GREEN HYDROGEN COMMERCIALISATION STRATEGY FOR SOUTH AFRICA

FINAL REPORT

Executive Summary

17 October 2023

1. The opportunity presented by GH_2 for South Africa

South Africa (SA), as a globally integrated economy has committed to domestic decarbonisation. While decarbonisation is being driven by science and direct climate change evidence, international policy impacts have the potential to threaten existing high carbon content supply chains. At the same time there exist opportunities for countries to engage with new and sustainable value chains in order to domestically decarbonise supply chains and create new export opportunities.

The conversion and storage of natural energy resources such as solar, wind and water into transportable and tradeable green molecules, such as green hydrogen (GH_2) is a critical part of decarbonising hard-to-abate industries and satisfying future global energy demand. GH_2 largely refers to hydrogen produced through electrolysers utilising an electricity input that is generated from renewable energy (RE) sources. GH_2 has the potential to decarbonize more industrial processes than RE alone by replacing fossil fuel inputs in these processes.

South Africa is a highly carbon intensive economy through coal-based electricity generation and petrochemical production. South Africa does however possess advantages in the development of the GH_2 value chain namely abundant solar and wind resources, land availability, an existing industrial and specifically petrochemical base, existing production, storage and transportation of grey hydrogen and associated chemicals, combined with access to key metals and minerals in the PGMs and battery minerals value chains. Further, SA has access to key production technologies and the skills and resources that surround them, a robust financial system, globally recognized renewable energy programme and inclusion of GH_2 as a key element of the Government's energy transition plans. This provides an opportunity for domestic industrial decarbonisation and manufacture of beneficiated green products for export. The GH_2 industry will establish South Africa as a green export economy and future energy market global trader, securing FDI, earning foreign income and creating economic growth and development by export of, among other products, green steel and green chemicals including green hydrogen derivatives such as green ammonia, aviation fuel, e- methanol and marine bunkering fuel. South Africa will also be able to position itself as a global equipment manufacturing hub in the green hydrogen value chain by targeting the manufacturing of electrolyser, fuel cells, renewable energy equipment, balance of plant equipment, battery storage components and associated components.

As this new GH_2 industry is developed for South Africa, significant opportunity exists to support the Just Transition. The Just Transition focuses on the transition away from coal towards cleaner sources of energy to achieve an inclusive, low emissions and climate resilient economy. This requires a transition that is equitable to workers and communities and is better for our people and planet. Transitioning away from fossil fuels will require the training and re- skilling of workers and communities reliant on fossil fuel industry. The development of new GH_2 value chains presents the opportunity for proactive socio-economic development while ensuring resilience of the various industrial and agricultural sectors that GH_2 will benefit.

Significant investments into renewable energy for electrification is urgently required. In parallel, the development of the GH_2 value chain will require significant investments into renewable energy generation. It will be essential to ensure that this does not redirect investments intended for electricity security within the country. Devoted renewable energy infrastructure for electricity generation will have to occur alongside investments into renewable energy for GH_2 production. Priority will be placed on renewable energy generation for electricity generation rather than for GH_2 projects, however the opportunity to provide energy security in grid constrained areas off the back of GH_2 value chains should not be under-estimated. While GH_2 is highly unlikely to solve South Africa's electricity crisis alone[3], GH_2 can play a potential role in electricity generation and the intermittency challenges with solar and wind generation.

2. The need for a commercialisation strategy

The GH_2 opportunities present a significant overarching commercial opportunity for South Africa to build resilience and sustainability into existing fossil fuel enabled industrial and agricultural sectors while developing new value chains to drive growth and development, employment, improve energy security and to transition to a lower carbon economy and society. This opportunity also presents a series of complex challenges and decisions for stakeholders. Alignment between the various policies and processes that govern the Just Transition, national climate ambitions (including Nationally Determined Contribution), the Just Energy Transition Implementation Plan (JET-IP) and value chain-specific support measures is paramount. Additionally, South Africa has a strong history in GH_2 with significant work undertaken by the HySA programme from 2008 under the guidance of the Department of Science and Innovation (DSI). This included various demonstration projects in the country across the value chain. The Presidency announced in June 2021 that GH_2 has been identified as the first of the five "Big Frontier" strategic investment opportunities. Additionally, the Hydrogen Society Roadmap (HSRM) developed by the Department of Science and Innovation was approved by Cabinet and released to the public in February 2022. This solid historical base supported the move to a commercialisation phase for GH_2. It is within this context that the Minister in the Department of Trade and Industry mobilised a green hydrogen panel (GHP) to develop the national GH_2 commercialisation strategy (GHCS).

