2 opportunity in South Africa"

Strategic Choices: (ii) Market Focus – Domestic Market

GH₂ Vision will progressively unfold penetrating multiple markets

**2023 to
2025**



Mining & Industry

Road transport, primarily Fuel Cell Vehicles (FCVs) with a focus on Heavy- Duty Vehicles (HDVs). Pilot projects already underway including hydrogen-powered trucks (Anglo Platinum's Mogalakwena mine), the Hydrogen Valley (835km industrial and commercial mobility corridor) and Sasol and Toyota South Africa Motor's partnership exploration of a mobility ecosystem.

**2025 to
2030**



Industry

Chemical and Industry, notably the non-ferrous metals, green steel, and cement sectors, which will need to decarbonize to remain globally competitive. Early opportunities in Green steel are under consideration.

**2028 to
2030**



Methanol

Green ammonia and methanol, which will replace current production from high carbon techniques. Ammonia is widely traded globally and regarded as an attractive transport vector for exporting and trading in green hydrogen.

2030



Sustainable Aviation
Fuels

Sustainable aviation fuel offers an opportunity to decarbonise air travel.

+ 2030



Balancing

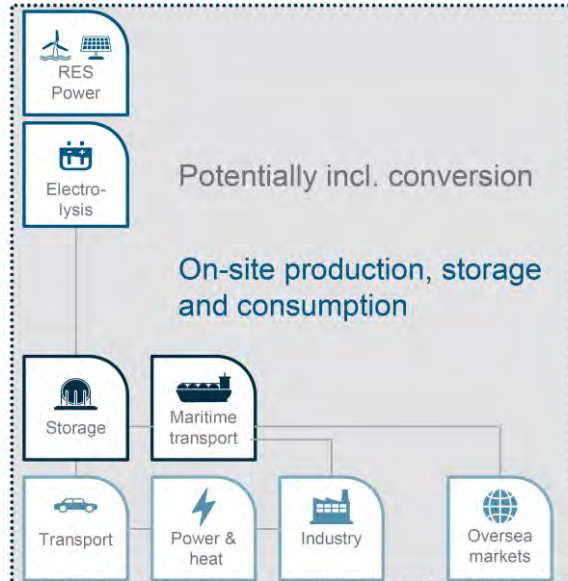
Power Storage and Balancing - Hydrogen being used for long-duration storage based on daily, monthly, and cross-seasonal balancing requirements.

Strategic Choices: (iii) Supply Location Archetypes

Three supply archetypes need to be considered for meeting SA's future GH₂ demand. Selection of the optimal archetype configuration across SA will require a coordinated infrastructure approach to build long term national competitive advantage

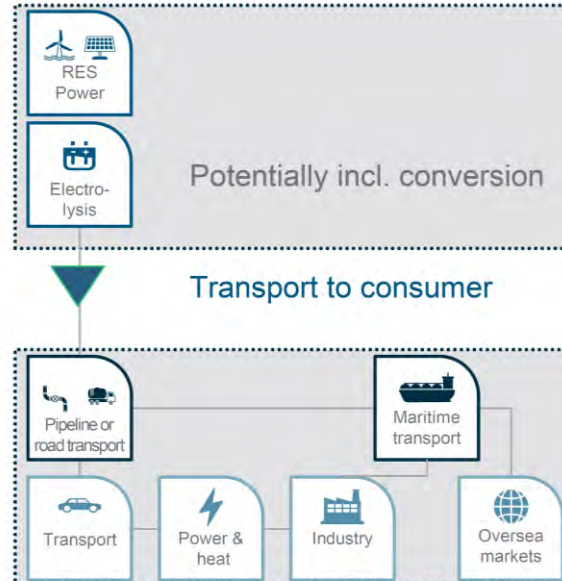
1 Co-locate RE and electrolyser with demand

On-site co-located power generation & GH₂ production ¹



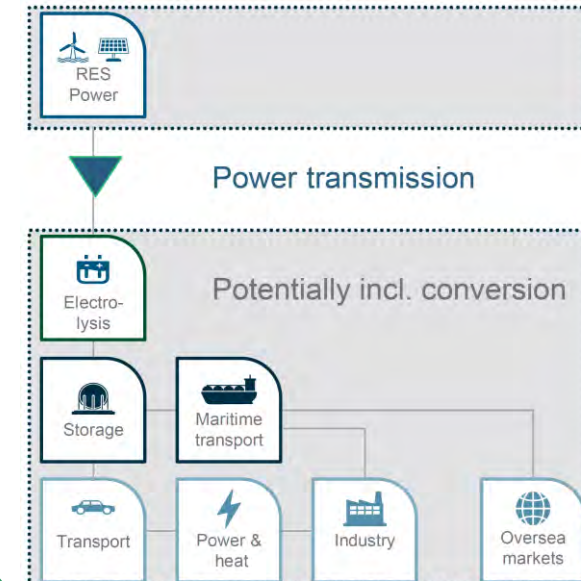
2 Decentralise RE and electrolyser (pipeline)

Decentral co-located power generation and GH₂ production (GH₂ molecule piped to demand centre.)



3 Decentralise RE, co-locate demand and electrolyser (wheeling)

Decentral power generation and on-site GH₂ production (power wheeled across grid to electrolyser)



1. RE and Electrolyser within 50-100km radius. 2. Ability to ensure power source for GH₂ production is completely green. Source BCG Analysis

Source : NBI BUSA BCG, "The Green H₂ opportunity in South Africa", October 2021

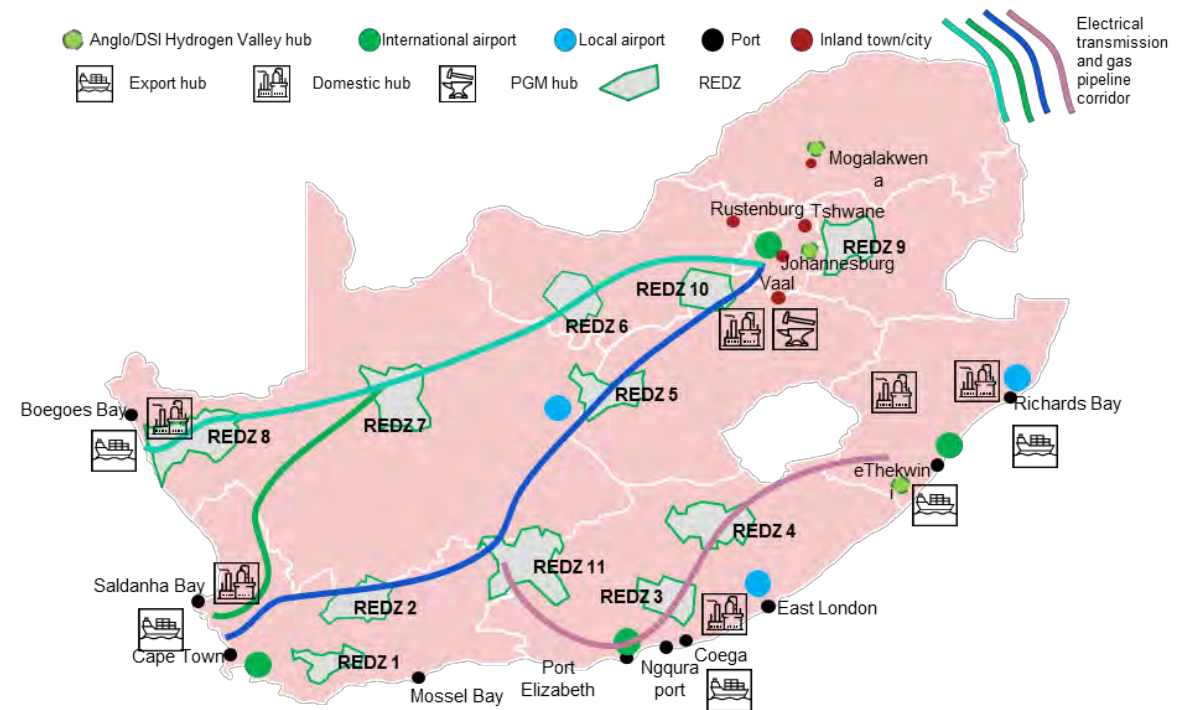
Strategic Choices: (iv) Spatial Considerations

South Africa has prioritized Hubs, Zones and Ports for Renewable Energy development and investment.

The REDZ zones are wide enough to include gas pipelines

- Hydrogen generation projects need to be located in areas with the best RE resources and when produced at scale, major hydrogen pipelines can be justified to transport hydrogen to demand nodes.
- The co-location of value chain players at GH₂ hubs could drive innovation, efficiency and economies of scale.
- Export projects are best placed near coastal ports in REDZs
- Equipment manufacturing projects are best located in SEZs to take maximum advantage of SEZ incentives
- Refueling infrastructure for mobility projects are best placed near transportation routes
- Location of GH₂ production projects required for demand centers not in close proximity to REDZs should be assessed on a case-by-case basis considering the 3 archetypes
- The cost associated with transportation of molecules or electrons need to be weighed against the difference in load factors between the demand centre and nearest REDZ.
- Locations able to aggregate demand are a further key consideration.

South Africa - Hubs, REDZs and Ports



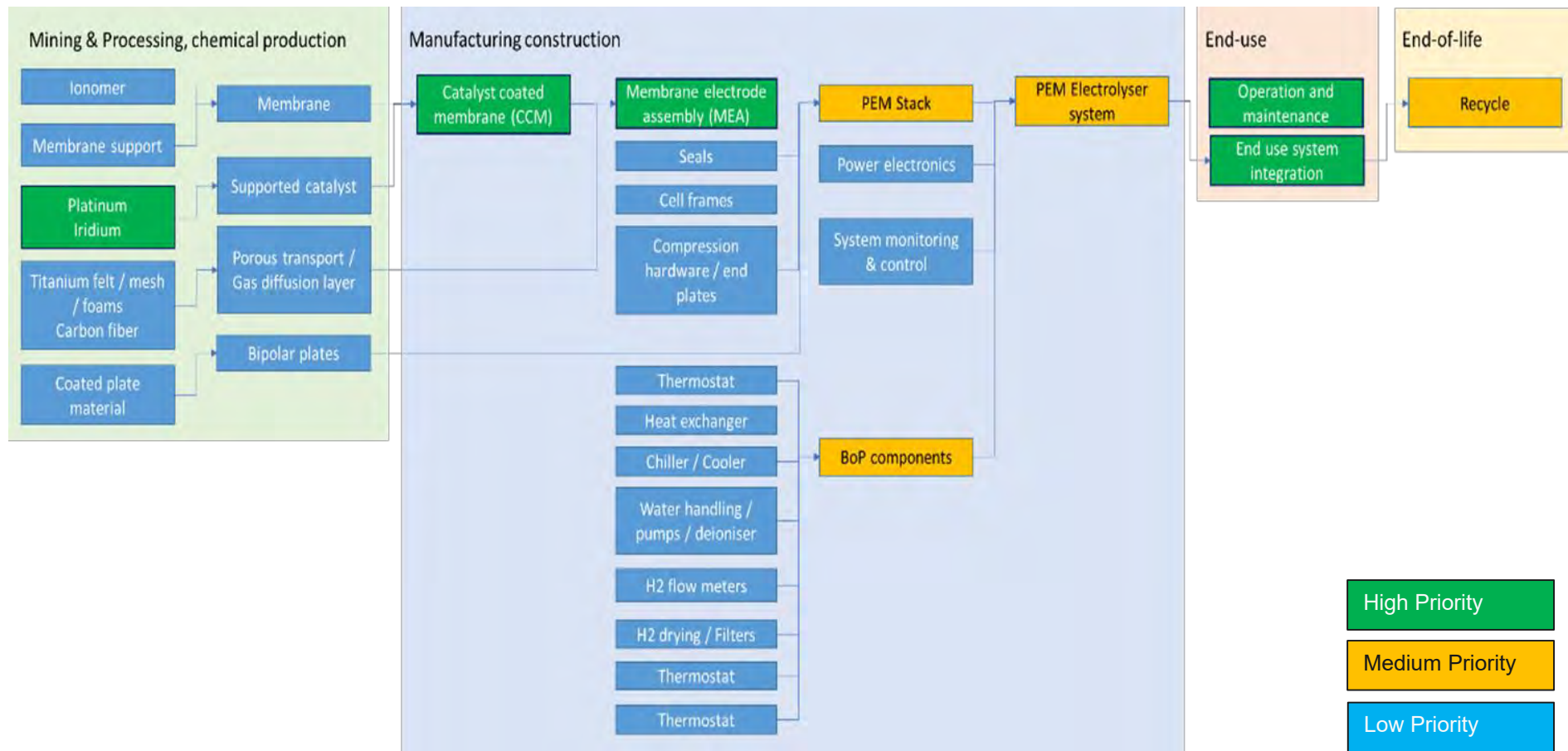
Strategic Choices: (iv) Hydrogen Hub Considerations

An analysis utilising the three archetypes suggested the following areas for GH₂ development in order to achieve an accelerated impact

	West Coast		Central (Inland)		Southeast coast	
	Boegoe Bay	Saldanha Bay	Vaal	Coega	eThekweni	Richards Bay
Advantages	- Potential R13bn investment into port infrastructure - Access to the Americas and Europe market - Option to upscale freely for future production - Incentivised renewable energy production - Possibility to anchor local hydrogen uptake through the mining industry - Driven by NCEDA (OBL) and Sasol (IBL)	- Best quality renewable energy resource - Access to the Americas and Europe market - Option to upscale freely for future production - Possibility to anchor local hydrogen uptake through industrial activity - Easy access to resources - Can fulfil short-term export trading requirements	- Incentivised renewable energy production - Possibility to anchor local hydrogen uptake through the PGM and manufacturing industry - Well established existing infrastructure - Very easy access to resources	- Access to the East and West markets without incurring additional costs - Option to upscale for future production freely - Incentivised renewable energy production - Possibility to anchor local hydrogen uptake through the manufacturing industry - Very easy access to resources	- Access to the East market - Possibility to anchor local hydrogen uptake through the mining industry - Very easy access to resources	- Access to the East market - Possibility to anchor local hydrogen uptake through ammonia production - Easy access to resources
Risks	Access to resources will be a constraint	Access to East markets is possible with an increase in logistics cost	Possible constraint on upscaling for future production	-	High traffic port with a lack of available space to increase capacity	Ammonia might be the only major option to drive local uptake of hydrogen
Aggregate factor	The Boegoebaai green hydrogen hub in the Northern Cape can be a strategic project to open Southern Africa's full green energy potential. Sasol has commenced with a 24 month prefeasibility study	Saldhana can leverage existing logistics and industrial infrastructure	The Vaal triangle's large industrial footprint gives it a strong domestic focus, with the added option to anchor local hydrogen uptake through the PGM industry	Coega could also fulfil short-term export requirements, but is mainly attractive due to its central coastal location and designated industrial development zone	The port of eThekweni's limited capacity and high traffic frequency isn't ideal when considering future upscaling requirements	Richards bay could support the local and export focus through the production and export of ammonia and hydrogen
Purpose	Export focused	Export focused	Domestic focused PGM focused	Export focused	Export focused	Support hub - Export and domestic focus

Strategic Choices: (v) Localisation of PEM Electrolysers

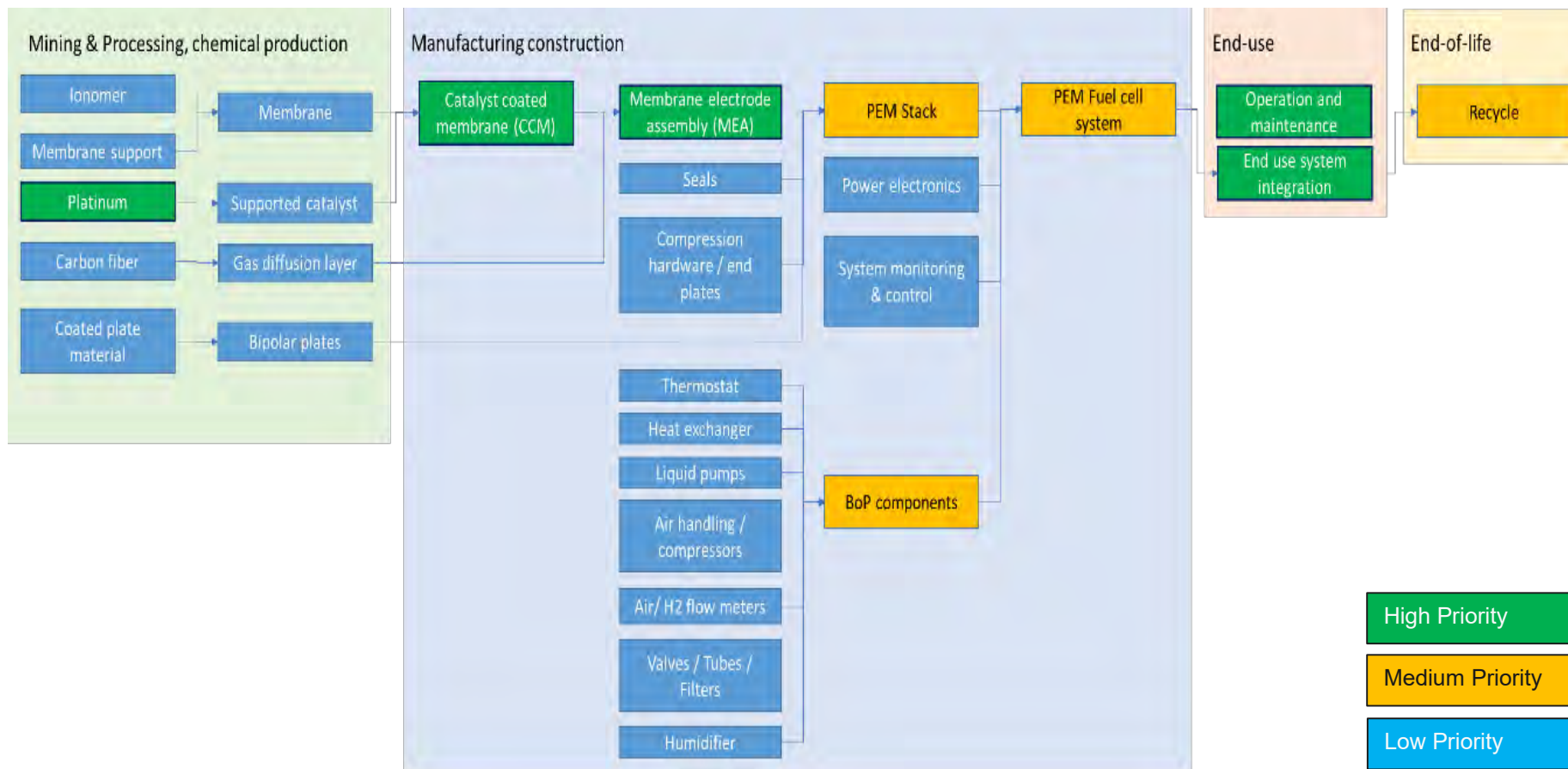
The GH₂ value chain presents opportunities for localisation – especially relating to the beneficiation of Platinum Group Metals. South Africa should attempt to leverage its PGM resources to promote localisation of PEM electrolysis technology equipment and components.



- Equipment and components include
 - electrolyser stacks,
 - electrolyser systems,
 - electrolyser catalyst coated membranes (CCMs) and membrane electrode assemblies (MEAs),
 - electrolyser Balance of Plant components.
- High priority components for localisation include platinum, iridium, CCMs, MEAs, system integration and O&M

Strategic Choices: (v) Localisation of Fuel Cells

PEM Fuel Cells are expected to generate substantial PGM demand 2030+ as GH_2 use becomes mainstream



- Equipment and components include fuel cell stacks, fuel cell systems, fuel cell catalyst coated membranes (CCMs) and membrane electrode assemblies (MEAs), as well as Balance of Plant components.
- High priority components for localisation are platinum, CCMs and MEAs



Strategic Choices: (vi) Inclusion & social impact

Significant opportunity exists for economic development and social inclusion which should be pro-actively driven through the commercialization strategy. **The estimates below are high level and will be validated by a comprehensive study.**

Gender equality and social inclusion

- The development of the hydrogen industry provides the opportunity to integrate the element of gender equality.
- Women's potential in green industry needs to be realised, and women need to be empowered to take leadership roles in green industries as entrepreneurs and / or industry professionals.