The aim of this GHCS is to outline the commercial opportunity, development approach and action plan for a viable GH_2 industrial sector. A GHCS must align to national objectives whilst being responsive to competitive market drivers and success factors. The South African GH_2 strategic vision is to develop a globally competitive, inclusive and low carbon economy by harnessing South Africa's entrepreneurial spirit, industrial strength and natural endowments. The role of the GHCS is to align on national co-ordination and a shared vision, provide policy certainty, encourage investors, guide decision makers (government and private) and ensure proactive industry development. The GHCS aims to achieve the following objectives:

- Secure early positioning for global export market share & competitive trade position;
- Establish domestic markets in hard to abate sectors, protecting export value chains and creating value added green products;
- Establish domestic markets in mobility applications;
- 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 long-term growth;
- Support Local industrial capability and participation;
- Ensuring skills development for a successful GH_2 and
- Ensure a Just Transition.

[3] This is based on the current development within the country, global technological evolution and commercial demonstration.

The report outlines significant opportunities and benefits that can be derived for South Africa and suggests options 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. South Africa's GH_2 vision must incorporate key strategic design principles to ensure a long term sustainable and vibrant sector design.

3. Alignment with addressing the energy crisis

A key input into GH_2 production is renewable electricity. There is potential for the development of **renewable energy for GH_2 production to be complementary to the general electricity supply situation in the country.** This Commercialisation Strategy recognises that GH_2 projects should not compete with RE projects that will supply electricity into the South Africa grid to address the electricity crisis. It is expected that RE generation capacity will have been significantly increased to address the electricity crisis before large-scale RE is required for the hydrogen projects, as many of the GH_2 projects plan to commence operation from 2025 onwards. GH_2 projects have the potential to supply excess electricity into the South African grid and measures to enable the GH_2 projects to support the electricity challenges are proposed below.

Renewable Energy and intermittency

Based on experience on GH_2 production in Europe, a GH_2 plant can operate as a combined hydrogen-and-power plant. Given the fluctuation in renewables conditions, GH_2 production systems are not built to use all the possible electricity that can be produced. Some portion of low carbon electricity is curtailed or lost. GH_2 can assist as excess electricity can be used to produce GH_2 which can then be harnessed when electricity is required, by producing electricity from the GH_2 through fuel cell technology. GH_2 acts as an energy vector which can produce electricity when renewables conditions are not good. Projects are already being developed in South Africa, where large scale hydrogen storage will be able to support grid stability.

These benefits from hydrogen mean that hydrogen projects are able to support the South African energy sector in three potential ways through this technical feature.

- Supply of Curtailed Energy: Projects can supply excess electricity into the national energy system to reduce the demand on electricity from other sources.

- Supply of Dispatchable Energy: In most large-scale green hydrogen systems there is a storage system[4]. Many developers are also looking at on-site re-electrification solutions from GH_2 and its derivatives that can act as power backup or as peaking/dispatchable energy plants. An opportunity exists for Government to leverage these technologies to provide dispatchable energy to the grid.

- Electricity supply to proximal/vulnerable groups: GH_2 projects can also increase electricity access for remote communities or groups currently facing electricity challenges as part of JET initiatives. Ensuring that large scale green hydrogen projects also supply electricity to nearby communities, using mini grid solutions for example, can increase supply to these groups.

[4] This is especially true in the case in fully islanded systems, one-way-islanded systems or where grid supply reliability is a challenge.

Facilitating transmission infrastructure and thereby enabling RE projects to connect to the grid

South Africa's power grid is under pressure and constrained. A number of RE developers have received communication from Eskom stating that new generation capacity cannot be accommodated due to the capacity constraints currently in the Northern, Eastern and Western Cape.

Eskom has a very detailed transmission development plan (TDP), Figure 1. The TDP is a practical and executable plan that is updated periodically. The major constraint is the lack of funding in executing the TDP. This can negatively impact not only the GH_2 projects but other IPP projects either as part of REIPPP or for private consumption in the commercial and industrial market sector. Such projects can become stranded assets if grid connection remains an issue.

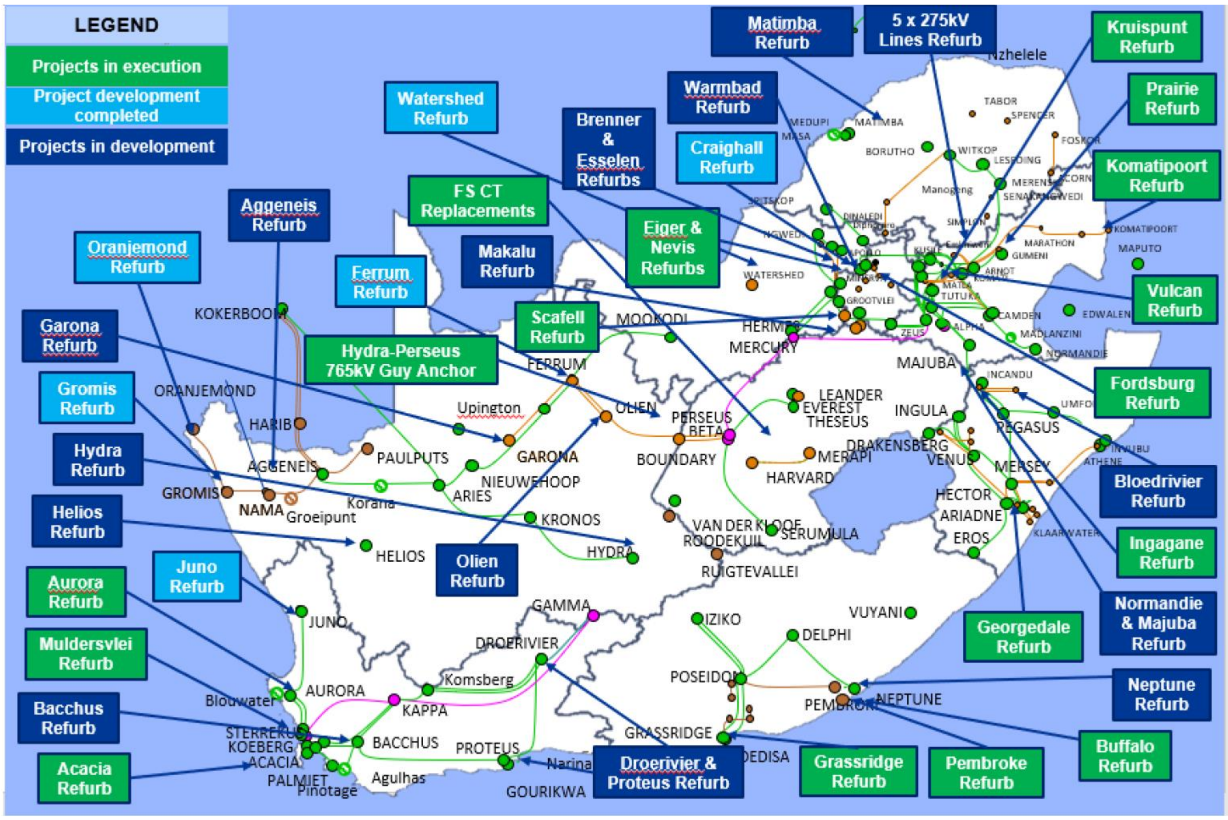

Figure 1: Eskom TDP 2023-2032, Source Eskom

There are approximately 20 GH2 projects at various stages of development. These projects are planned to commence operation from 2025 to 2027 onwards. It is estimated that approximately 3 to 5 GW of renewable energy will be needed for these projects. GH_2 projects that will need connection to the Eskom grid will have to ensure that required infrastructure is in place for this, including substation and transmission line infrastructure. Current GH_2 projects being developed have undertaken grid assessment studies to identify the areas where grid infrastructure strengthening is required. When this infrastructure is built for GH_2 projects, other RE projects can also make use of this common infrastructure to supply electricity into the grid thereby enabling additional electricity production. It has been estimated that by upgrading infrastructure in specific areas in the grid about 15 GW of developed RE projects can connect to the grid in addition to the GH_2 projects utilising the grid. A number of GH_2 projects are considering funding of the grid infrastructure as part of the overall project funding, increasing affordability and accelerating grid development. GH_2 projects could serve as an enabler to grid strengthening allowing for more renewable energy projects to be connected for electrification.

The development of the TDP and IRP, however, do not currently accommodate the need for RE for GH_2. Preliminary discussions with Eskom have highlighted the need for closer collaboration to ensure the RE needs for GH_2 are incorporated into the TDP.

4. Market driven commercialisation

GH_2 represents a significant market opportunity for South Africa to decarbonise agriculture and heavy industry and enable global decarbonisation through exports, allowing other countries to decarbonise. South Africa can be positioned as a leader in the energy transition and could become a critical player in the new global GH_2 economy. Accordingly, GH_2 production and development will be driven by two distinct markets: export demand driven by the international trade of GH_2 and derivative between countries and regions; and domestic demand, driven by fuel switching and new vectors for the use of GH_2 for mobility, industrial processes, agriculture and power.

4.1. Export market potential

From a trade perspective, countries with strong renewable resources and efficient infrastructure will tend towards being net exporters of GH_2. Large, energy-intensive economies with lower quality natural resources, space limitations and limited alternate energy sources, will tend towards being net-importers of GH_2. The EU and Japan are predicted to be the largest global import nodes of GH_2 currently, which will have important bearing on an optimal South African demand mix using export demand to support domestic demand through economies of scale.