BBBEE including community empowerment

- Opportunity to empower previously disadvantaged people by taking ownership in new businesses and by providing new job opportunities.
- Communities can be empowered by shareholding in projects and by SMMEs contracting along the GH₂ value chain.

Impact on the South African economy

Based on projected exports by 2050:

- Export Sales - ~ R223bn per annum
- GDP - ~ R 74bn per annum
- Tax Revenue - ~ R 19bn per annum

Significant net job gains

- In total up to **650,000** additional jobs in South African by 2050 from exports and from local demand



Strategic Choices: (vii) Costs vs. Benefits

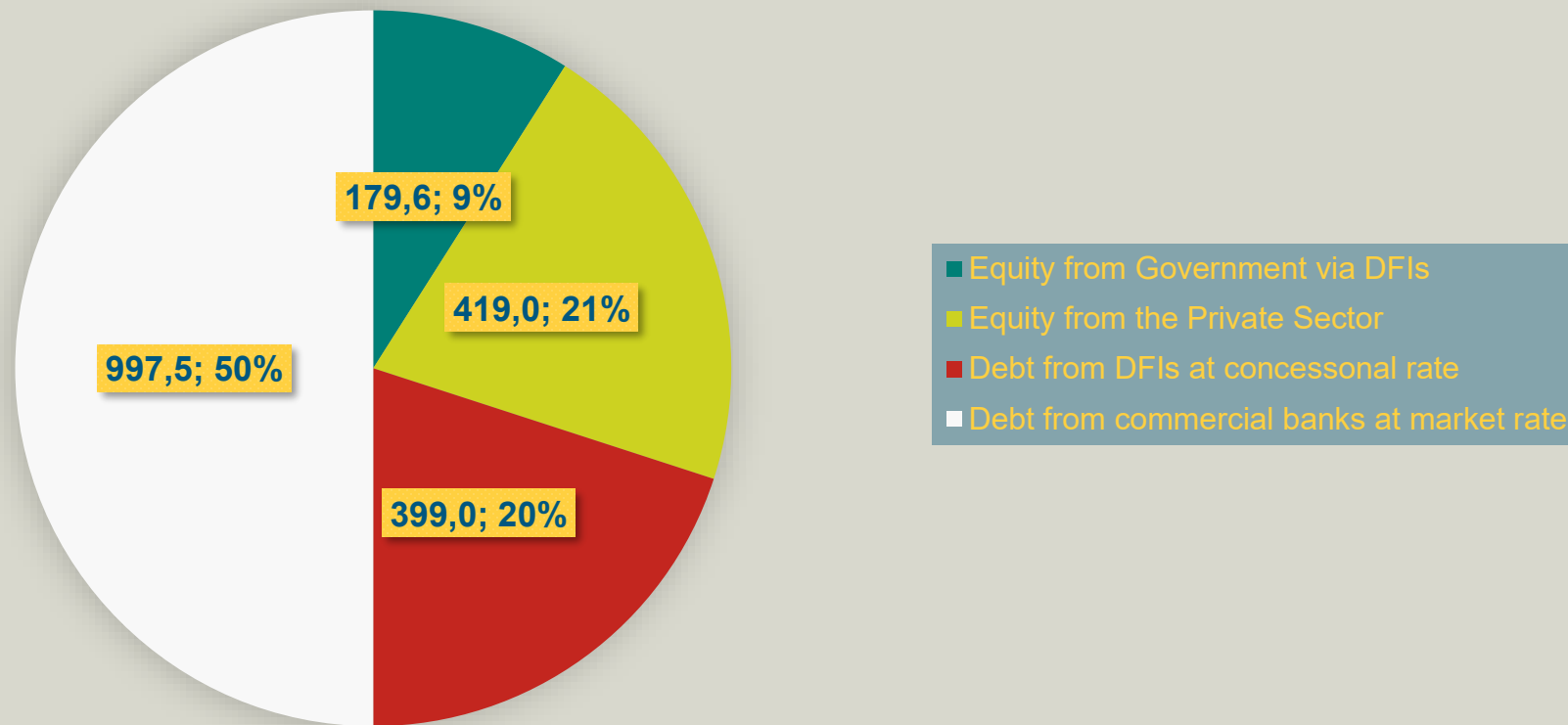
The **costs** associated with the development of the Hydrogen Economy is summarised below. **The estimates below are high level and will be validated by a comprehensive study.**

- 1 There will be a need for funding from DFIs in the form of grants, project development funds or concessional debt facilities. It is estimated that DFIs will need to contribute about **R180bn in equity and R400bn in debt at concessional rates by 2050.**
- 2 Capex funding requirement from private sector. It is estimated that the private sector will need to contribute about **R410bn in equity** and would need to source a further **R956bn in debt from commercial banks.**
- 3 Government subsidies and incentives will be required to support the catalytic hydrogen projects by the introduction of supportive policies and a regulatory framework for GH₂ that aids GH₂ price parity to increase domestic GH₂ demand.
- 4 Costs associated with changes / new regulations and policies.
- 5 R&D spending to stay ahead of innovation and technology and remain competitive (amount still to be determined)
- 6 Gradual reduction in income from petrochemical levies (impact to the economy still to be determined)
- 7 Development of state procurement programme / s
- 8 Costs to develop hydrogen infrastructure
- 9 Cost associated with establishing global partnerships and bi-lateral government to government agreements.
- 10 Costs to develop training and skills development programmes to support job creation within the GH₂ sector.

Strategic Choices: (vii) Investment required

The breakdown of the investment required for debt and equity from both private sector and Government is summarised below. **The estimates below are high level and will be validated by a comprehensive study.**

Investment required by 2050 in the GH₂ Industry in Rbn¹



1. Assumptions:

- a) Debt to equity ratio 70:30
- b) DFIs contribute 30% of total equity requirement
- c) DFIs contribute 30% of total debt required



Strategic Choices: (vii) Costs vs. Benefits

Although there are challenges and costs associated with developing the GH₂ economy, in the long term both the economic and social **benefits** to the country will far outweigh the costs. **The estimates below are high level and will be validated by a comprehensive study.**

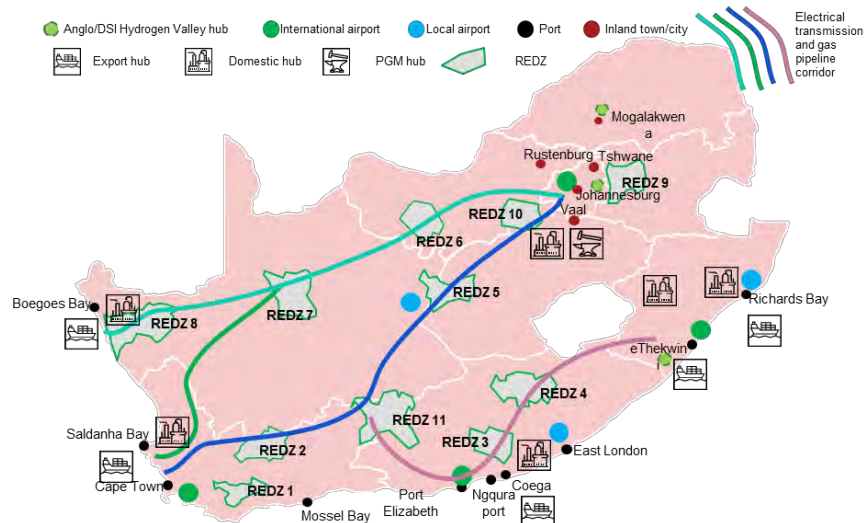
1	New industrialisation opportunities in multiple sectors will enable South African to have a comparative advantage
2	Foreign direct investment into new hydrogen projects in South Africa will include grants and concessional debt facilities from DFIs
3	Creation of new jobs in many new industries across the hydrogen value chain - estimated at 650,000
4	Income from exporting hydrogen, ammonia, methanol, marine bunkering and sustainable aviation fuel estimated at R 223bn in export sales by 2050.
5	Income from increased beneficiation and exports of minerals (especially PGMs) (Macroeconomic impact to be determined)
6	Income from export of locally produced equipment for example fuel cell components and electrolyzers
7	Green house gas emission reduction by using GH ₂ as a replacement energy carrier in traditional fossil fuel based processes e.g. steel making, transportation, petrochemical production and other heavy industries, will contribute towards reaching South Africa's emission reduction goals as per the Peak, Plateau, Decline Emissions Trajectory Range reflected in the NCCRP and NDP. Estimated 540 million tons of carbon dioxide will be displaced.
8	Security of energy supply by providing alternative, reliable and clean base load energy to the commercial and industrial market will support decarbonisation, green steel, mining etc. and maintain South Africa's competitiveness over time
9	Gradual reduction in importation of petrochemical products and positive impact on balance of payments
10	Maximisation of social inclusion including empowerment of BEE/women/youth/BIs

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Key Enablers: (i) Co-ordinated development of efficient value chain

Capturing the GH₂ opportunity requires a nationally coordinated approach / master plan (value chain design) to ensure end-to-end efficiency, planning and control of GH₂ molecules.



- **Co-ordination:** Since the value chain touches on land, water, energy, natural resources, logistics and finance, it will require significant co-ordination between the various government departments, public sector institutions and the private sector.

- **Technology:** Securing technology partnerships as well as targeted industrialisation plan will unlock significant economic benefits for SA economy. Fortunately, SA is not starting from scratch thanks to the RD&I efforts already underway by the DSI.



- **Value Chain Elements:** GH₂ production is an industrialisation opportunity. Equipment manufacture can service both domestic and export markets.

Recommendations

1. Existing private sector project opportunities identified should be expedited and supported. (these have been identified and plotted in the GH₂ roadmap)
2. Export hubs (SEZ) at **Boegoebaai**, Coega and Freeport Saldhana to be prioritised to enable exports.
3. A manufacturing hub (SEZ) at Vaal must be prioritised to enable early manufacturing and foreign technology partnerships and transfer.



Key Enablers: (ii) Regulatory & Policy Framework

The key regulatory recommendations are as follows



Prepare a Regulatory Development Timeline

- Outline detail and timing of regulatory review and introduction of new law and policy.
- Outline regulatory responses for the GH₂ industry including the introduction and phase out of such mechanisms.



Develop regulatory objectives for how the GH₂ industry should be regulated.

- Agree on regulatory objectives to simplify coordination of regulatory responses across government departments.
- Conduct feasibility studies to establish the financial impact of possible GH₂ regulatory incentives.



Develop a set of Regulations specifically aimed at creating enabling environment for GH₂

- Utilise section 19(1) of the National Energy Act to introduce GH₂ regulations.
- Consider other existing laws and policies that could support the uptake of GH₂ and amend accordingly.
- Develop GH₂ standards and specifications for mobility, production, refuelling, storage, transportation and end-use applications based on international best practice standards.



Key Enablers: (ii) Regulatory & Policy Framework

Development of regulatory measures and incentives for the import and export market production

Export Market

1. Introduce measures for SEZs to produce and export hydrogen at a cost competitive price.
2. Design and introduce a **Guarantees of Origin** system to install investor confidence in key import nodes.
3. Special Economic Zone and REDz incentives: Reduced corporate tax rate from 28% to 15%; accelerated depreciation allowance of 10% for buildings; VAT and customs relief; employment tax Incentives under SEZ Act.
4. Guarantees of Origin System: Engage with zaRECs Pty Ltd to explore expansion of current renewable energy certificate system to include GH₂; ensure alignment of South African GO system with EECS (European Energy Certificate System) in order to satisfy European GH₂ investors.

Domestic Market

1. Introduce explicit and implicit carbon pricing mechanisms coupled with GH₂ revenue recycling mechanisms.
2. Build on existing regulatory tax incentives set out in the Income Tax Act to support the GH₂ value chain.
3. Introduce a single institutional body to expedite licensing processes and facilitate the development of the GH₂ sector.
4. Explicit Carbon Pricing: Increased carbon tax rate or carbon fuel levy under the Carbon Tax Act and Customs and Excise Act.
5. Implicit Carbon Pricing: Removal of fossil-fuel subsidies and reallocation of subsidies to GH₂ development.
6. Tax allowances: Apply Incomes Tax Act provisions to GH₂ (Sections 12L, 12B(1)(h), 12I, 12K, 11D, 11A, 12C, 13(1))
7. Import duties: Exempt imported GH₂ equipment under Schedule 7 of the Customs and Excise Duties Act. (Still in draft)

Key Enablers: (iii) Finance & Investment

The estimated total capital investment scaling from \$970m for pilot projects to \$164bn as 2040 target
(indicative in 2021 terms)

	Project 1 - 20 ktpa Hydrogen (to be commissioned in 2025)	Long term high growth scenario - 3.8mtpa tons Hydrogen 2040 (investment over 15 years)	Long term low growth scenario - 3.8mtpa tons Hydrogen 2050 (investment over 25 years)
Value chain	<pre> graph LR Solar --> Transmission Wind --> Transmission Transmission --> Desalination Transmission --> Electrolysis Desalination --> Electrolysis Electrolysis --> Ammonia_synthesis[Ammonia synthesis] Ammonia_synthesis --> Storage_logistics[Storage & logistics] Storage_logistics --> Domestic_H2_NH3[Domestic H2/NH3] Storage_logistics --> Export_NH3[Export NH3] </pre>		
Value Chain capacity	20,000 tpa hydrogen* 114,000 tpa Ammonia (Export capacity - 114,000 tpa) 180,000 tpa water	3.8 mtpa hydrogen production* 22 mtpa Ammonia (Export capacity - 11 mtpa (50%)) 34 mtpa water	
Scale & land take	290 MW electrolyser 370 MW solar - 730 ha 160 MW wind - 5,600 ha (based on identified pilot projects)	60 GW electrolyser 70 GW solar - 0.14 Mha; 30 GW wind - 1.05 Mha (6.5x IRP allocation for RE) (indication of size required: equivalent to 66% of Gauteng Province)	
Capital Cost	\$970m total; 67% RE capex; 22% electrolysis capex; 10% Ammonia plant capex	\$164bn total; 65% RE capex; 21% electrolysis capex; 13% Ammonia plant capex	\$133bn total; 67% RE capex; 9% electrolysis capex; 23% Ammonia plant capex

Key Enablers: (iii) Finance & Investment

Eight distinct challenges identified in SA Hydrogen ecosystem & funding landscape

1 Lack of an integrated policy and gov alignment



- Multiple policies or roadmaps that are not interlinked to provide a coherent and clear path forward for green H₂
- Different departments within government using different strategies to make decisions

2 Green H₂ Supply-demand mismatch blocks offtake



- All projects on IDC-KfW radar have no offtake agreements
- Offtakers don't want to lock-in prices long term since price will go down
- Market unclear on whether green or blue hydrogen will dominate market

3 No clear path on which H₂ projects to invest in



- Lack of strategic catalytic project pipeline and map on how capital stack evolves as project matures

4 Low IRR creates barrier for private funding



- High LCOH makes green H₂ less competitive today
- Low IRR, long payback period compared to other projects
- Current tech maturity increases risk profile for private investors

5 Lack of local blended finance



- Public-private blended finance in RSA green projects is 100% from international sources
- Domestic bias with increase, local blended finance required

6 Insufficient funds for key parts of H₂ value chain



- Synthesis concept dev only has debt today, too high-risk for that stage
- Direct Air Capture, Carbon Capture and Carbon Storage tech in low maturity, but only debt offered for these problems

7 No strategy or funds for distri. & storage infra.



- Only debt financial instrument is offered
No clear path on who will support funding for green H₂ infrastructure
- No plan on how infrastructure will be shared or how "no island grid" policy will change to accommodate new projects

8 Lack of common understanding of 'green'



- No global definition of green H₂
- No global method to track green funds and their uses
- Unclear standards for measurement criteria of LCOH
- True cost of tech kept proprietary



Low criticality



Medium criticality



High criticality

Source: KfW/Boston Consulting Group/IDC 2022



Key Enablers: (iii) Finance & Investment

Potential sources of funding will need to be obtained from government, private finance and development finance institutions

1

Government on-
balance sheet
finance



- **Direct public funding:** includes allocation of taxation revenue, budget surplus', borrowings
- **Green/project bond financing:** Effective means of encouraging development of infrastructure focused on reducing carbon emissions and provides a form of de-risking by providing long-term grant and concessionary funding to an investment

2

Private Finance



- **Traditional private sources of private finance such as** direct equity investments and lending
- **Public-private partnerships:** Combining public and private sector involvement by partnering government with key private stakeholders, including infrastructure developers, renewable energy companies, research institutions, vehicle manufacturers, and infrastructure focussed private equity funds, are key themes in this space globally.