Countries have begun to position themselves in the global value chain as potential exporters and importers of GH_2 and have begun to set policy priorities for GH_2 development. Net-Zero commitments will also stimulate imports where higher carbon pricing systems, such as the EU emissions trading system (ETS), provide a significant green premium to incentivise imports. The uneven global endowment of renewable energy resources combined with space constraints in certain countries spurs trading of GH_2 between countries and trading blocks.
Ambitious nations have already made clear their intentions of global supply, so South Africa's entry into the market will face competition from other supplying countries. Countries have already begun to form trade relationships around green hydrogen and support packages for development. These arrangements can secure export demand and enhance investment into countries aiming to supply into global markets. The projected net-import demand scenario indicates that approximately 10% of total global demand will be traded between countries. The key countries that have indicated demand for imported GH_2 are indicated below:

- European Union: The 2030 forecast based on the REPowerEU plan indicates GH_2 demand projections of 10 million tonnes per annum (Mtpa) by 2030. The port of Rotterdam has set a target of importing 20 Mtpa of hydrogen for European markets by 2050.
- Japan: In 2022, Japan imported 2 million tonnes (Mt) of grey hydrogen and the revised Hydrogen Strategy (May 2023) aims for imports of hydrogen (grey, blue and green) of 3 Mtpa by 2030 and 14 Mtpa by 2040. Japan is expected to procure 0.3 Mt of GH_2 in 2030, with the share of GH_2 as a percentage of all hydrogen increasing to 2050.

- South Korea: Imported GH_2 demand is expected to be 0.3 Mt per annum from 2030 and 1.5 Mt per annum from 2050. Based on the South Korea Hydrogen Roadmap, the country's hydrogen demand today is 130 000 tpa. By 2040, the annual need will be some 5 Mtpa, with 20% from GH_2.

- United Kingdom: Based on the expansion of hydrogen production pathways analysis (July 2022), hydrogen may be imported to the UK, particularly from global regions with high resource availability of renewable electricity or natural gas. The UK hydrogen strategy focuses on domestic production using offshore wind resources. However, since the UK is a significant net energy importer, it could import as much as 0.7 Mt by 2050 depending on the development of domestic hydrogen production from offshore wind.

Summing up expected demand[35] from the primary import markets it is expected that the **import market for hydrogen will be between 14 and 27 Mt per annum by 2050**.

Many studies have been undertaken recently assessing the potential export market for hydrogen[46], indicating a 2% share of the global market for hydrogen. These studies indicate a significant variation in the quantum of exports relative to the total market for imports globally. A 1% market share for South Africa of the total global GH_2 market would equate to 4.2 Mtpa of GH_2. 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 about 2 Mtpa by 2050 with upside to be as high as 6 mtpa in longer term.**

4.2. Domestic market potential

Domestic demand uptake will largely be driven by relative price parity to incumbent routes, and scale with incumbent fossil fuels plus any carbon related taxes. The strategic co-location of GH_2 production that can be located with applications such as mining, where the cost of distribution infrastructure can be avoided, will likely be the earliest to achieve price parity. Longer term demand will grow with market maturity and will rely on reducing production costs, expanding infrastructure, developing new applications, and using carbon markets and other incentives to sustain price parity. Domestic demand can also be leveraged using South Africa's existing technology endowments such as the Fischer Tropsch process for sustainable aviation fuel production, and the direct reduced iron process for the production of green steel.

GH_2 has a strong role in driving domestic decarbonisation. Hydrogen is currently used in the mining, processing, and chemical industries in South Africa. Green hydrogen can also decarbonise the agricultural industry by being in input in the manufacture of green fertilisers.

Most of South Africa's energy (95%) is fossil fuel based (primarily coal) and represents a significant opportunity for decarbonisation. Domestic demand drivers include:

- decarbonisation based on the export country or company commitments;

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[5] It must be noted that these estimates reflect the current import demand based on countries that have assessed their domestic hydrogen needs and where they wish to be positioned. Given that numerous countries are in the process of developing their approach to engagement with international hydrogen value chains, this import demand will likely evolve in quantum and distribution across countries. Related to this, increased supply competition may manifest based on new supplier entry into the global market.

[6] Notably the IHS Markit Super High Road; NBI BUSA BCG; Engie – South Africa Hydrogen Roadmap.

- current consumption of grey hydrogen to be switched to GH_2;
- cost competitiveness of GH_2 enabled through incentives and taxes versus its fossil alternatives;
- the availability and access to GH_2;
- early production of green products for export to countries with decarbonisation priorities and
- the maturity and acceptance of the application technology and access to support ecosystems.

Domestic demand will accelerate as price parity gets closer to fossil fuels. Co-located production projects (e.g. Mining sector) will have accelerated commercial value due to lower infrastructure and supply chain dependencies and hence lower cost. Domestic potential is estimated at about **2 - 3 mtpa by 2050 with upside as high as 6mtpa.** Sasol currently produces about 2mtpa of grey hydrogen for self-consumption in the petrochemical process.