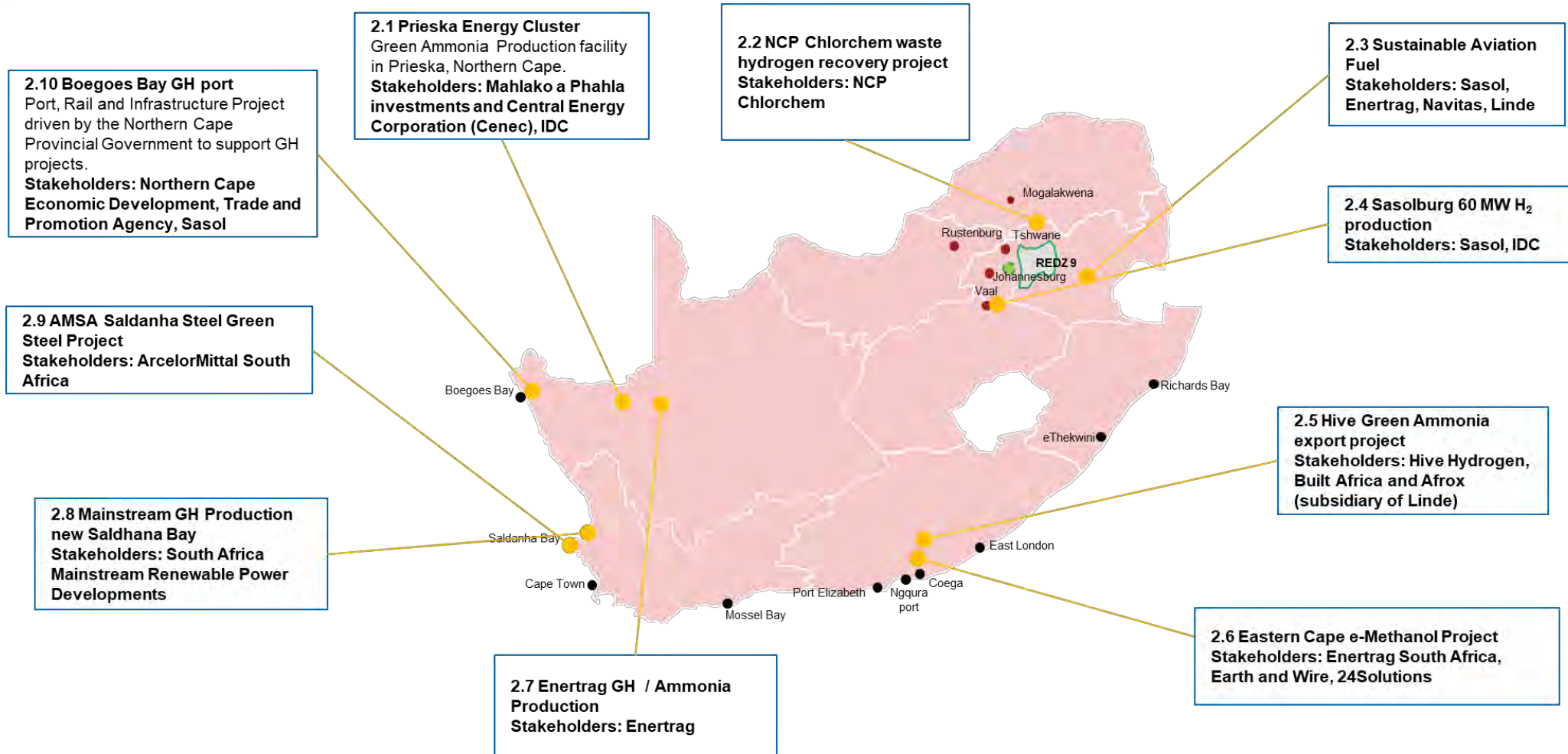
3

Development
Finance



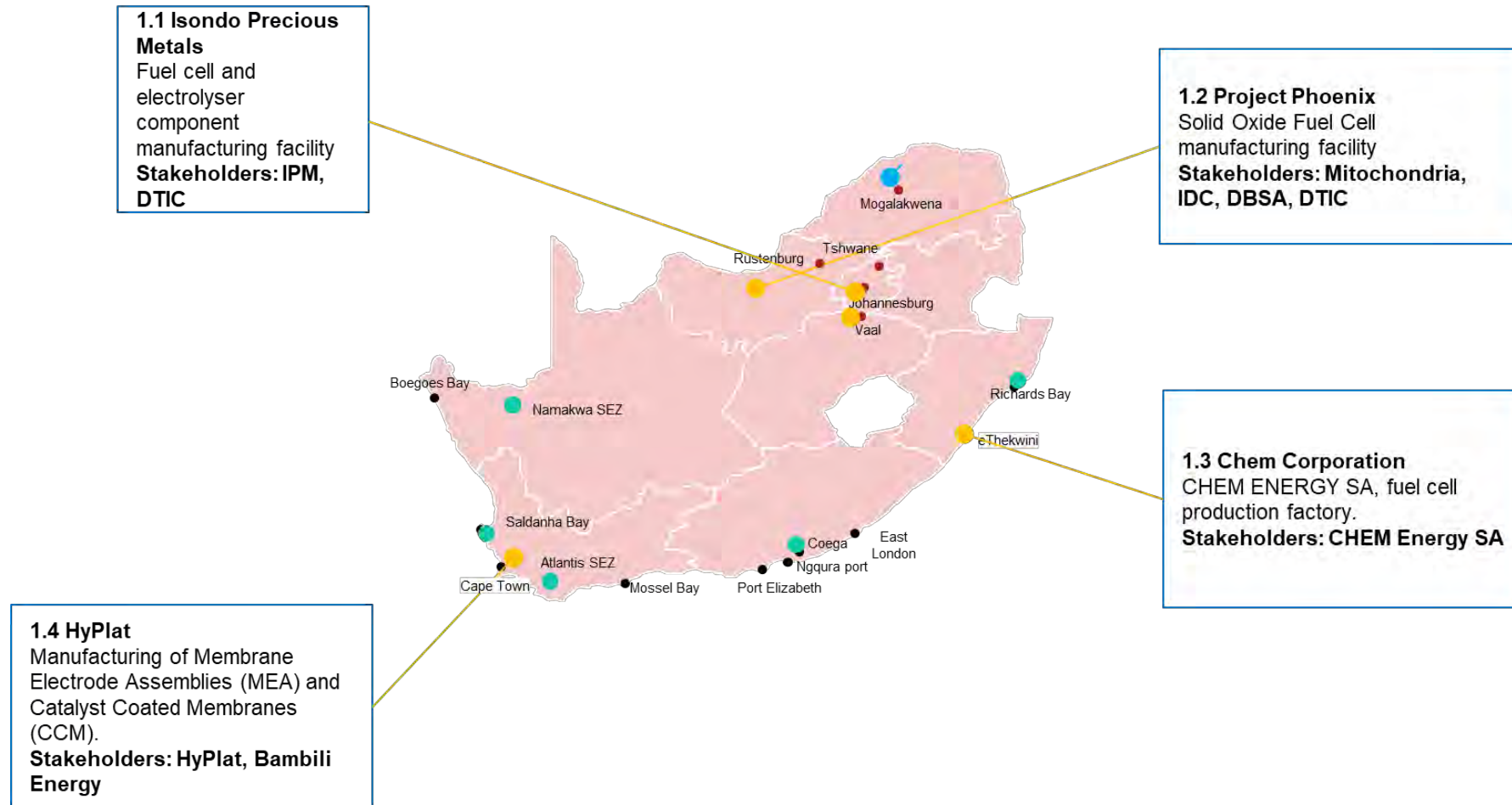
- **Leveraging funding from developed markets:** A number of larger, developed countries have committed funding to support the decarbonisation initiatives of developing countries. Taking advantage of those additional pockets of funding will support the development of larger scale projects locally, which will enhance efficiencies and ultimately reduce pricing.
- **Leveraging funding from export credit agencies:** often used to fund infrastructure projects (especially those in the developing world) in conjunction with, or as an alternative to, more traditional project financing. It enables project companies to obtain more flexible (and often cheaper) financing arrangements. In addition to financing, export credit financiers may also provide insurance, particularly political risk insurance that is either unobtainable or prohibitively expensive in the commercial market place, which incentivises investment by international financiers.
- **Blended finance mechanisms** including on-lending structures from DFIs and subordinated debt

Key Enablers: (iv) Catalytic Projects – GH₂, Chemicals and Green Steel Production



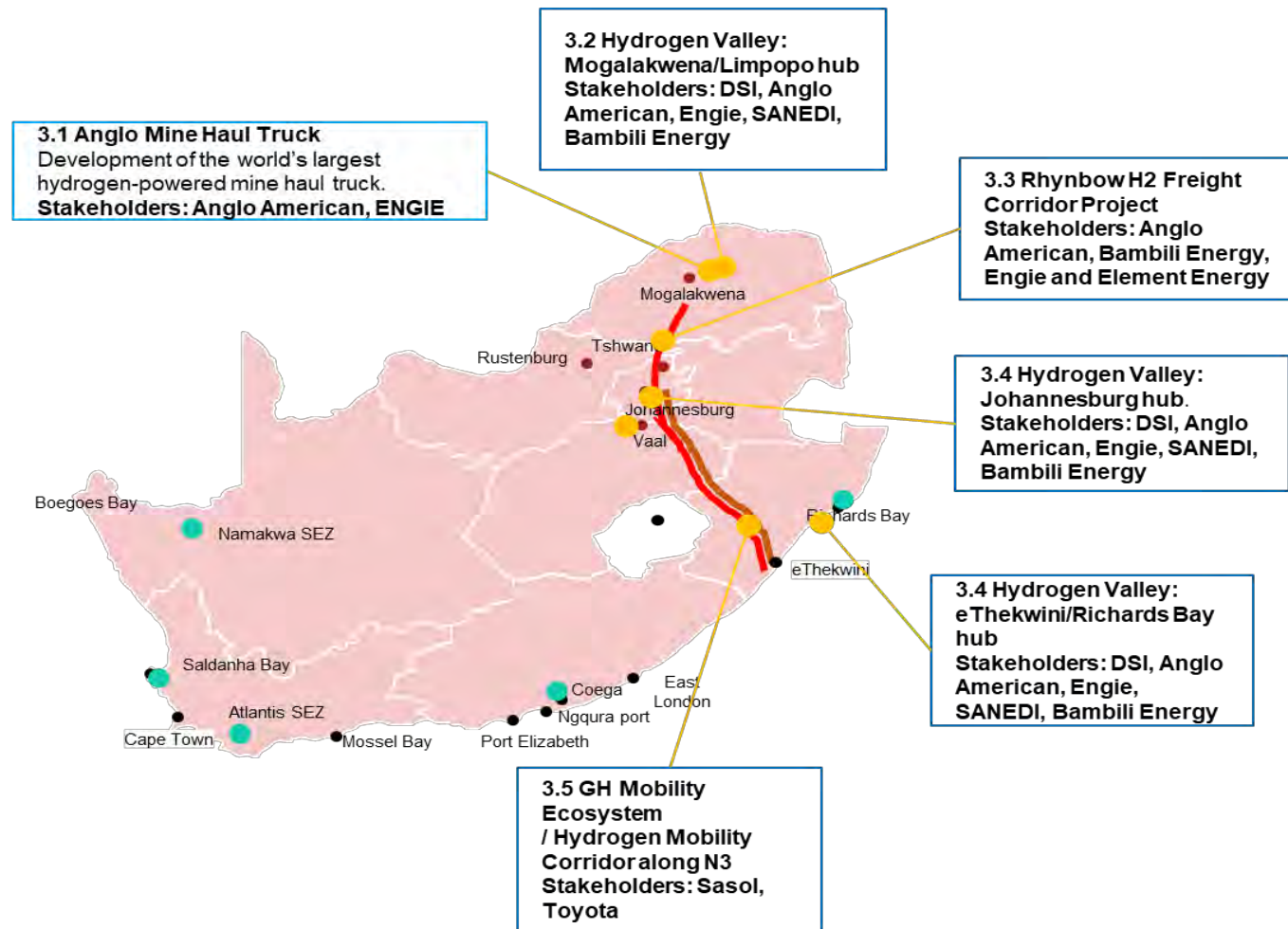
The current strong pipeline of GH₂, chemicals and green steel projects will support the export focus element of the commercialisation strategy

Key Enablers: (iv) Catalytic Projects – Manufacturing in Value Chain



The current strong pipeline of equipment manufacturing projects will support the industrialisation element in the commercialisation strategy

Key Enablers: (iv) Catalytic Projects - Mobility



The current strong pipeline of mobility projects will support the domestic demand stimulation and decarbonisation strategy

Key Enablers: (v) Skills

The creation of a hydrogen economy will require a new skill sets as well as an increase in capacity of a productive workforce.

The DHET will be central to the implementation of the skills action plan with consultation of the DSI.

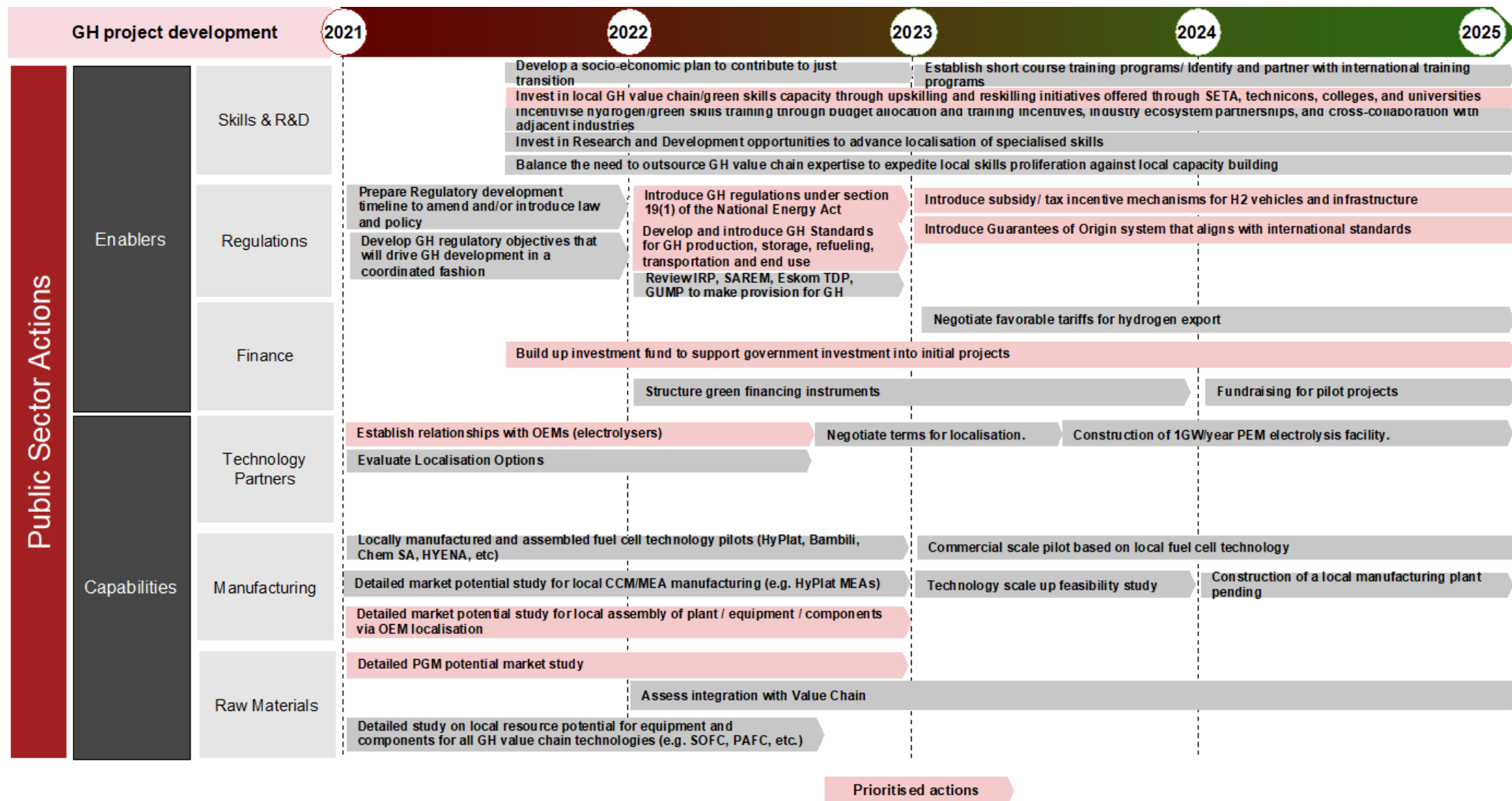
Value chain	Localisation opportunity (Priority)	Skills required	Skills sourcing	Government can build local skills capacity by...
Renewable Energy generation	Hydrogen and renewable energy specialists (High)	Circular economy skills	Outsource	• Incentivising the private sector to support local capacity as they outsource for missing and limited skills. • Supporting educational institutions with development and funding of training programmes focused on the GH industry. • Creating financial incentives for the private sector to roll out upskilling initiatives.
		Green architecture and future cities planning skills	Outsource	
		Green engineering and tech skills	Local, but limited	
		Natural capital skills	Outsource	
		Sustainable agriculture skills	Local, but limited	
Electrolysers and Balance of Plant	PGM mining and processing (High)	Technical engineering (renewable, marine)	Local, but limited	Incentivising the private sector to support local capacity as they outsource for technical engineering expertise specific to electrolyser manufacturing
	Recycling of used PGM products (Medium)	Circular economy skills	Local, and growing	Supporting the roll out of upskilling initiatives through funding and financial incentives to encourage quicker uptake by the private sector
	CCM* and MEA* electrolyser component manufacture (High)	Circular economy skills	Local, but limited	• Incentivising the private sector to support local capacity as they outsource for technical engineering expertise specific to CCM and MEA component manufacturing, fuel cell stack manufacturing, green engineering, and circular economy integration. • Supporting educational institutions with development and funding of training programmes focused on the GH industry.
		Green engineering and tech skills	Outsource	
		Manufacturing and Assembly	Local, but limited	
Beneficiated Products	Fuel cell stack and systems manufacture (Medium)	Circular economy skills	Outsource	
		Green engineering and tech skills	Local, but limited	
		Manufacturing and Assembly	Local, but limited	
	Automotive manufacture (Medium)	Manufacturing and Assembly	Local, and mature	
All	Systems Integration and Operation and maintenance (High)	Circular economy skill	Local, but limited	• Incentivising the private sector to support local capacity as they outsource for missing and limited skills. • Incentivising the private sector to roll out upskilling initiatives to develop growing skills, through funding models and financial incentives • Developing ecosystem and research partnerships to diversify mature skills into other segments of the GH value chain and other industries.
		Environmental justice skills	Local, and growing	
		Green career pathways	Outsource	
		Green architecture and future cities planning skills	Outsource	
		Operations management and system integration skills	Local, and mature	
Foundational skills South Africa has developed strong expertise in		Ancillary and support services/ Architecture and Engineering design services/ Business and Management services		
		Construction/ Finance and Legal services/ Information and Communications Technology/ Insurance and Healthcare services		
		Logistics and transport/ Manufacturing and Assembly/ Risk Management/ Skilled labourers/ Technical engineering		

* CCM (catalyst coated membrane) and MEA (membrane electrode assembly)

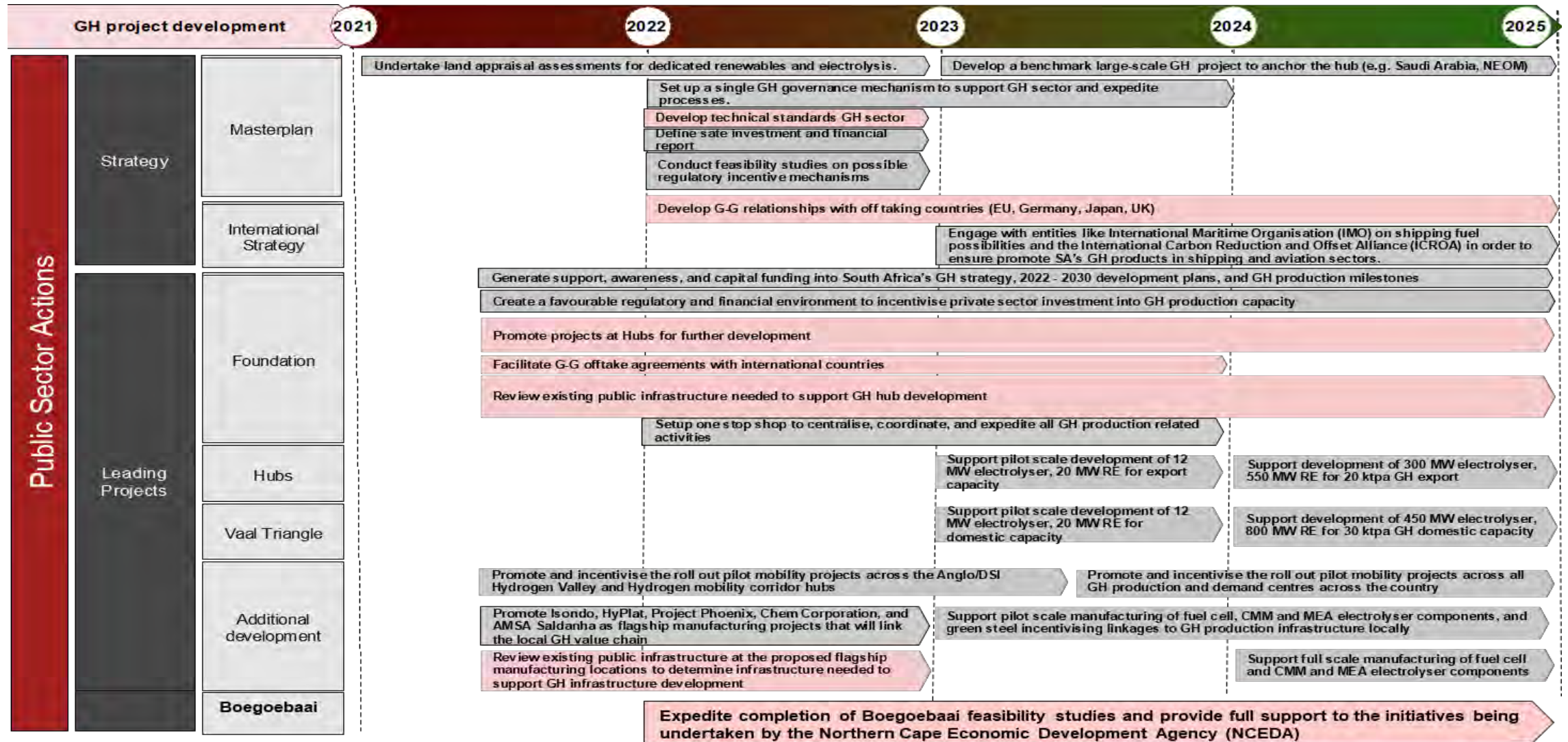
Presentation Outline

- 1 Opportunity Statement
- 2 The need for a Commercialisation Plan
- 3 Demand-driven commercialisation
- 4 Competitive Supply
- 5 Strategic choices
- 6 Key Enablers
- 7 Commercialisation Roadmap**

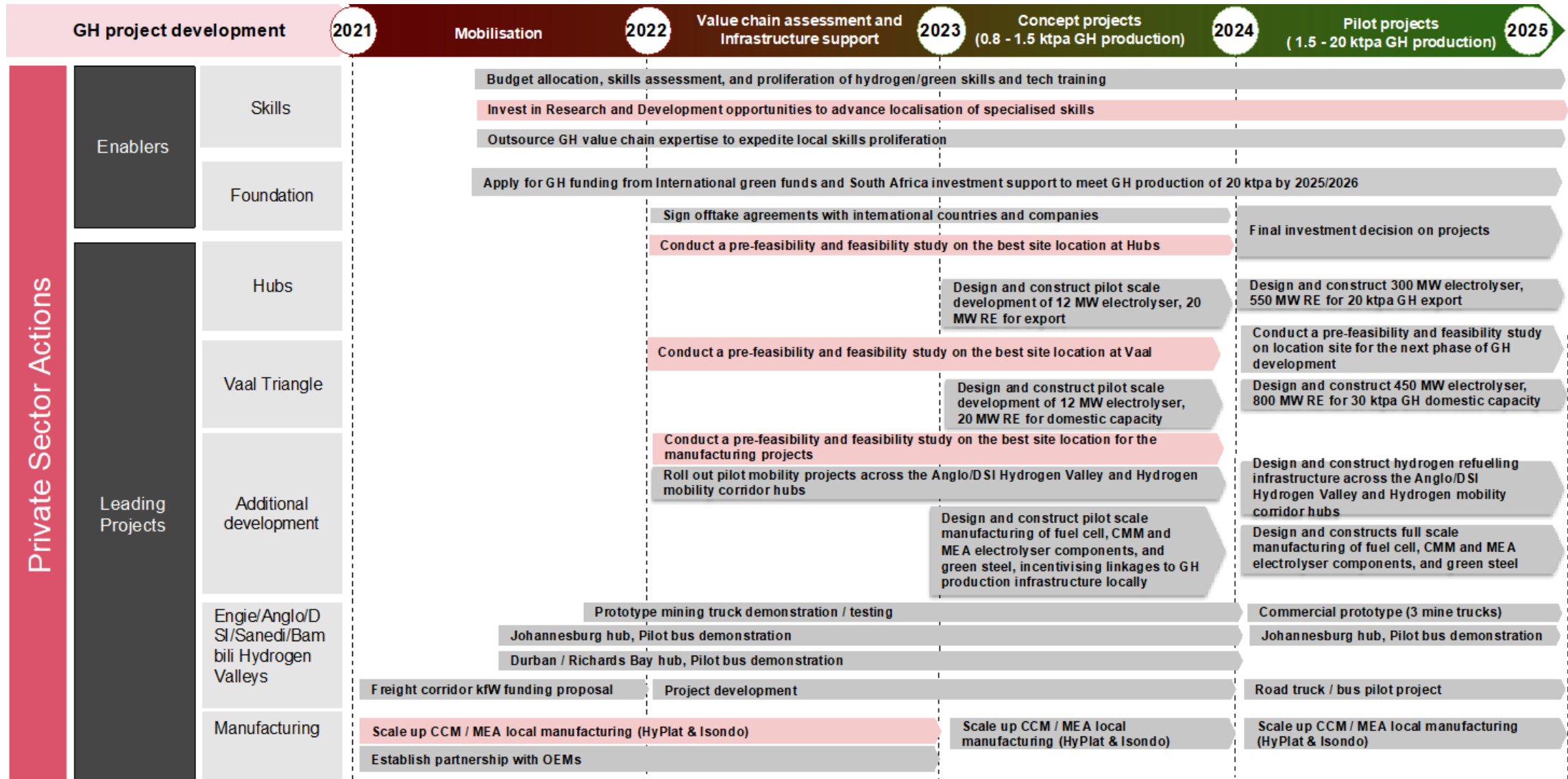
Detailed Action Plan : Short Term Roadmap : 2022 - 2025



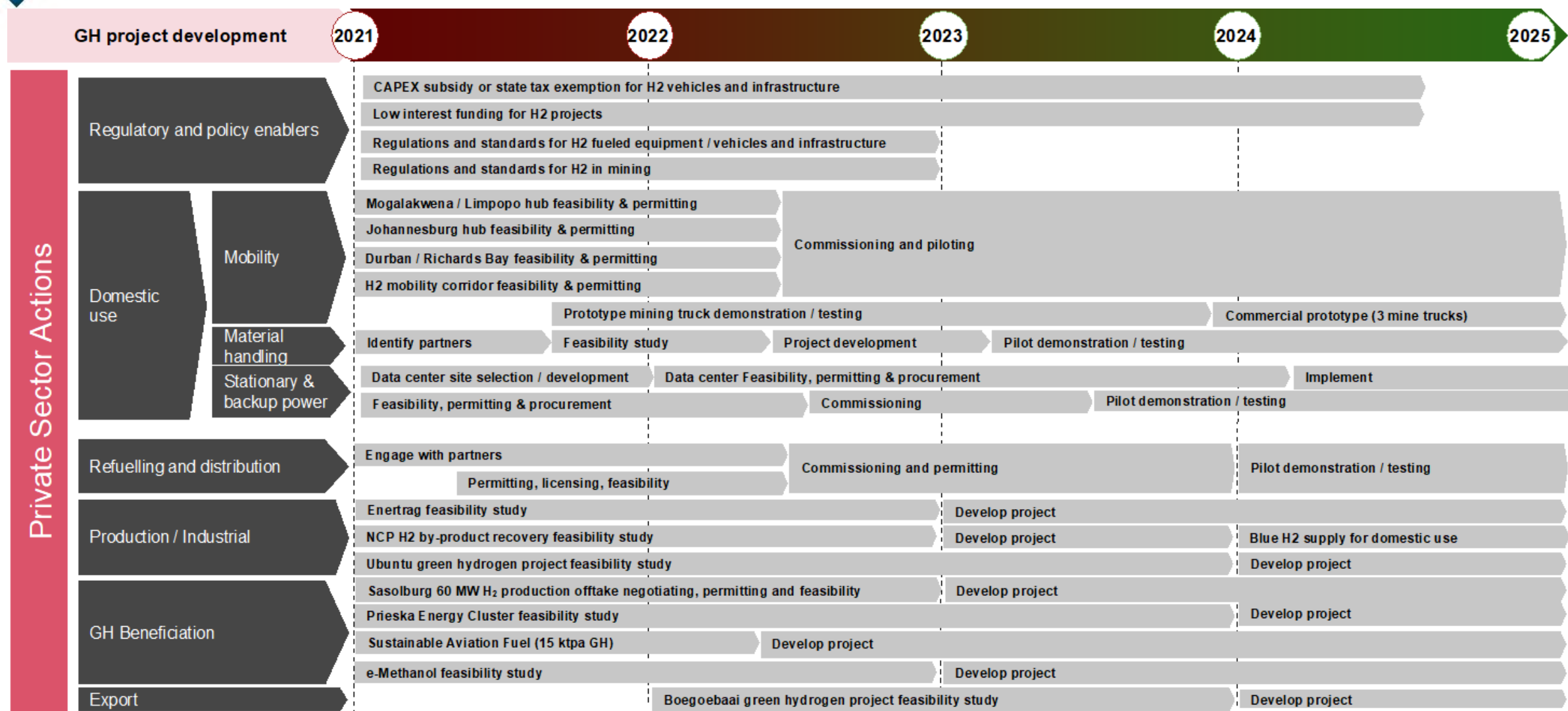
Detailed Action Plan - Short Term Roadmap : 2022 - 2025



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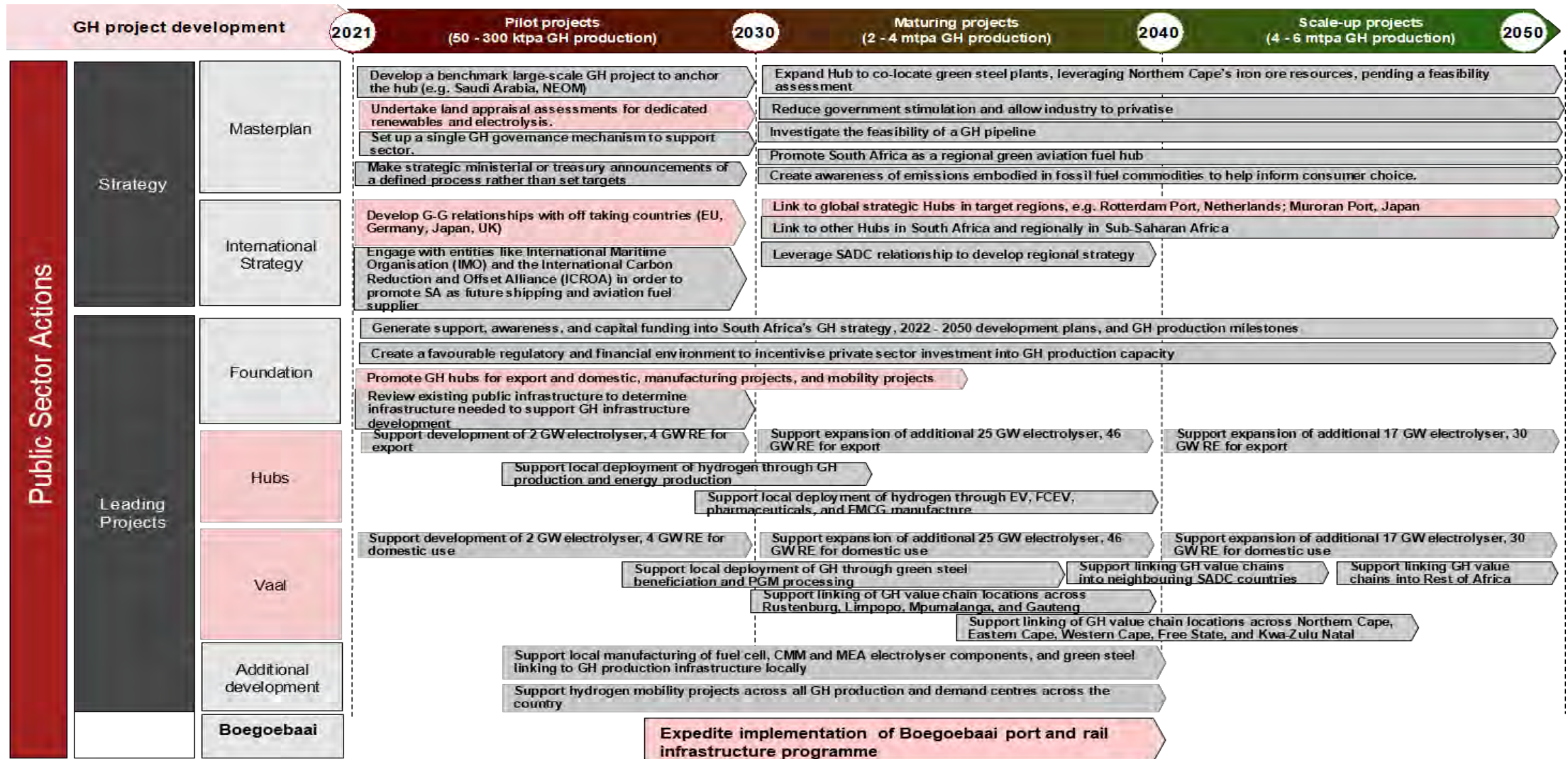


Detailed Action Plan - Long Term Roadmap : 2022 - 2050

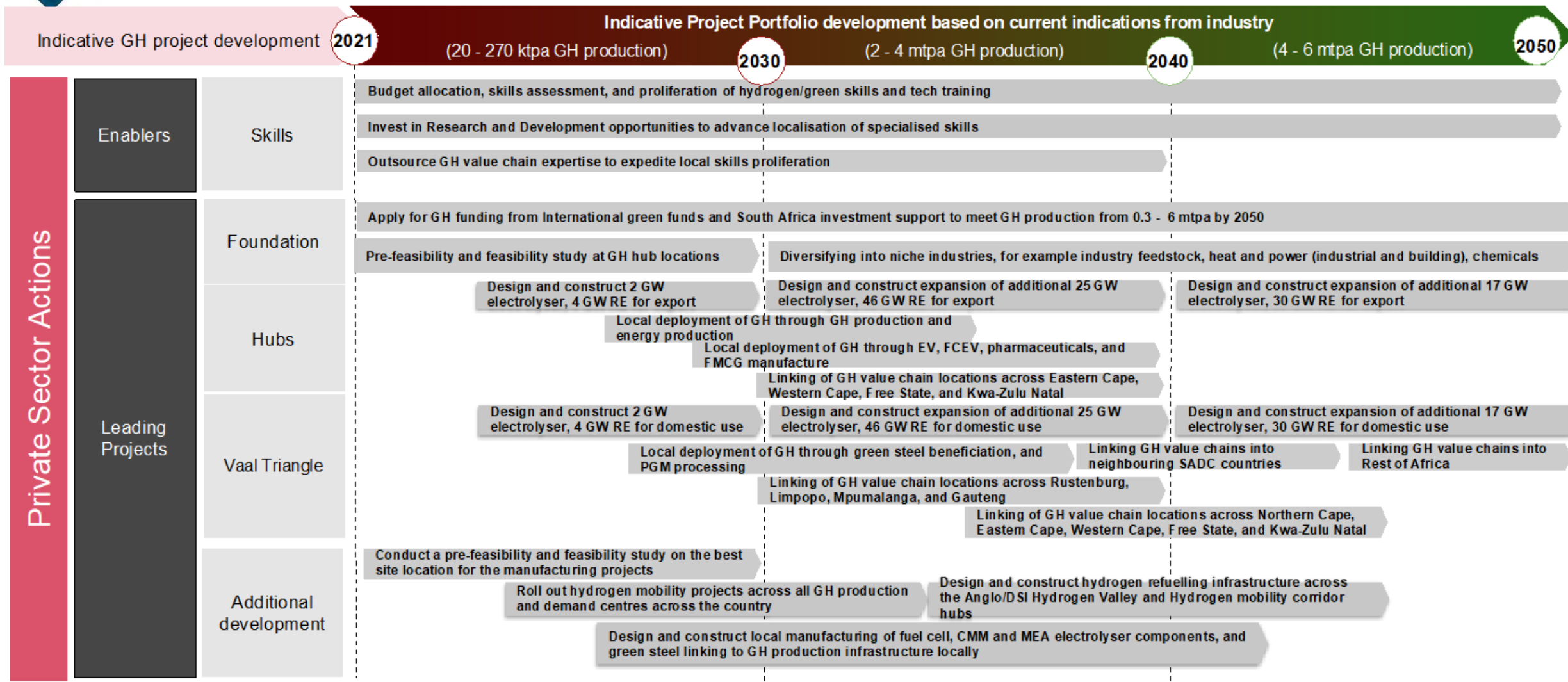
GH project development			2021	Pilot projects (50 - 300 ktpa GH production)	2030	Maturing projects (2 - 4 mtpa GH production)	2040	Scale-up projects (4 - 6 mtpa GH production)	2050
Public Sector Actions	Enablers	Skills	Implement a socio-economic plan to contribute to just transition						
			Invest in local GH value chain/green skills capacity through upskilling and reskilling initiatives offered through SETA, technicons, colleges, and universities						
			Incentivise hydrogen/green skills training through budget allocation and training incentives, industry ecosystem partnerships, and cross-collaboration with adjacent industries						
			Invest in Research and Development opportunities to advance localisation of specialised skills						
			Balance the need to outsource GH value chain expertise to expedite local skills proliferation against local capacity building						
	Regulations	Implement a revised IRP incorporating GH capacity				Reduce tax incentives as industry matures			
		Introduce GH regulatory framework and standards (production, storage, refueling and transport)				Introduce explicit an implicit carbon pricing and revenue recycling mechanisms to drive investment in GH			
		Introduce regulatory incentives (reduced import duties and tax incentives)							
	Finance	Develop GH Guarantees of Origin system in order to secure product premiums							
		Negotiate favorable tariffs for hydrogen export				Secure long-term off-take arrangement with key countries / customers			
		Build up investment fund to support government investment into initial projects				Blended finance still required, but private sector scaling up			
	Structure green financing instruments				Competitive market financed by private sector				
	Capabilities	Technology Partners	Establish relationships with OEMs (electrolysers)				Manufacture established to support 1GW/year electrolysis capacity.		
			Auction electrolyser capacity, and invite global participation – min 10 MW (e.g. Chile)						
			Investigate direct air capture opportunities and biomass						
		Manufacturing	Demonstrate clean hydrogen as an input into existing plants and support fuel cell pilots				Expand replicable business model to other countries / regions		
			Promote >1 GW of local electrolyser / FC capacity, which incentivises OEMs to invest in local production capacity				Sector coupling – Long duration electricity storage		
			Invest in local component manufacturers (CCM & MEA) Targeting 15% of global market. Leverage local PGM.				Increase investment in local component manufacturing (CCM & MEA) Targeting 25% of global market.		
		Raw Materials					Increase investment in local component manufacturing (CCM & MEA) Targeting 30% of global market.		
Target PGMs of 536 koz, 65 GW elect, 31 GW FC				Target PGMs of 1,51 moz, 90 GW elect, 145 GW FC					
				Target PGMs of 3,19 oz, 140 GW elect, 673 GW FC					
Prioritised actions									

Prioritised actions

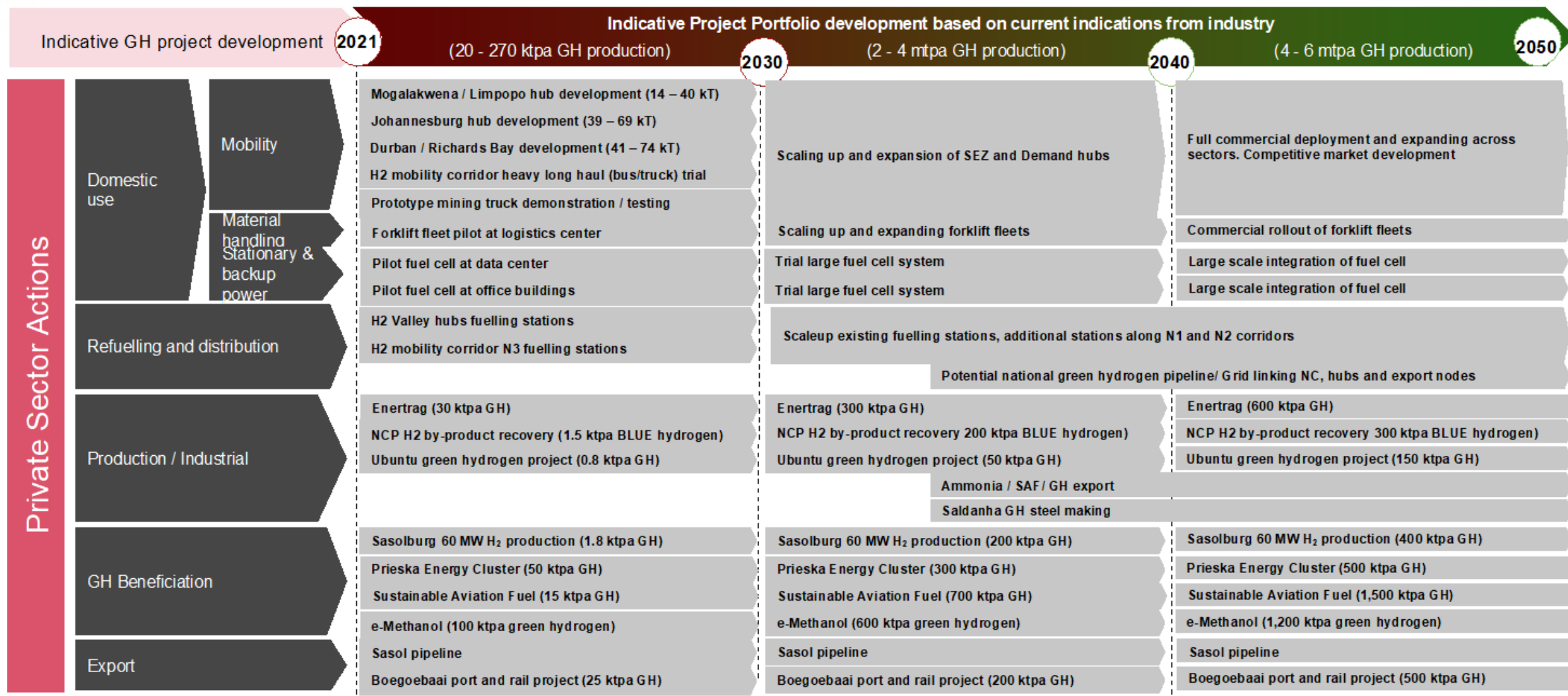
Detailed Action Plan - Long Term Roadmap : 2022 - 2050