5. Industrialisation opportunities

Both the above export market potential and domestic market potential presents many new industrialisation opportunities for South Africa. A range of local and export use cases that can anchor demand for GH_2 in South Africa are shown in 2.

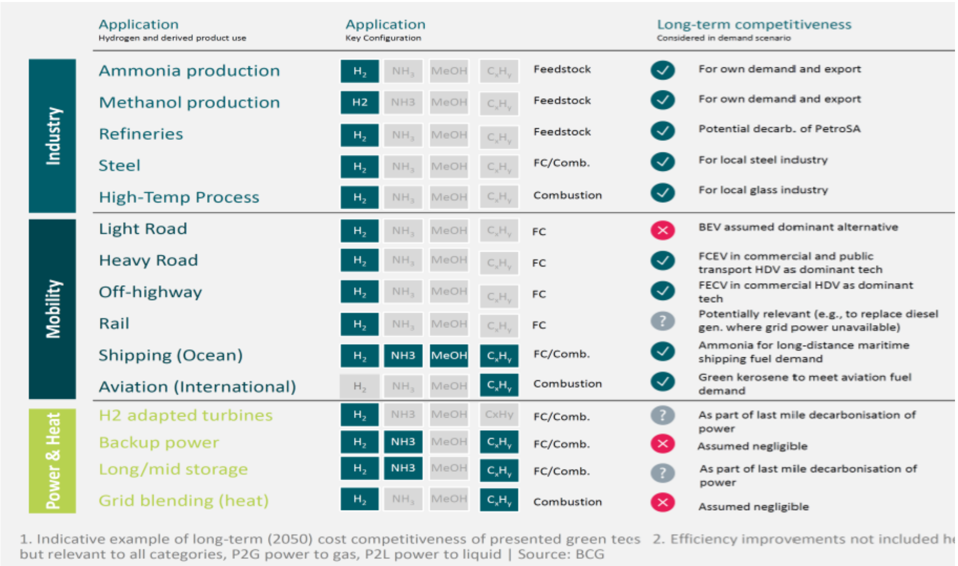

Figure 2: GH2 use cases for South Africa (source NBI, BUSA, BCG, 2021)

5.1. Ammonia production

Ammonia is widely traded globally, and there are many pilot projects underway globally to evaluate ammonia as means to export hydrogen or as a direct fuel in many use cases, notably marine fuels. Green ammonia can also be used to manufacture green fertiliser locally and substitute imported grey fertiliser products. Projects are being developed in South Africa to produce green ammonia for the export and local market.

5.2. Green steel production

The steel industry contributes 7% of global emissions or 2,6 Gt of CO_2. Steel is an important circular material that should be decarbonised. The H2 direct reduced iron (DRI) is an important steel making input to decarbonise steel making. Arcellor Mittal South African (AMSA) Saldanha Bay plant asset has the potential for the production of green steel as it has an existing Midrex facility and installed electric arc furnace. AMSA is investigating the opportunity of producing green DRI at its Saldanha Works plant for local consumption and to export to EU and other countries.

5.3. Aviation fuel exports

Sustainable Aviation Fuel (SAF) is deemed as the only viable large-scale solution for the aviation sector. In 2017, the International Air Travel Association (IATA) members unanimously agreed to a resolution on the deployment of SAF and committed to only use sustainable fuels. The attractiveness of the SAF opportunity is underpinned by decreasing renewable energy costs and green hydrogen production costs, with green hydrogen expected to decline below $2/kg H_2 by 2030, from the current $4,00 - 6,00/kg H_2 cost range. The global SAF market is estimated to be about 10% by 2030 ($30bn of the $314bn global aviation fuel market) and is forecast to reach 47% by 2050 ($180bn of the $387bn global aviation fuel market). These estimates make SAF an attractive market in a relatively short period of time.

5.4. E-methanol for local consumption

Hydrogen and beneficiated products have also attracted global attention in the mobile telecommunications industry for backup power using fuel cells (IEA, 2019). Here, the use of fuel cell backup systems substitutes for diesel consumption, particularly in remote areas with limited grid access. Vodacom, for example, already has installed over 200 fuel cell backup systems across the country supplied by Chem Energy, the latter which is based at the Dube TradePort Special Economic Zone (Engineering News, 2023). These systems use a blend of methanol and water to produce hydrogen that is used in the fuel cell systems. An opportunity exists to roll out the fuel cell back-up power systems to all the mobile networks and consecutively ramp up e-methanol production using GH_2.

5.5. Electrification support and ramping RE for scale

The investments into renewable energy and storage to support electrification and GH_2 production, presents a sustained and predictable demand for inputs that can be locally produced. This includes solar and wind energy generation and storage. Linkages with the renewable energy industry can be leveraged to provide scale of demand and enable local manufacturing of renewable energy components for example solar panels, solar cells, wind towers, wind nacelles, steel and aluminium structures and balance of plant components.