Detailed Action Plan - Long Term Roadmap : 2022 - 2050



Detailed Action Plan - Long Term Roadmap : 2022 - 2050





Conclusion : The path to achieve our Vision for 2050

VISION 2050 – A WELL ESTABLISHED NEW SUSTAINABLE GREEN HYDROGEN INDUSTRY FOR SOUTH AFRICA

- The National Hydrogen Commercialisation will build on momentum of HySA programme and the Hydrogen Society Roadmap to position South Africa as a global player in GH₂ and green chemicals
- The development of this **new green hydrogen industry** will support South Africa's Economic Reconstruction and Recovery Plan
- Implementation of the action plans should ensure a just transition tackling gender equality and social inclusion, addressing the triple challenge of poverty, inequality and unemployment.
- Stronger partnerships will be built between Government, the private sector and civil society by creating an enabling environment
- Implementation should drive international partnerships while protecting national interest
- South African should be rebranded as a destination for sustainable investment incorporating Environmental, Social and Governance principles



- Projects along the value chain will be developed and implemented over the next 20 year
- “Needle moving” export revenues will be generated
- Policy and regulatory changes driven by Government will be implemented
- Financial support instruments will be sourced e.g. grants, concessional debt and contract for difference
- Incentives to sustain the development of the industry will be developed
- Skills training programs and institutions will be established
- Socio economic development will take fruition, jobs will be created and the just energy transition will be well on its way
- Significant decarbonization will be achieved in South Africa and across the Globe

GREEN HYDROGEN COMMERCIALISATION STRATEGY FOR SOUTH AFRICA

EXECUTIVE SUMMARY

30 NOVEMBER 2022

Released for public comment December 2022

1 Introduction and Background

The rapidly developing global Green Hydrogen (GH) market is a significant opportunity for South Africa to position itself as a global competitor in future green energy markets. Developing a vibrant GH domestic demand landscape and manufacturing capability in South Africa will be critical to decarbonise our economy and to mitigate the risk of declining fossil fuels usage linked to industrial activity. Ultimately, a thriving GH sector in South Africa will contribute to the country's sustainable competitiveness as the world transitions to Net Zero.

Under the guidance of the IDC and the Green Hydrogen Panel (GHP), the GH strategy report addresses six (see Figure 1) of the broader work packages identified under the remit of the GHP with the primary aim of establishing a strategic framework and roadmap for commercialisation. This will support further efforts to develop a full and detailed GH sector master plan. Such a sector master plan will require significant further quantitative studies and modelling as well as stakeholder alignment, some of which is already ongoing under the GHP. The report does not provide the technical, financial, socio or economic quantitative analyses ultimately required for investment decision making and quantifying economic cost-benefits.

This Green Hydrogen Commercialisation Strategy (GHCS) builds on the strong foundation of the work undertaken by the Department of Science and Innovation (DSI) with respect to its HySA programme and the recent development and publication of the Hydrogen Society Road Map (HSRM).

The report approach outlines a commercial framework, principally a) Strategic objectives for a GH sector vision b) Assessment of demand drivers, c) Technical value chain definition and related delivery supply chain options, d) opportunity to embed local manufacturing and local content and e) creating an attractive and enabling investment environment. A combination of direct analysis, benchmarking through a literature review and stakeholder input from the GHP has been used to develop the outputs.

In defining the opportunity for South Africa, it is important to recognize that GH is currently a nascent market representing less than a quarter of a percent of global energy. However long-term demand potential for a green transportable fuel could grow to between 15% to 20% of global energy demand. Although the potential scale is enormous at this early stage of market development, the end-state remains very uncertain. The pace and scale of such GH market development and adoption will depend on the combination of production cost, driven down over time by equipment and operational learning curves that are synonymous with renewable energy technologies and increasing carbon pricing and fossil fuels costs as the world drives more stringent decarbonization policies.

The timing to achieve price parity between GH and fossil fuels will differ between countries, between export and domestic markets as well as between sectors, thus emphasizing the complexity and risk that must be dealt with in a holistic national GH sector master plan.

National development opportunities that leverage GH can be considered under three key areas as outlined below. Although these opportunities have differing needs, timing and opportunities, they must all be supported by a holistic national plan for sector development.

1. Production of GH that will attract foreign direct investment as well as generate export revenues.
2. Industrialisation and manufacturing of GH related equipment that will stimulate the local economy and job creation

3. Decarbonising South Africa's economy and industry in order to remain globally competitive

This report builds on the findings of the GHP interim report and aims to address the following six core Work Packages as a key next step towards a South African GH sector masterplan.



Figure 1: Six core work packages of GH commercialisation plan

The report outlines significant opportunities and benefits that can be derived for South Africa and suggests initial prioritisation and focused actions. It is important to note that recommendations are made based on relative ranking of multi-criteria and qualitative analysis as the detailed technical and financial quantitative modelling typically required for investment decisions has not been developed at this stage.

Developing a clear and coherent policy and regulatory environment is a priority action and will need strong public sector alignment considering the interfaces between Industrial development, Energy, Environmental and Infrastructure development. Optimising large scale infrastructure and project development is complex and often requires a strong state capability in balancing national objectives, economic viability, commercial bankability, procurement mechanisms and a fair and competitive market for private sector investment.

Bold policy and government support for private sector investment must take multiple forms, especially when considering that South Africa's low economic growth and fiscal weakness will not allow for large subsidies as has been seen in developed countries. Securing international technology partnerships, financing support and bankable long term off-take agreements through bi-lateral and commercial arrangements should be expedited by government.

2 Strategic design and objectives

Based on a review of other foreign National Hydrogen strategies, the following critical elements were identified as leading and best practice and should be developed in detail in future phases of South Africa's GH strategy and master plan:

- Direct investment by the state
- Economic and financial support mechanisms
- Legislative and regulatory measures and policies
- Setting of standards and priorities

- Research and development
- International strategy

South Africa's Green Hydrogen Vision must incorporate key strategic design principles, be responsive to competitive market forces and optimise South Africa's natural endowments, including minerals to ensure a long term sustainable, responsive and vibrant sector master plan design:

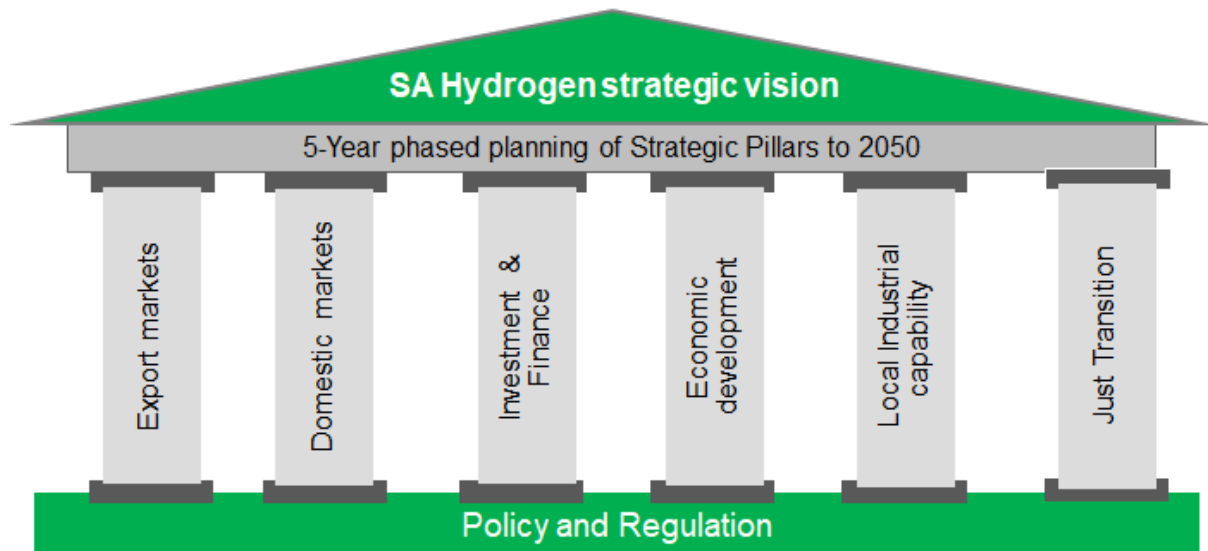


Figure 1: Potential SA Hydrogen Strategic Vision - *Developing a globally competitive, inclusive and low carbon economy by harnessing South Africa's entrepreneurial spirit, industrial capability, strong financial sector and natural endowments.*

The following key objectives should be considered in pursuit of South Africa's Green Hydrogen Strategic vision outlined above:

- 1. Export Markets: secure early positioning for global market share and competitive trade position:**
 - Strategically position South Africa as a preferred and reliable provider to key markets, specifically EU/ UK, leveraging trade relationships and government support.
 - Secure global market and offtake MoUs with national procurement programmes such as H2 Global.
 - Expedite an export pilot project to ensure SA is seen as a serious global player and achieves early market entry.
 - Progress international strategy.
- 2. Domestic Markets:**
 - Introduce supportive policies and a regulatory framework for GH that aids GH price parity to increase domestic GH demand.
 - Support research and development in hydrogen mobility applications, specifically focussed on Heavy Duty Fuel Cell Vehicles.
 - Demonstrate feasibility of GH applications in hard-to-abate sectors such as non-ferrous metals, green steel, and cement in order to foster short term pilot projects and long-term commercialisation.
- 3. Investment & Finance: Foreign Direct Investment and low-cost green finance:**

- Secure international engagements and commitments through green finance programmes to provide grants, concessional finance and export credit commitments.
- Establish a dedicated GH regulatory and market framework attractive to local and foreign direct investment. Include GH incentive schemes for both production as well as local manufacturing that leverage appropriate SEZ development benefits.
- Define government role and financial investment and support for pilot projects in order to expedite and enable private sector investment. Such projects could be declared as Strategic Integrated Projects (SIPs) through Infrastructure South Africa (ISA).

4. Economic and socio-economic development:

- Quantify the benefits and value of emissions reductions and offsets that can be achieved through accelerated GH adoption.
- Focus on decarbonising hard-to-abate industrial sectors in SA economy to ensure they can remain globally competitive through the energy transition.
- Ensure integration of GH renewable energy and broader energy sector coupling through a robust GH sector and regulatory framework and Integrated Energy Plan (IEP).
- Incorporate non-financial criteria in procurement processes that support socio-economic development, skills transfer, local supply and enterprise development, and opportunities for local ownership.
- Develop training and skills development programmes and capacity to support job creation within the GH sector.

5. Local industrial capability and participation

- Target international technology partnerships and transfers to expedite local manufacturing capability. Invest and implement research and development programmes.
- Focus on localised industrialisation and manufacturing for key parts of the GH value chain, with specific consideration for leveraging raw material and beneficiation as a competitive advantage.
- Green industrial sector transition plans should be clear, specifically sectors such as heavy-duty mobility, steel, cement and automotive sectors.
- Expedite development of manufacturing hubs or centres of excellence through SEZ's.
- Work closely with the Department of Science and Innovation and Department of Higher Education and Training to drive the identified skills action plan.

6. Consider the need and role of a Just Transition:

- Analyse and plan for a Just Transition, ensuring appropriate public and social dialogue and understanding.
- Quantify the commercial and economic impact and sustainability of industrial sectors as they invest in decarbonising their businesses through the energy transition.
- Ensure appropriate training and skills development programmes to limit job losses and support employment as industry sectors decarbonise.

- Engage in a social dialogue between workers and their unions, employers, government and communities in order to ensure that GH development contributes to climate change mitigation as well as adaptation.

Work package summary

3 Salient points of literature review

It is abundantly clear that GH is a global focal point due to its versatile nature as a clean energy carrier and ability to decarbonise hard to abate sectors. Benefits in terms of storage, trade and energy efficiency are clear. However significant cost reductions must be realised to make GH price competitive, therefore significant focus on technology and scaling of manufacture capability is necessary. Focus is predominantly on GH with other colour derivatives mostly seen as bridging options. Various technology options for electrolysis are being developed with PEM electrolyzers being of particular interest to SA due to the PGM contribution.

All countries are planning to meet some of their GH demand through local production, but those countries with favourable renewable energy conditions and space are likely to become net exporters of GH vs countries with less favourable conditions and higher demand likely to become net importers.

Multiple countries and regions feature GH as a key strategic contributor to their Net Zero targets. As of 2021, more than 30 countries have a roadmap highlighting over 200 hydrogen projects with governments committing to over \$70 billion in public funding.

The global market for GH is nascent, but countries are already positioning domestic production and potential export market share. Leading countries are already breaking ground on projects. The race for first-mover advantage is under way. South Africa is lagging behind competing export countries such as Morocco, Ukraine, Saudi Arabia, Chile, Australia and others.

Other Key Takeaways:

Carbon pricing is key to pricing in favour of green energy and specifically GH over conventional fossil fuels. This may be a useful leverage point for South Africa, but affordability of the energy transition must be assessed.

Every country's GH strategy is unique to local conditions, production, and sector targets. Some key common themes are:

- **Defining scale of assets and infrastructure** required to meet desired targets. The pace at which scale is reached is crucial as well as choosing **optimal locations for initial projects** with the resources and ability to expand (this should be included in a SA sector master plan);
- **Opportunities for sector-coupling.** This relates to optimising integration with other energy sectors such as gas and electricity infrastructure to deliver low-cost GH (this will be key to ensuring SA global competitiveness and integration with IRP and network planning);
- Seeding **local market focus** areas, for example Australia will focus on heavy road transport and manufacturing. The strategy for South Africa should include key focus areas for prioritisation into the market, for example sustainable aviation fuel or the green steel industry. Localised heavy mobility in the mining sector is also seen as an early mover advantage for South Africa;
- Clear **commercial and market model** to expedite investment opportunities and define the **role of the state**. SA must ensure an attractive investment environment for the private sector to limit the need for state subsidies;

- **Clear policy and regulatory environment** to support the development of the GH sector through well-defined regulatory incentives;
- Identifying focus areas for **Research and Development** to improve technologies and identify initial projects. This will be important for **localisation** and an area SA government should emphasise support; and
- A **social licence assessment** – looking at the holistic impact of the new GH market on domestic socio-economics is key for a South African strategy to ensure a smooth adoption of GH production and a just energy transition.
- The **creation of hydrogen hubs** is being leveraged e.g. Australia's national strategy to support producing hydrogen at a globally cost-competitive price. This would be the equivalent of SEZ's being created in SA but which should differentiate between export production vs component manufacturing hubs.
- Countries identified as dominant **export nodes** are all establishing early mover advantage through a combination of optimised supply chains, early project development and technology pilots.

4 Hydrogen Demand Analysis

GH production will be driven by two distinct markets, namely: export demand as international trade of GH between countries and regions; and domestic demand for fuel switching through applications such as mobility, industrial processes and power.

The demand analysis has been considered from four perspectives, namely:

- 1) Public domain information (studies from IEA, IHS Markit, Sasol, Engie have been shown as potential ranges).
- 2) Using a global GH production cost model developed by PwC, the World Energy Council and the Electricity Research Institute, the forecast of local demand vs production has been used to show net imports or global trade.
- 3) Based on known data of potential export countries, a market share analysis has been completed to assess the likely market share of global trade that SA could capture.
- 4) Local industry data analysis, including marine bunkering trade.

4.1 Export Demand

A global demand baseline for 2050 of 300 to 320 Mtpa is used based on the International Energy Agency's (IEA) Net Zero GH Scenario for 2050. Of this total demand country forecasts indicate circa 90% of this demand (279 Mt GH) could be met through local production within each country or region, indicating a minimum net balance of (27 Mt GH) to be sourced through trading and imports. The primary import markets for GH to 2050 will be the European Union (2050: 11-15 Mt GHpa); Japan (2050: 5-10 Mt GHpa); South Korea (2050: 1.0-1.2 Mt GHpa) and the United Kingdom (2050: 0.5-0.7 Mt GHpa). Depending on long term pricing dynamics of GH, these figures could increase substantially.

It is therefore recommended that South Africa should expedite production capacity for exports targeting a minimum of 2 Mtpa with a master plan that could expand up to 7Mtpa. Depending on global market growth in net imports these SA figures could range from 7% to 30% of global tradable market share when compared to all exporting countries.

The demand analysis shows that SA currently lags other exporting countries and significant intervention by government and the private sector will be required to move to higher levels of market share. By example, leading countries already have detailed sector master plans, are

advancing pilot projects; developing technical expertise and capability; creating investment anchors through the development of GH hubs, and securing bilateral agreements with importing countries.

Included in export demand is potential for marine bunkering of green fuels. SA positioning on east-west global sea trade routes could enable bunkering demand of 0.8 to 1.0 Mtpa in shipping ammonia / methanol marine fuels by 2050.

4.2 Domestic Demand

Given South Africa's energy intensive economy, an important driver of South Africa's domestic GH economy will be decarbonisation commitments made on both national, as well as company levels. Other domestic drivers for South Africa will also include fuel switching and new user applications in mobility, industrial processes and power generation. Current demand for hydrogen in South Africa is dominated by Sasol through the Fischer Tropsch processing for Petro-chemicals but also in key mining applications.

On a similar analysis of demand studies, the domestic market for GH in South Africa has the potential to range between 2 to 6.0 mtpa (million tons per annum). Based on the current price and analysis it is recommended that South Africa should progress capacity development on the lower end of the range (2mtpa - 3mtpa) while keeping close watch of market and price trends. This will require specific incentives, supportive policies and coordination between the public and private sector and further detailed studies will be needed to consider the overall economic cost-benefit impact and value for money proposition of deeper government support and interventions to achieve more aggressive domestic market adoption targets.

4.3 Summary of Demand Analysis

Modelling of demand scenarios and associated costs have been completed with the following broad recommendations:

- Existing private project opportunities identified should be expedited and supported. (these have been identified and plotted in the GH roadmap)
- An export hub (SEZ) at Coega should be prioritised to enable early exports.
- A manufacturing hub (SEZ) at Vaal must be prioritised to enable early manufacturing and technology partnerships.

Expediting the identified early stage projects could result in the 3 - 5-year production target of nearly 300 000 tpa of GH and capital investment of USD 13 billion. Based on a comprehensive country strategy and clear sector master plan a 2040 production target of 4mtpa and capital investment of USD 164 billion could be realised. If global market growth continues to accelerate and based on successful sector development South Africa could continue to increase production to 7 mtpa requiring additional investment of USD 133 billion by 2050. Potential aspiration to 13mtpa total production has been identified but is likely to push beyond 2050 and be very dependent on market development over the next 20 years.