Detailed analysis on local content is obtained from the South African Renewable Energy Masterplan (SAREM). Key findings on the economies of scale required to attract investment and ensure sustainable development of localisation are outlined below:

- Wind: A local market of 400 MW/year/OEM for a minimum of 5 years is required for the local manufacture of blades. Further, a local market of 1,000 MW/year is required for local nacelle assembly, and manufacturing of generators and converters.
- Solar PV: A sustained demand of at least 1,000 MW/year is required for local module assembly.
- Components: Production of components locally is an enabler for the growth of local raw material supply chains (e.g. glass, steel, concrete, copper, and aluminium).
- Similarly, deployment of PV and wind locally will expand existing local manufacturing supply chains and services for Balance of Plant.

South Africa has sufficient GH_2 production demand potential to justify the above localisation breakpoint estimates.

- Meeting SA's 2030 potential GH_2 demand requires an additional 17GW PV (3.4GW/year) and 8GW wind (1.6GW/year) deployment.
- The above needs to be considered and included in the SAREM, the Integrated Energy Plan (IEP), the Integrated Resource Plan (IRP), and the Gas Utilisation Master Plan (GUMP).
- Huge transmission and distribution grid expansion will need to happen rapidly for both electricity security and GH_2 ambitions by 2030.
- This also needs to be considered and included in Eskom's Transmission development plan (TDP).

5.6. Water security

Sourcing of water is essential to the electrolysis process to produce GH_2. The water source must also be sustainable for the hydrogen to qualify as sustainable or green. Extreme climate and rainfall fluctuations make South Africa a highly water-stressed country. The use of potable water for hydrogen generation is neither feasible nor sustainable. For the production of coastal GH_2, the feedwater will likely be desalinated seawater. Export hydrogen in particular will be produced at or near the port of shipment.

The desalination cost component of water has been calculated to vary between 0.005-0.020 $/kg of hydrogen produced.[7] For a targeted hydrogen production cost of $1/kg by 2050, the water cost thus equates to between 0.5% to 2% of the 2050 target price, showing that water is a relatively small cost component in the overall cost of production of GH_2. This important factor can be used to oversize the desalination part of GH_2 projects and make the excess desalinated water available to surrounding communities. It is recommended (Roos, 2020) that desalination plants supplying the electrolysis plants for bulk hydrogen production be oversized to be at least 300% the capacity required for the electrolysis plant alone. The extra capital costs as shown above will not significantly influence the hydrogen price.

For the production of hydrogen for inland domestic use, the feedwater can be treated water from heavily contaminated sources not treatable by municipal wastewater treatment plants i.e. mine water, acid mine drainage and industrial waste-water specifically in the Vaal region. Municipal

7 T. Roos, "Renewable Hydrogen Generation and Transport Costs," CSIR Energy Centre Report, 2020, (Roos 2020)

waste-water should only be used when these other sources are fully exhausted, as industry may need this water source in the future (Roos, 2020).

Hydrogen production can therefore contribute to water resilience rather than detract from it. Excess potable water can be made available to surrounding communities thereby also increasing access to potable water.

The volume of water required for GH_2 production is insignificant compared to the volume of water consumed in the country. Assuming that 12kg of water is required to produce 1kg of green hydrogen (Roos, 2022) and based on water demand projections for South Africa up to 2035[8] (2018, Institute for Security Studies), the water required to produce the quantities of GH_2 as targeted in this GHCS is approximately less than **0.5%** of the projected water demand for South Africa.

5.7. Fertiliser production

South Africa is a net importer of fertilisers. As a fertilizer precursor, ammonia is a well-known chemical, with mature and well-established synthesis processes (Haber-Bosch). Green ammonia can be used to manufacture green fertiliser locally and replace the expensive imported grey fertiliser products. Local ammonia consumers are dependent on ammonia imports which are presently constrained by challenges with rail logistics. Omnia Group and WKN WindCurrent S.A (PTY) LTD (WKN)., a fully owned subsidiary of German based PNE AG, have signed a Memorandum of Understanding (MoU) to evaluate the onsite production of green hydrogen and ammonia at Omnia's Sasolburg plant. This will assist Omnia in achieving their decarbonisation targets by replacing CO_2 intensive, conventionally produced ammonia with green ammonia.