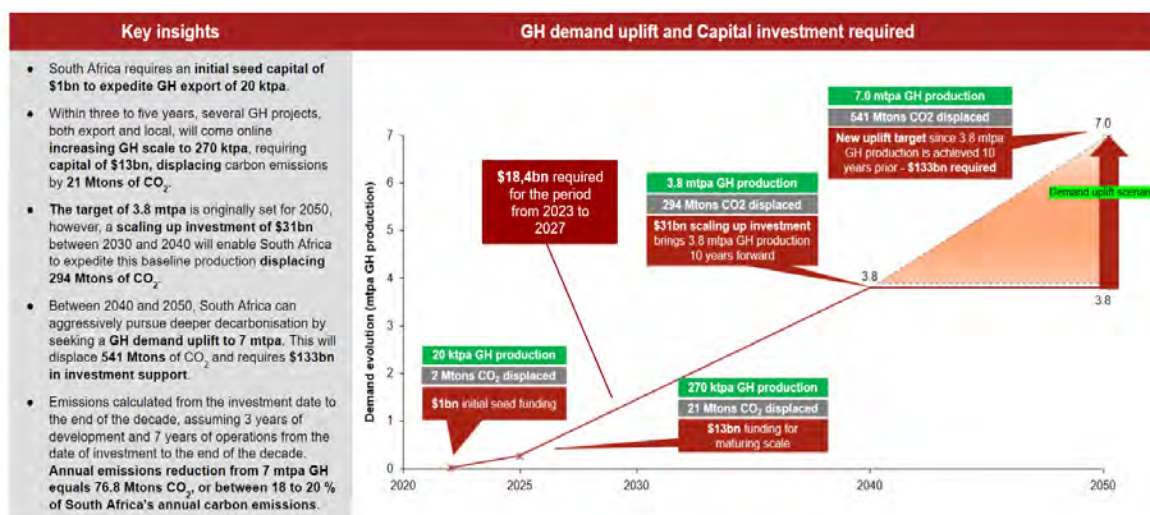
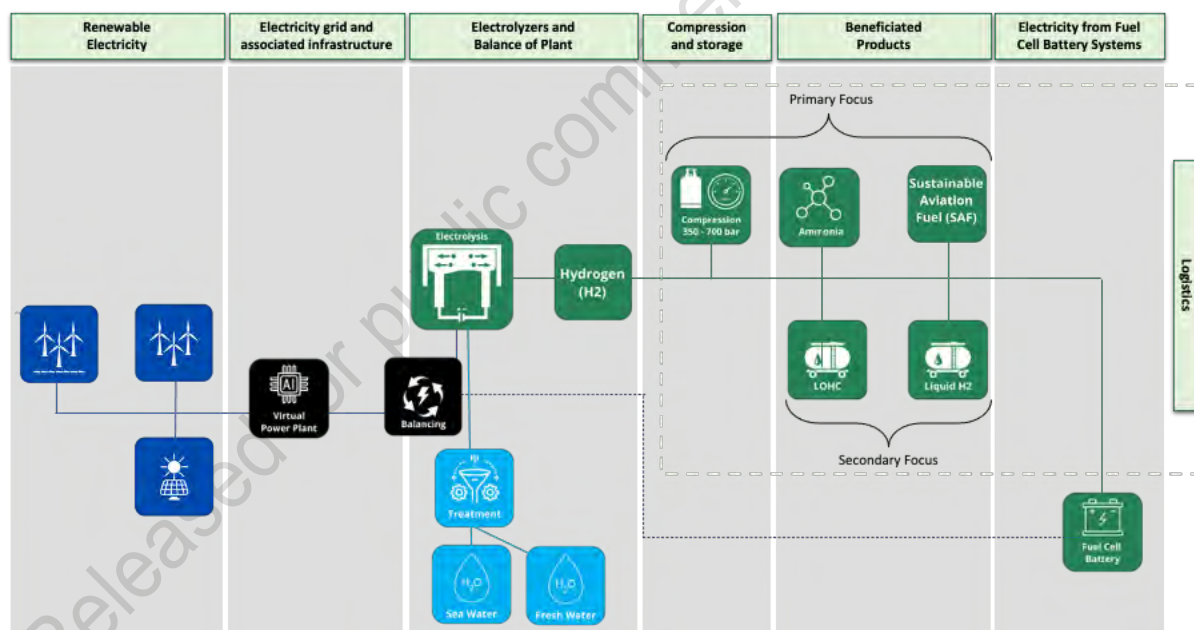


Figure 2: GH Demand projection and capital investment required.

5 Value Chain Analysis

The primary value chain elements defined and analysed in the report are outlined in the graphic below.



Since the value chain touches on land, water, energy, natural resources, logistics and finance, it will require significant co-ordination between the various government departments, public sector institutions and the private sector. To enable a GH project requires interaction with the following departments and / or state entities (non-exhaustive): Water Affairs and Sanitation; Agriculture, Forestry and Fisheries; Environmental Affairs; Human Settlements; Trade, Industry and Competition; Mineral Resources and Energy; Transport; International Relations and Cooperation; National Treasury; NERSA, Transnet (TNPA); and the Ports Regulator; and Infrastructure coordination through Infrastructure South Africa (ISA).

Global projects largely fall into 2 categories as follows: a) large scale GH projects for multiple GH customers or open markets, and b) isolated or co-located GH production for specific use case/s. Such in-house or specific user projects are simpler to develop and quicker to market as they solve in-house demand challenges and use carbon incentives for fuel switching to fund these projects from internal resources.

To get to GH production levels advocated in global forecasts i.e. contributing 15-20% of global primary energy demand by 2050, it is estimated that more than two million GH projects will be required globally consisting of large scale but mostly smaller isolated/co-located GH projects.

This emphasises the importance of a holistic master plan that does not treat the sector development under a “one-size-fits-all” approach. While SEZs and state supported hubs are important enablers, direct user-case projects and private sector led developments should also be recognised and incentivised (an example of a such a private sector led development would be the Hydrogen Valley). SEZ hubs can be categorised as export focused or manufacturing focused and detailed analysis is included in the report.

Irrespective of the size or type of project, all GH projects will face similar price parity pressure in order to secure and grow market share. This emphasises the need for sector coupling, integrated planning, lowest capital cost and efficient supply chain development to produce the least cost product in the market.

By focusing on leveraging its natural endowments and engaging strategically with industry players to localise production / assembly of key components for GH production through strategic hubs, will allow South Africa to maximise its participation in the GH value chain.

Estimated total capital investment of **\$164bn** (indicative in 2021 terms, investment over 15 years including learning curve estimates)

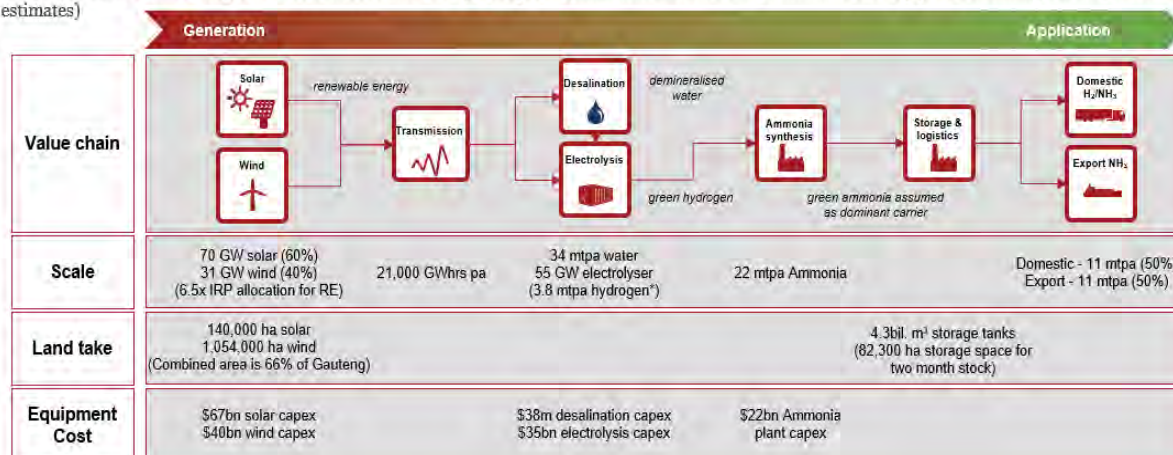


Figure 3: Value Chain components of GH

6 GH localisation and manufacturing opportunities

As the most industrialised economy in Africa, South Africa has the benefit of a strong balance between export and domestic demand. This provides a larger market opportunity for stronger localisation and manufacture of both SA production demand as well as becoming a global competitor for supply of components and equipment for GH.

The projected SA GH production ramp-up implies end state electrolysis installed capacity of between 48GW (3.8Mtpa GH) to nearly 90GW. In the near term an estimate of 13 GW of

installed electrolyser capacity is required by 2030. Based on discussions and an understanding of international OEM operations, South Africa requires approximately 0.5-1GW/year in order to anchor local manufacturing. To match this level of electrolysis production of GH, an additional 17GW PV and 8GW wind deployment is required by 2030. This scale of renewable energy demand provides further opportunity for localisation and economic benefits through construction and operations etc. Grid capacity is however seen as a short-term constraint and will also require further investment.

Under the demand analysis it was emphasised that all countries requiring GH are to some extent trying to develop local production capability. Although this reduces the demand for net import of GH product from South Africa, the manufacturing and supply opportunity can target the full global market requirement for both electrolysis as well as fuel cell components.

As the largest global producer of platinum-group metals (PGMs), producing more than 72% of the world's PGM demand, as well as having other important renewable energy mineral endowments, this global component manufacturing demand has emerged as a very attractive industrialisation opportunity for South Africa. PGMs in particular are used as a catalyst in polymer electrolyser membrane (PEM) electrolyser and multiple fuel-cell technologies but are largely beneficiated outside of South Africa.

PGM beneficiation to produce equipment used in GH equipment supply chain (i.e. catalyst coated membrane (CCM) and membrane electrode assembly (MEA)) is also a nascent market. However, to the extent that South Africa can leverage its raw materials endowments as a competitive advantage, it is estimated that South Africa could become a dominant global supplier of such equipment. In this regard, the country has a window of opportunity to develop PGM based component manufacturing capacity and position itself to claim a considerable portion (15-30%) of this global market. CCM and MEA component manufacture alone is estimated to exceed USD 100 million by 2030 with significant expansion opportunities beyond that as the market scale accelerates beyond 2035.

South Africa's attractiveness to promote localisation opportunities are therefore it's

- Abundant local resources, particularly PGM's.
- Abundance of renewable energy resources (wind and solar).
- Large land availability served by a transmission grid that is the size of Europe.
- Established manufacturing, engineering, and technical expertise to support a developing manufacturing industry as well as the operation and maintenance of the hydrogen production plants.

Support to assist existing local content must be the highest priority. Several existing local system and component manufacturers and system assembly entities are already established. Supporting these entities will ensure scale up of capabilities, getting components and systems in demonstration and pilot projects, thereby building confidence in South Africa's GH products and capabilities.

7 Supply chain and GH Hub development

7.1 Identification of hydrogen hub and Supply chain analysis

Based on analysis and industry engagement, the following SEZ hubs have been identified as preferred locations for GH development to support exports and manufacturing. When considering the technical Value Chain definition outlined above, it is evident that supply chains can be designed on 2 models as follows: a) co-locating renewable energy (RE) and production equipment (electrolysis process) and evacuation of the product or GH molecules by transport or pipeline if economies of scale can be achieved. Or b) locating Production (electrolysis process) near the demand node and evacuate RE via wheeling on the national grid or

dedicated grids if economies of scale can be achieved. Distribution of hubs and supply chains are shown in the Figure below.

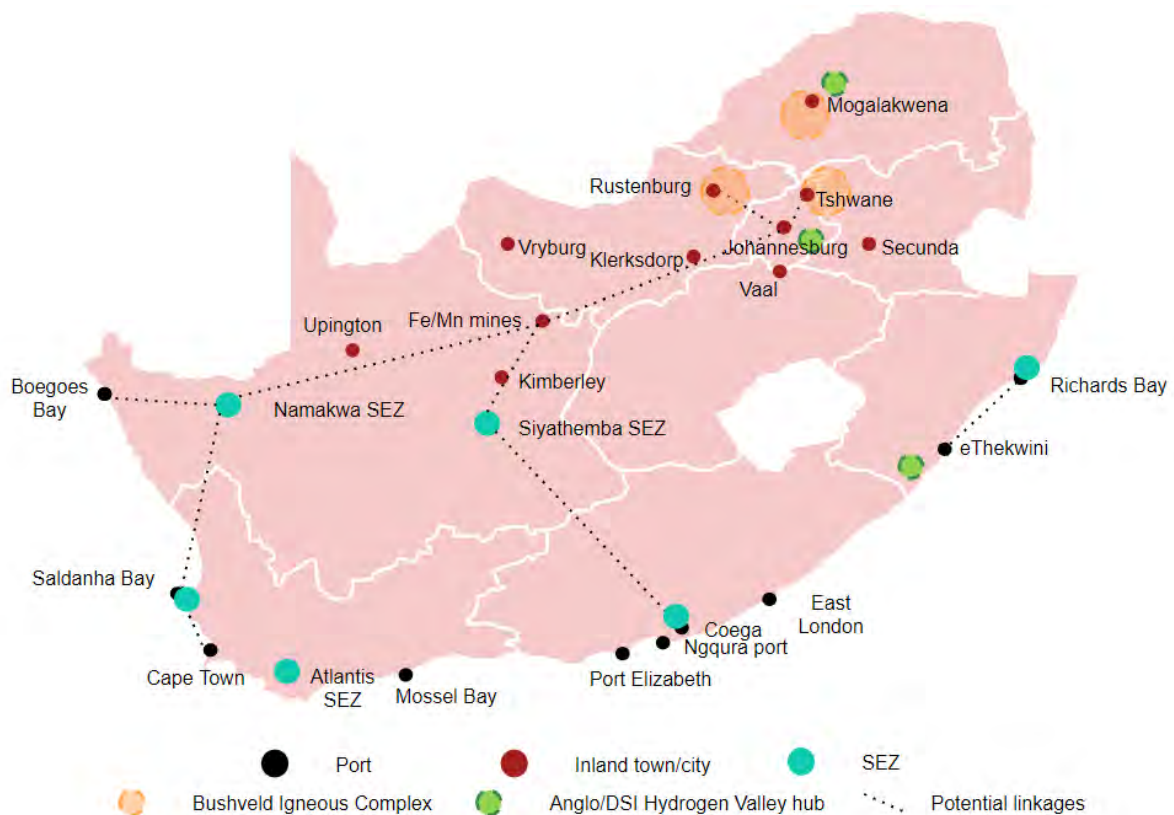


Figure 4: Geographic location of potential GH hubs

7.1.1 Overview of key options

At a strategic review level, the preferred priority hubs based on a criteria analysis such as status of infrastructure, location and cost would be to target the Boegoebaai GH hub in the Northern Cape, Coega and Freeport Saldanha as export hubs and Vaal as a priority manufacturing hub. These locations can develop quickly and have strong political sponsors to support expedited development. **Supporting the efforts by the Northern Cape Economic Development Agency in the development of the Boegoebaai programme needs to be given top priority.**

This does not preclude the development of other hubs or supply chains but as stated above, it is evident that SA must accelerate the GH sector development to be seen as a market leader.

Inland, the Vaal Triangle is an attractive location due to the concentrated industrial manufacturing activity developed over the years, including Sasol's Sasolburg plant, ArcelorMittal's (AMSA) steelworks, and Safripol's polymer processing. The Vaal would specifically focus on domestic uptake of GH (Sedibeng District Municipality, 2012) and could also serve the purpose of anchoring GH in the PGM industry; the existing pipeline infrastructure could also be used to transport GH across the North West, Gauteng, Limpopo, and Mpumalanga where most PGM activity occurs.

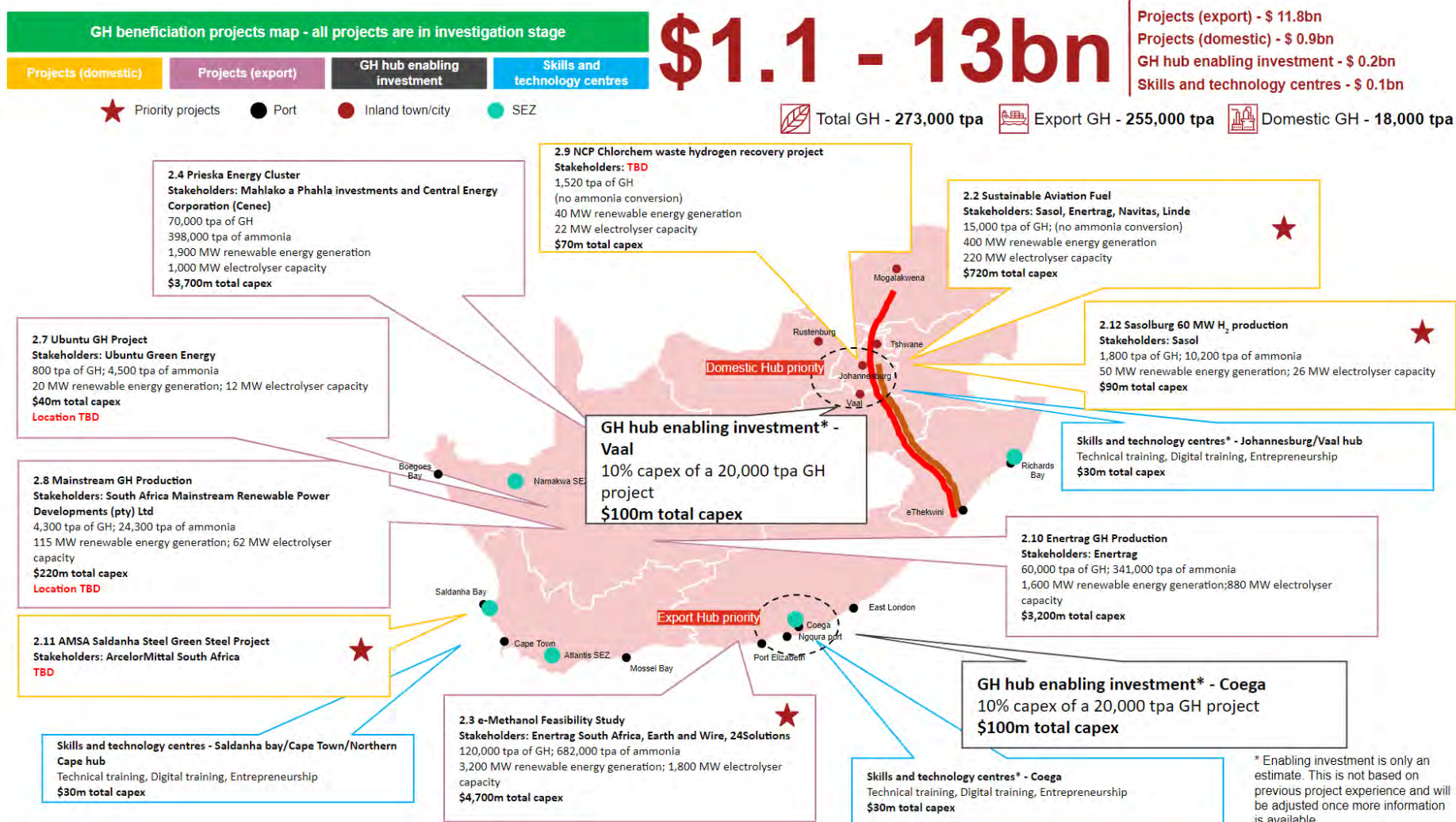


Figure 5: Capital investment support needed for GH production projects to be commissioned in 2025

8 Designing an Enabling ecosystem

Key ecosystem enablers that will help make South Africa a globally competitive player in the GH economy include GH Skills development, Regulation and Financing mechanisms.

8.1 Skills development for a successful GH economy

The creation of a hydrogen economy will require new skill sets as well as an increase in capacity of a productive workforce. A key benefit is that such new skills can be broadened to include a green economy and only to service the GH sector. It is well documented globally that for equal investment, renewables and green sector development creates 3 - 4 times the amount of jobs as fossil fuel sector investment. The broadening of skills must include aspects such as climate mitigation, circular economies and the social compact for a Just Transition. A holistic skills development approach should include the following steps at a minimum:

- Determination of future skills and roles in the green energy and hydrogen sector;
- Understanding of SA skills and competencies capacity and alignment to above; Understanding and the creation of the skills pipeline in the Higher Education Sector (including TVET);
- Inform Learning and Development initiatives and investments;
- Inform the Strategic Workforce Planning conversations; and
- Understand and inform diversity and inclusion initiatives.

Skills development must be done through both public and private sector and should include reskilling or upskilling initiatives to build and grow local capacity; these initiatives can be incentivised through SETA funding with a long-term view to support upskilling in tertiary and technical institutions. The skills required for a successful GH economy have been discussed in the report and are outlined in the figure below.

Value chain	Localisation opportunity (Priority)	Skills required	Skills sourcing	Government can build local skills capacity by...
Renewable Energy generation	Hydrogen and renewable energy specialists (High)	Circular economy skills Green architecture and future cities planning skills Green engineering and tech skills Natural capital skills Sustainable agriculture skills	Outsource Outsource Local, but limited Outsource Local, but limited	• Incentivising the private sector to support local capacity as they outsource for missing and limited skills. • Support educational institutions with development and funding of training programmes focused on the GH industry. • Creating financial incentives for the private sector to roll out upskilling initiatives.
Electrolysers and Balance of Plant	PGM mining and processing (High) Recycling of used PGM products (Medium)	Technical engineering (renewable, marine) Circular economy skills	Local, but limited Local, and growing	• Incentivising the private sector to support local capacity as they outsource for technical engineering expertise specific to electrolyser manufacturing • Supporting the roll out of upskilling initiatives through funding and financial incentives to encourage quicker uptake by the private sector
Beneficiated Products	CCM* and MEA* electrolyser component manufacture (High) Fuel cell stack and systems manufacture (Medium) Automotive manufacture (Medium)	Circular economy skills Green engineering and tech skills Manufacturing and Assembly Circular economy skills Green engineering and tech skills Manufacturing and Assembly	Local, but limited Outsource Local, but limited Outsource Local, but limited Local, but limited	• Incentivising the private sector to support local capacity as they outsource for technical engineering expertise specific to CCM and MEA component manufacturing, fuel cell stack manufacturing, green engineering, and circular economy integration. • Supporting educational institutions with development and funding of training programmes focused on the GH industry.
All	Systems Integration and Operation and maintenance (High)	Manufacturing and Assembly Circular economy skill Environmental justice skills Green career pathways Green architecture and future cities planning skills Operations management and system integration skills	Local, and mature Local, but limited Local, and growing Outsource Outsource Local, and mature	• Incentivising the private sector to support local capacity as they outsource for missing and limited skills. • Incentivising the private sector to roll out upskilling initiatives to develop growing skills, through funding models and financial incentives • Developing ecosystem and research partnerships to diversify mature skills into other segments of the GH value chain and other industries.
Foundational skills South Africa has developed strong expertise in		Ancillary and support services/ Architecture and Engineering design services/ Business and Management services Construction/ Finance and Legal services/ Information and Communications Technology/ Insurance and Healthcare services Logistics and transport/ Manufacturing and Assembly/ Risk Management/ Skilled labourers/ Technical engineering		

* CCM (catalyst coated membrane) and MEA (membrane electrode assembly)

Figure 6: GH Skills matrix

8.2 An enabling GH regulatory framework

South Africa does not currently have a dedicated GH regulatory framework. Thus far, pilot projects have been implemented within the confines of South Africa's existing regulatory frameworks and laws, of which many implicitly support the development of GH projects.

Considering the opportunities that GH presents, and the sector complexities highlighted in the report, the government should consider introducing a set of regulations specifically aimed at promoting South Africa's GH economy. Based on the preliminary assessment, key regulatory recommendations include, but are not limited to the following:

1. Prepare a GH Regulatory Development Timeline:

- a. The timeline must, where practicable and relevant, detail the timing of the review of the relevant law and/or including the expected date for the promulgation of new law and policy based on actions outlined in the commercialisation roadmap.
- b. Outline timed regulatory responses for the GH industry in alignment with anticipated technological and commercial developments. This includes the introduction of incentive mechanisms, as well as the phase out of incentive mechanisms once economies of scale and GH price parity is achieved.

2. Develop objectives for how the GH industry should be regulated.

- a. Agreeing on regulatory objectives would simplify coordination of regulatory responses across government departments given the overarching objective would be consistency across all sectors and departments.
- b. A key element in this regard would be to ensure that integrated stakeholder management processes and coordinated public sector responses are in place in order to align public and private sector opinions and inputs.
- c. Conduct feasibility studies to establish the financial impact and benefits of possible GH regulatory incentive mechanisms.

3. Develop a set of regulations specifically aimed at creating enabling environment for green hydrogen

- a. Utilise section 19(1) of the National Energy Act to introduce regulations that regulate and support South Africa's GH economy and includes measures and incentives designed to promote the production, consumption, investment, research and development of GH.
- b. Consider and leverage other existing laws and policies that could support the uptake of GH.
- c. Develop GH standards and specifications related to production, storage, transportation, refuelling and end-use applications based on international standards and best practice such as ISO 19880-1:2020 related to Gaseous hydrogen, SAE International standards (SAE J2601/2, "Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles," and SAE-J2601, "Fueling Protocols for Light Duty Gaseous")

4. Introduce regulatory measures to support South Africa's GH export market

- a. Introduce measures for GH SEZs to produce and export hydrogen at a cost competitive price.
- b. Design and introduce a Guarantees of Origin system that aligns with international standards such as the EECS (European Energy Certificate System) in order to install investor confidence in key import nodes.

5. Introduce regulatory measures to support South Africa's domestic green hydrogen market

- a. Introduce explicit and implicit carbon pricing mechanisms coupled with GH revenue recycling mechanisms.
- b. Build on existing renewable energy-based regulatory tax incentives set out in the Income Tax Act to support the GH value chain.
- c. Introduce a single institutional body to expedite licensing and permitting processes and facilitate the development of the GH sector.

8.3 Securing availability and low-cost finance

Although there is a growing investment appetite globally for “green investment”, given the market maturity, risk and complexity of the value chain, financing green hydrogen projects will still require innovative financing structures and support to achieve bankable projects. Ensuring that the financing landscape incentivises investment both from local and international sources is also critical.

The broad principles of traditional project finance are likely to apply, necessitating collaboration by government, local and international development finance institutions, multilateral financing agencies, local commercial lenders and private sector investors to achieve bankable transactions. Given the anticipated involvement of international OEMs, export credit agencies are another key stakeholder. As discussed earlier, strong bilateral and trade relationships and agreements with developed country GH programmes should be pursued by government.

Globally, various forms of funding mechanisms are being applied to enhance the financing landscape, including:

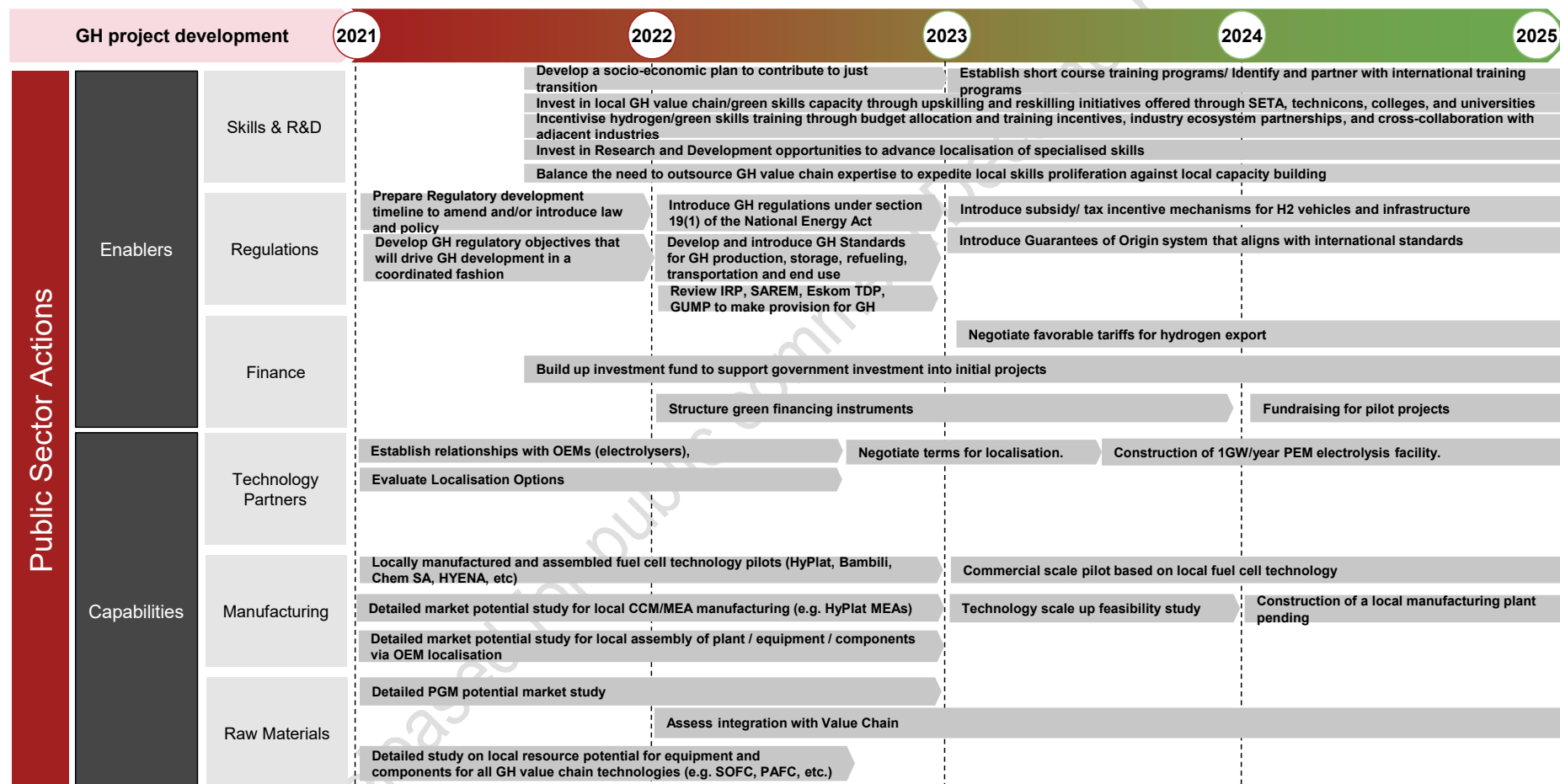
- **Government on-balance sheet finance**
Direct public funding, green/project bond financing and partial guarantees;
- **Government to government enablement**
Concessional finance and technical assistance grants, climate swaps and emissions credits;
- **Private finance**
Public-private partnerships;
- **Development finance**
Leveraging funding from developed markets specifically set aside to support the green transition in developing/carbon intensive countries; leveraging funding from export credit agencies and blended finance mechanisms.

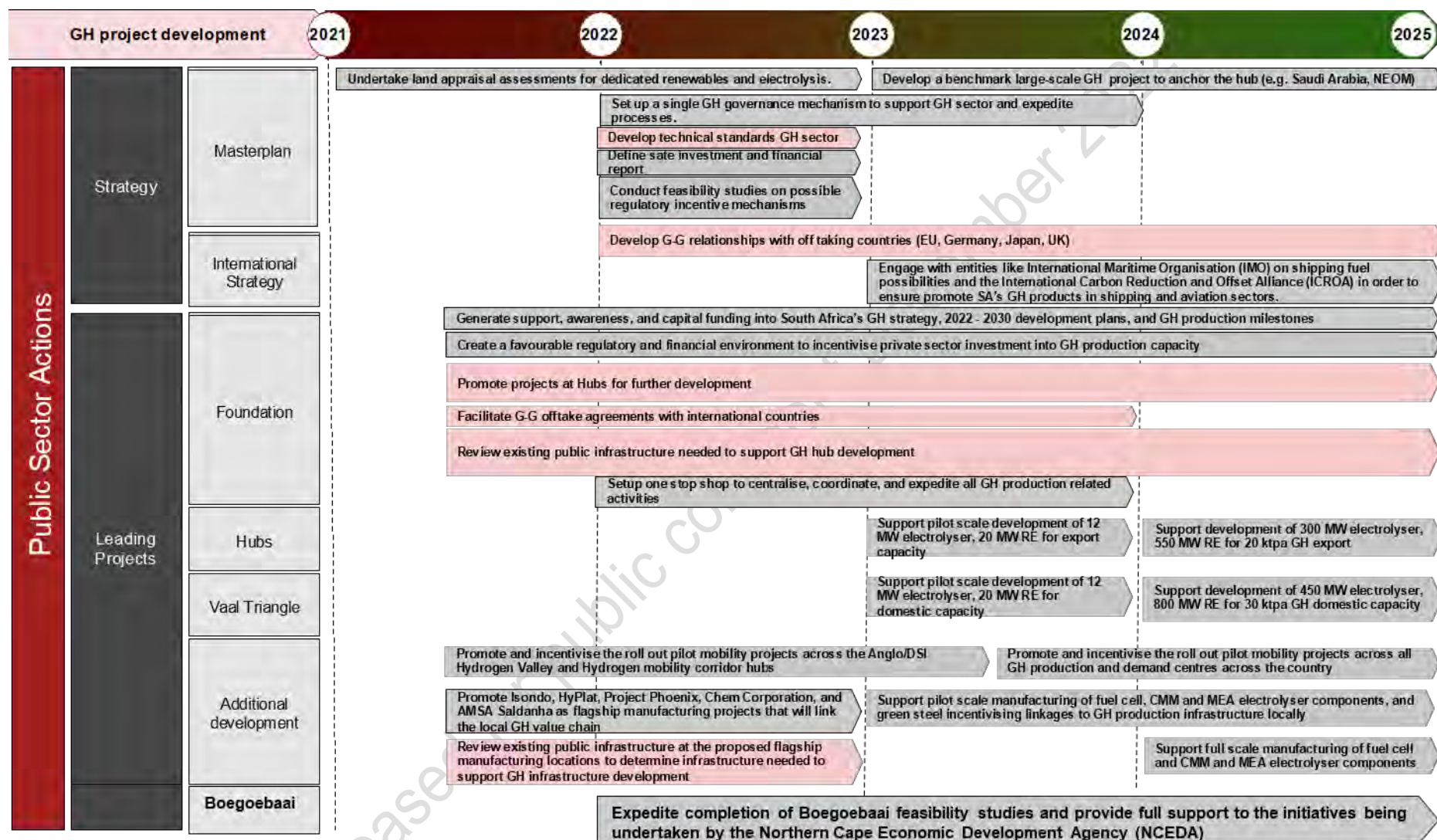
Possible innovative sources of funding for government to support the above objectives include:

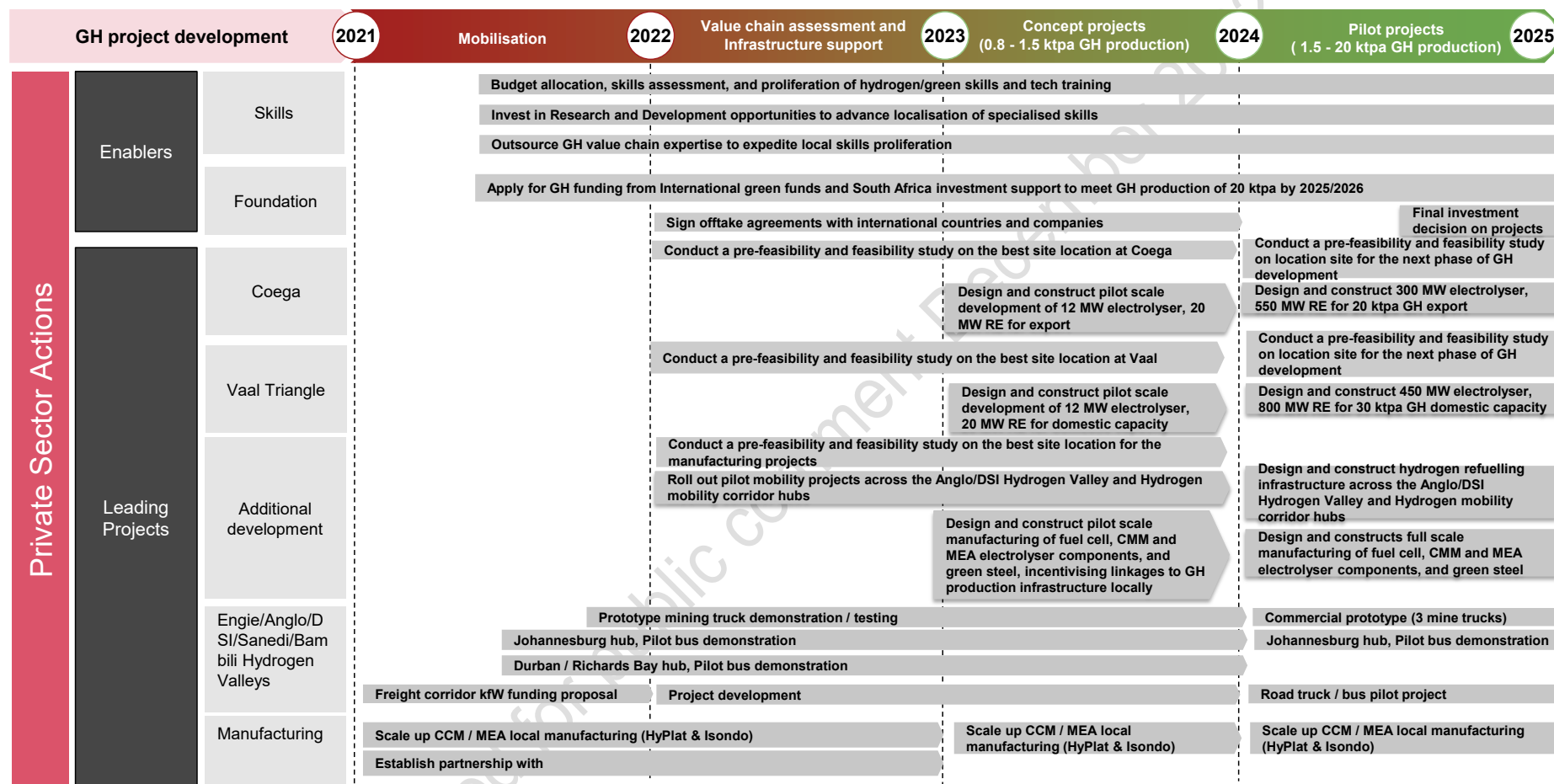
- issuing a government-backed green bond;
- introducing special, marginal levies on existing carbon fuel consumption (e.g. additional levy on fuel at the pumps) which could generate a pool of funding which could be applied to the country’s movement towards greener fuels; and
- redirecting income from carbon taxes towards green initiatives.