5.8. Mine haul vehicles and heavy-duty vehicles

GH_2 has been recognized as an alternative fuel for the mobility sector in the EU and other countries. In South Africa, hydrogen powered vehicles or fuel cell electric vehicles (FCEV), in particular buses and heavy-duty vehicles, might play a significant role in climate change mitigation within the transport sector and the development of the GH_2 economy. Fuel Cell Electric Vehicles (FCEVs) shows promise particularly over long distances, where electric vehicles face challenges and uses in mining applications show promise. Many projects are underway globally, in South Africa the following mobility projects are currently at various stages of development:

- Hydrogen powered truck at Anglo Platinum's Mogalakwena PGMs mine Anglo American launched the world's first zero-emission hydrogen-powered mine haul truck capable of carrying a 290-tonne payload on 6 May 2022. Anglo American also intends on a full roll out of this initiative by 2028 which will allow the displacement of diesel at the mines. Anglo American are also exploring switching smaller heavy-duty vehicles to hydrogen and fuel- cell technology (Anglo American, 2022).

- Hydrogen Valley – This is an 835km industrial and commercial corridor focused on mobility. Three catalytic green hydrogen hubs have been identified in the Valley: In Johannesburg hub (JHB hub with spokes extending to Rustenburg and Pretoria); Durban hub, compassing both Durban and Richards Bay, and a third hub encompassing Mogalakwena and Limpopo. Nine promising pilot projects have been identified to kickstart the Hydrogen Valley in the mobility

[8] 2018, Institute for Security Studies - A delicate balance Water scarcity in South Africa, Zachary Donnenfeld, Courtney Crookes and Steve Hedden

(mining trucks, buses), industrial (ammonia/chemicals) and buildings (fuel cell power) sectors.

- Sasol and Toyota South Africa Motor's (TSAM) partnership to commence exploration of the development of a GH_2 mobility ecosystem. Sasol and TSAM will jointly pursue the development of a proof-of-concept demonstration for a green hydrogen mobility ecosystem. The parties intend to develop a mobility corridor and expand the demonstration to a pilot project using one of South Africa's main freight corridors, such as the N3 route between Durban and Johannesburg, for hydrogen powered heavy-duty long- haul trucks.

- West Coast mobility – opportunities also exist for hydrogen mobility corridors in the west coast with projects being developed in this area.

Mobility represents a significant opportunity for South Africa, but this will be sequenced based on economic viability, which will be dictated by volume of vehicles and carbon emissions. Mining represents the best early adopter of hydrogen for mobility, followed by heavy duty logistics (trucks and buses) and later, when hydrogen refuelling stations are more widely available, fuel cell vehicles for mass transportation. The ambitions on GH_2 mobility will be calibrated with the planned shift to New Energy Vehicles (NEVS) and the time frames will be aligned with the rollout plans for battery electric vehicles that will be complementary to both BEVs and FCEVs.

5.9. Marine Bunkering Fuel

The current use of hydrogen-based fuels in shipping is limited with ships currently using oil and gas products. The equivalent demand of hydrogen for oil and gas products in shipping is about 3.5 Mt. If the volume of international shipping triples by 2050 under current trends, this demand from shipping will increase to the equivalent of about 10.5 Mt of hydrogen per year by 2050. This represents a key downstream opportunity for hydrogen to substitute for existing oil and gas fuels. There are currently pilot initiatives exploring the commercial case for green ammonia and green methanol. Technology and cost will ultimately decide whether ammonia or methanol prevail as a maritime fuel. Domestically, Sasol and ITOCHU have signed a MOU in September 2022 to jointly study and develop the market and supply chain for green ammonia, focussing on its use as bunkering fuel. South Africa's access to both the Indian and Atlantic oceans could enable the country to secure an 8-10% market share of the global ammonia or methanol fuels market for shipping. This equates to 0.8 to 1.0 Mt per year of GH_2 (about 4 Mt of green ammonia or 3.2 Mtpa green methanol) by 2050.

5.10. Equipment manufacturing

Localisation of certain elements of the value chain are possible for catalysts, electrolysers, fuel cells and energy storage components. South Africa has firms that currently manufacture or are establishing manufacturing facilities to produce these key components. In addition to the RE component manufacturing mentioned in section 5.5 certain GH_2 value chain components are expected to drive localisation as export and domestic industries grow. These include electricity grid and associated infrastructure, compression and storage equipment, beneficiated products, and logistics. This growth in localisation requires planning, commitment and investment enablement.

5.10.1. Value chain component - Electrolyser systems

- **PGM raw material mining and beneficiation:** SA is responsible for 72% of global PGM

supply and considered the most important component in the hydrogen economy.
    - PGMs currently contribute approximately 8% of the cost of a PEM electrolyser.
    - Iridium demand is expected to increase substantially.

- **CCM electrolyser components:** Beneficiation of locally mined PGMs into higher value components. The CCM contributes approximately 7.5% of the PEM electrolyser system costs.
    - CCM requirements to meet anticipated global installed electrolysis will result in a substantial market for CCM revenues.
- **System integration and O&M:** A domestic GH_2 market will drive the need for local development. Skilled local talent is available and can be trained. Installation contributes 33% of installed system costs.