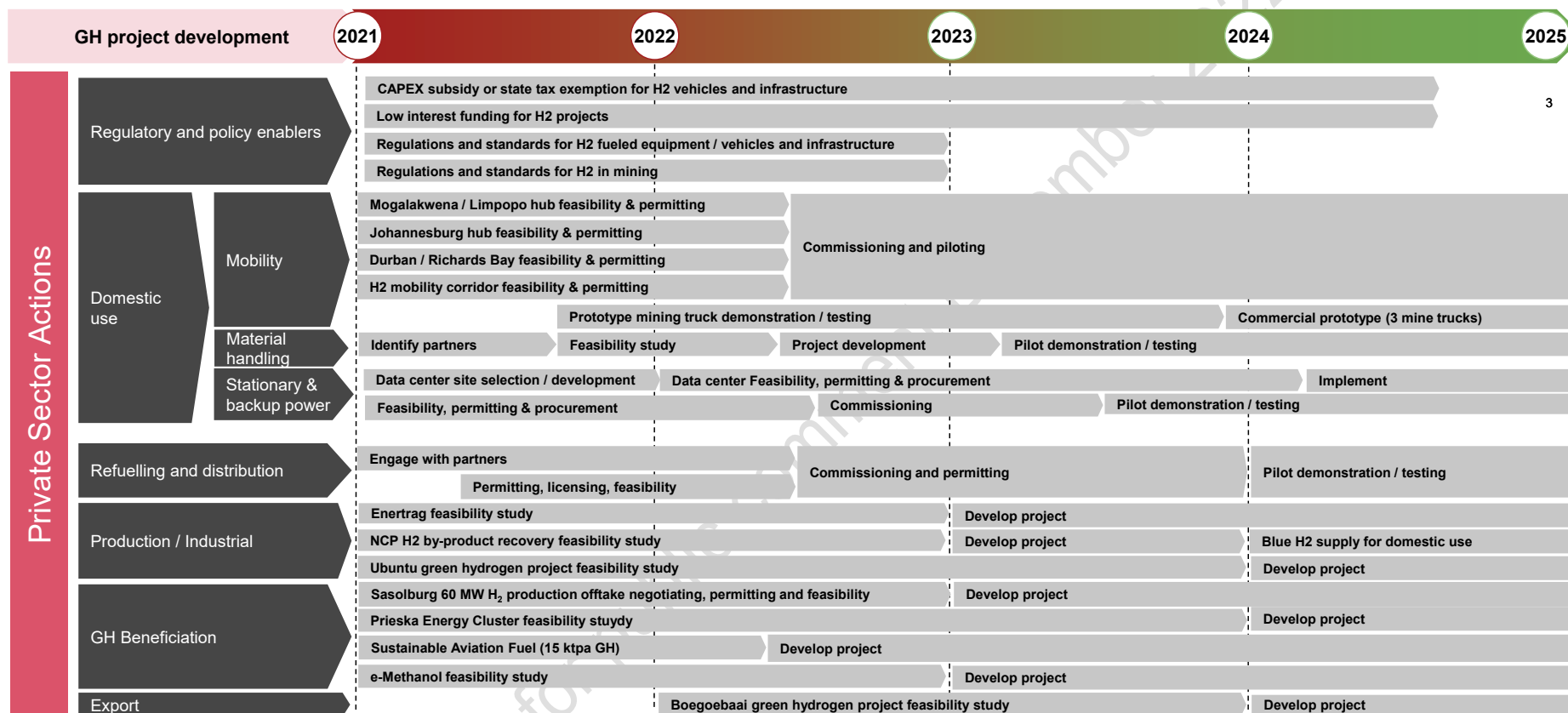
9 GH Commercialisation Roadmap and Funding Plan

9.1 Short-term Roadmap (2021-2025)

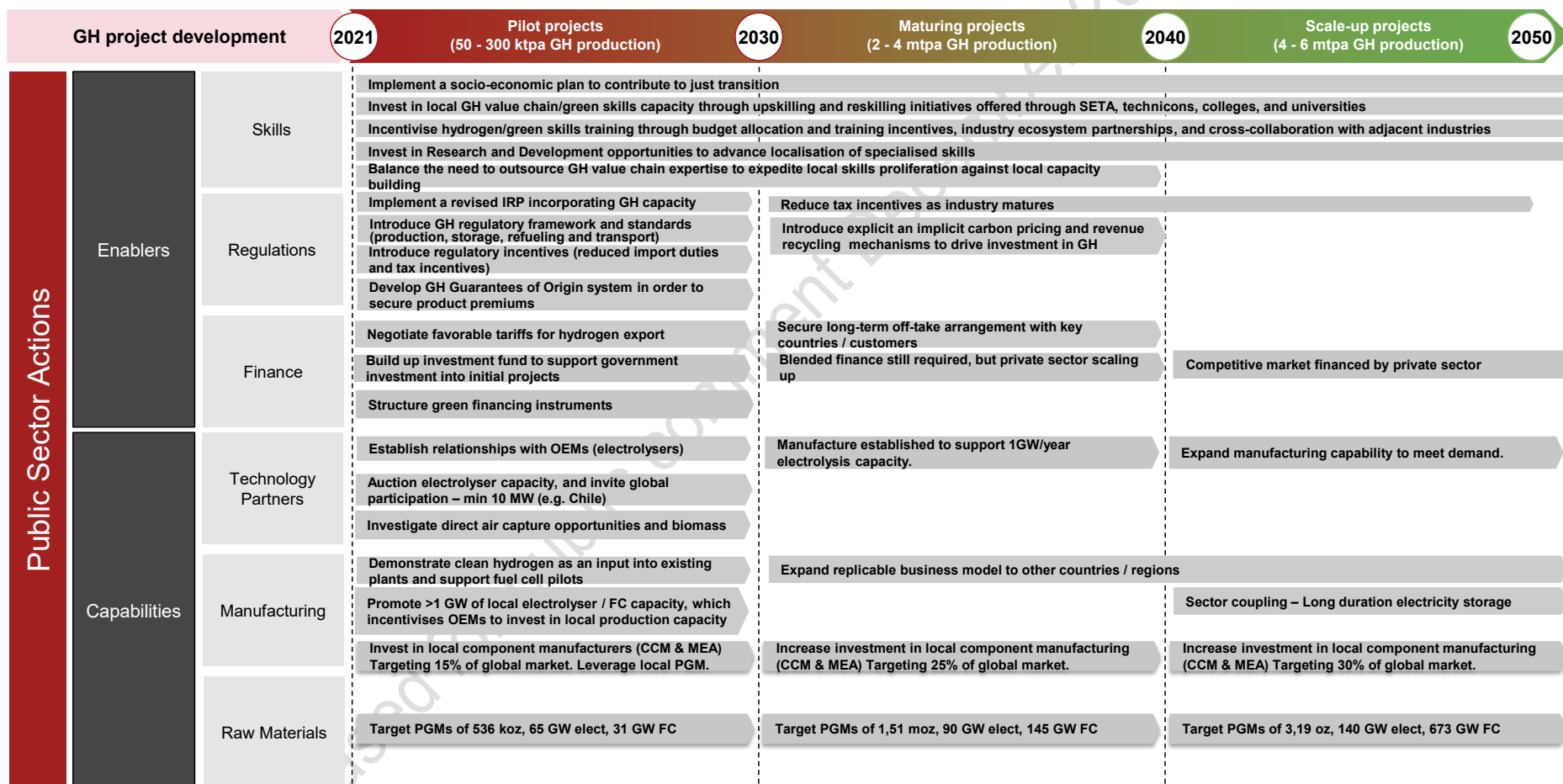


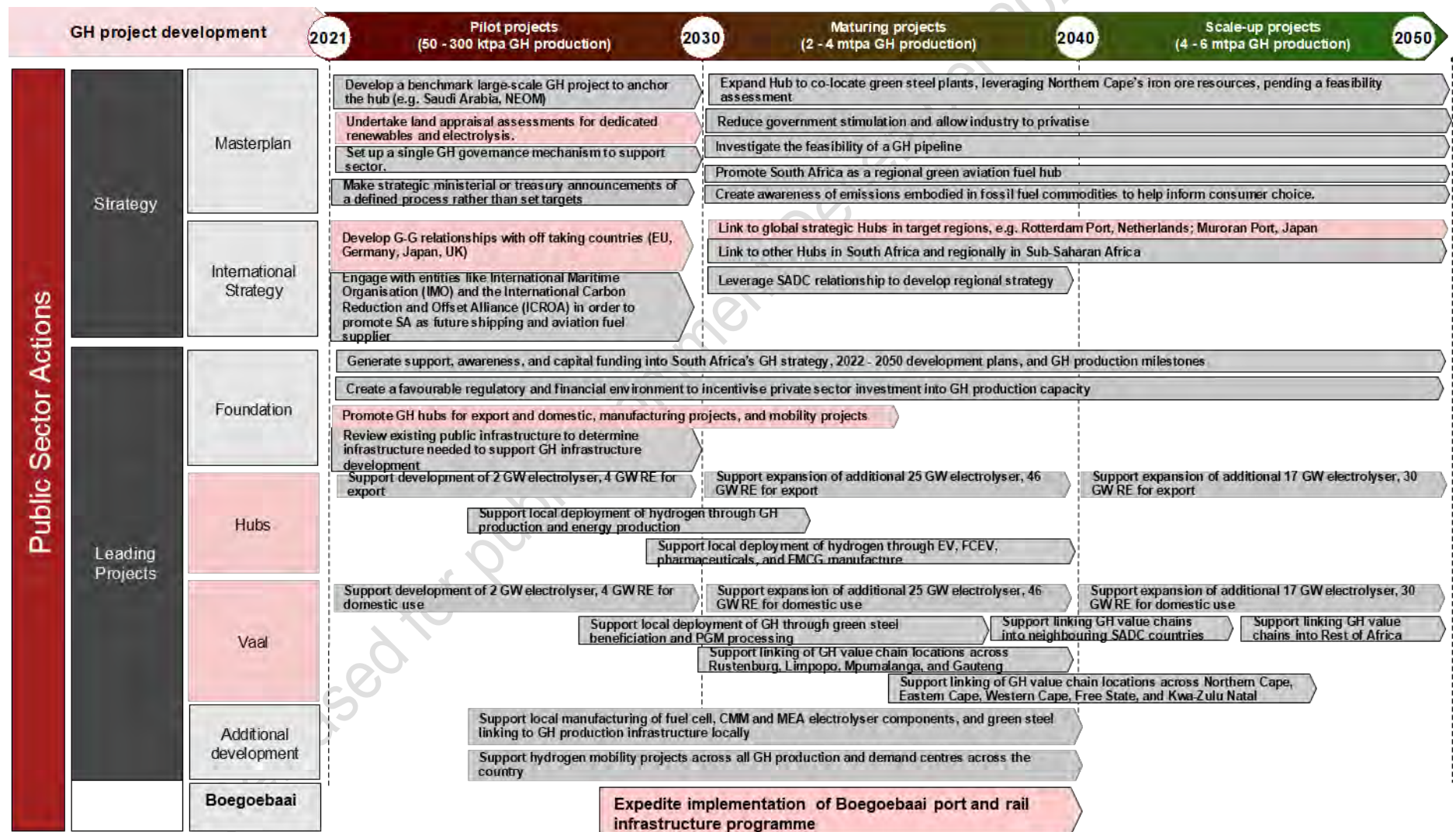


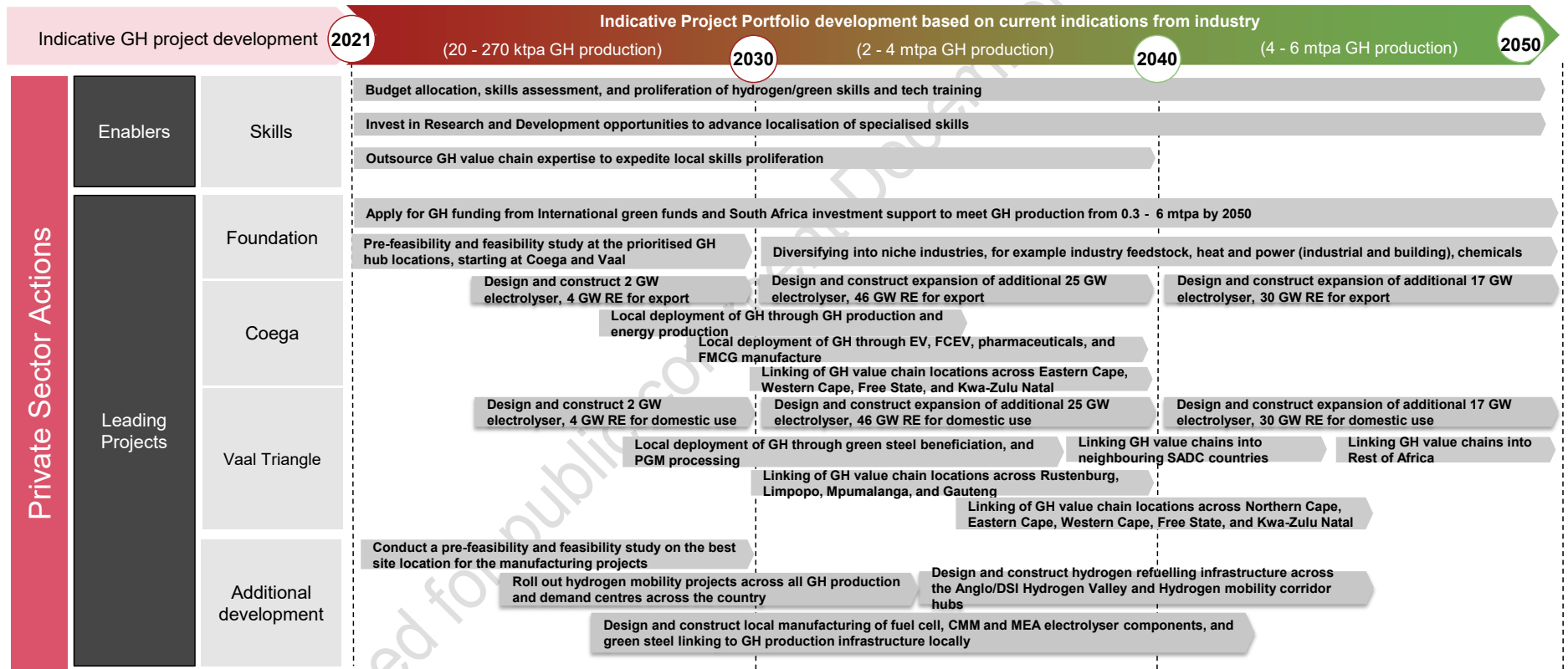


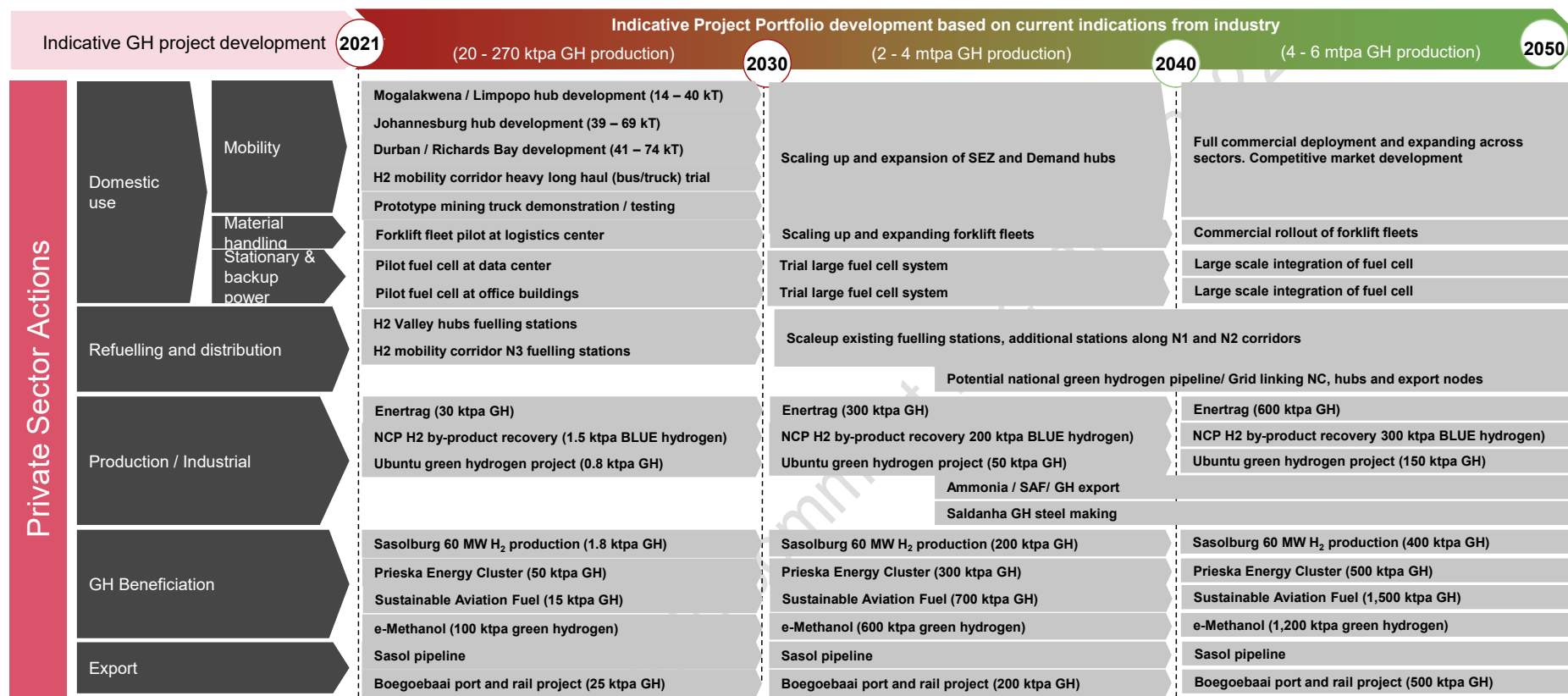


9.2 Long-term Roadmap (2021-2050)









9.3 Short term funding plan (2023-2027)

Based on the projected production targets, required projects and the roadmap actions, investment needs for the period from 2023-2027 is summarised below.

Funding for project development (pre-feasibility and feasibility studies)	
Description	ZAR billion
Sustainable Aviation Fuel Production	0.10
e-methanol Production	0.12
Fuel Cell Manufacturing	0.16
GH and Green Ammonia Production	3.70
Green Steel Production	0.20
Hydrogen Mobility	0.10
Infrastructure	0.13
Port project development	1.00
TOTAL	5.51
Capital Costs for the implementation of the above projects	
Description	ZAR billion
Sustainable Aviation Fuel Production	8.00
e-methanol Production	12.00
Fuel Cell Manufacturing	1.40
GH and Green Ammonia Production	109.30
Green Steel Production	13.20
Hydrogen Mobility	6.60
Infrastructure	13.00
Port infrastructure capital	150
TOTAL	313.5
TOTAL FOR PROJECT DEVELOPMENT AND CAPITAL COSTS FOR IMPLEMENTATION	319.01 (\$18,4bn)

9.4 Summary of Commercialisation Strategy

The successful implementation of the commercialisation strategy will depend on the execution of the six key elements :

1 PRIORITISE EXPORTS	2 STIMULATE DOMESTIC MARKET	3 SUPPORT LOCALISATION	4 SECURE FINANCING	5 PROACTIVE SOCIO ECONOMIC DEVELOPMENT
Target exports of green hydrogen and green chemicals by leveraging on South Africa's proprietary Fischer Tropsch technology and utilising financing support mechanisms including grants, concessional debt and contract for difference / price subsidies to improve the financial viability of these projects	In parallel to the export strategy, develop projects along the value chain to stimulate demand for green hydrogen in South Africa. "Low hanging fruit" opportunities to be prioritised to provide confidence in the domestic market. Examples include green steel, hydrogen valley mobility programme and sustainable aviation fuel projects.	Develop local industrial capability to produce fuel cells, electrolyser, ammonia cracking and balance of plant equipment and components by leveraging on South Africa's PGM resources. Together with demand stimulation this will drive longer term GH ₂ price reduction allowing penetration in various sectors.	"Crowd in" and secure funding from various sources and in various forms including grants, concessional debt and contract for differences.	Maximise development impact (incl. skills and economic development and social inclusion). Ensure gender equality, BBBEE and community participation. Maximise job creation and alternative options for potential job losses.
6 ROLE OF GOVERNMENT IN POLICY AND REGULATORY SUPPORT Position GH ₂ as a key early contributor to decarbonization and a just transition in the country programme of work being collated by the JET-IP Task Team ensuring a fair proportion of climate finance is sourced to enable development of this industry. Prioritize the execution of the green hydrogen commercialisation strategy and the development of a national GH ₂ infrastructure plan Drive the required policy and regulatory changes required to sustain long term growth of the new hydrogen industry. Mobilise and coordinate the Government support required to support the development of this new industry for South Africa.				