Medium priority localisation opportunities identified include:

- **Local electrolyser stack, systems and components:** The availability of PGM materials at competitive prices is a key enabler in developing local factories that are globally competitive businesses for the manufacture of such equipment and components.
    - Localisation of electrolyser stack or systems can be achieved.
    - Localisation opportunities require agreements with international OEMs.
    - This is considered medium priority for now as it is a long-term consideration and dependent on the development of an off-take market, incentives, and policies to make localisation of facilities attractive for international OEMs.
- **Recycling:** Secondary PGM supplies because of recycling are expected to increase. Currently this route contributes approximately 25% to the platinum supplied.

5.10.2. Value chain component - Fuel cell systems

High priority for localisation identified in the short-term include:

- **PGM raw material mining and processing:**
    - PEM fuel cells potentially can create a demand for platinum that will become a substantial percentage of mined platinum.
- **PGM Beneficiation:** Further beneficiation of locally mined PGMs into higher value components. MEAs contribute approximately 7% of a PEM fuel cell system cost.
    - Substantial local manufacturing can support additional potential for localisation of up-stream supply chain components (e.g., membranes).

Medium priority opportunities identified include:

- **Local fuel cell stack, systems and components:** The availability of PGM materials at competitive prices is a key enabler in developing local factories that are globally competitive businesses for the manufacture of equipment and components.
    - Technologies that will benefit from competitive PGM prices include PEM and PAFC.
    - This is considered medium priority as it is a long-term consideration and is dependent on the development of an off-take market, incentives, regulations, and policies to make localisation of facilities attractive for international OEMs.
- **Recycling:** Secondary supply because of recycling is expected to increase and contributes approximately 25% to the platinum supplied with the number expected to increase.
- **Automotive manufacturing:** Several major automotive OEMs are already present in South Africa.
    - The automotive industry is transitioning from ICE to BEV and FCEV.
    - BEV is expected to dominate the global passenger vehicle market with FCEV

being more applicable to the heavy-duty mobility industry.
  - Several new FCEV OEM start-ups are emerging. The industry is still new, and OEMs have not yet established manufacturing contracts.

5.10.3. Value chain component – Energy Storage

High priority for localisation identified in the short-term include:

- Investment in mining and mineral beneficiation of battery minerals across the continent to supplement SA's limited resource base.
- Processing of material into battery-grade minerals and chemicals as commodities.
- Particular focus on accelerating the vanadium redox flow battery (VRFB) value chain, including the manufacture of batteries.
- Developing the local Battery Energy Storage System (BESS) market (including financial instrument for commercial and industrial consumers) and supporting the growth of battery assemblers and ancillary operations

High priority for localisation identified in the medium-term include:

- The development of a mineral processing hub and ensure value addition on the continent, taking advantage of AfCFTA developments and SA's current industrial capabilities.
- Development of the precursor processing industry.
  Holistic development of a downstream ecosystem for the assembly of electric vehicles.
  Supporting local technological advancement (in addition to capacity) and industrial scale manufacturers for BESS applications, both for the local market and exports.

6. South Africa’s Comparative Advantage

South Africa possess advantages in the development of the GH_2 value chain namely abundant solar and wind resources, land availability, an existing industrial and specifically petrochemical base, existing production, storage and transportation of grey hydrogen and associated chemicals, combined with access to key metals and minerals in the PGMs and battery minerals value chains. Further, SA has access to key production technologies and the skills and resources that surround them, a robust financial system, globally recognized renewable energy programme and inclusion of GH_2 as a key element of the Government’s energy transition plans.

7. Key Enablers

The success of a South African GH_2 industry lies in a holistic and investor friendly ecosystem with clear and focused government support. Key enablers that help create such an ecosystem have been outlined below. Crucially, mechanisms have to be set in place to facilitate the interaction between the state and the private sector to assist with engaging across multiple ministries and to co-ordinate interactions at government-to-government level, i.e., effectively a one-stop shop for engaging with government to secure the delivery of GH_2 projects.

7.1. Infrastructure build

The delivery of appropriate infrastructure will be key to enable the GH_2 value chain to be developed. To effectively leverage infrastructure build, a nodal or regional approach to development should be undertaken.

7.1.1. Transmission Grid Infrastructure

South Africa currently faces challenges around the quality and availability of transmission infrastructure. The future planning and investment for grid infrastructure should consider transportation of electrons to meet GH_2 demand. This should include the use of GH_2 as an energy storage vector. It is estimated that the transmission grid will require investment of ca. R132 billion over the next five years (2023-2027) and a total of R374 billion over the next 12 years (2023-2035). In Eskom's latest Transmission Development Plan (2023-2032), the increased demand for electricity for GH_2 production is not considered as an input into transmission investment plans. The demand for electricity for GH_2 from renewable sources is estimated to range between 25GW and 39GW between 2030 and 2035, covering roughly the same period as Eskom's investment plans. This 25-39GW represents additional renewables capacity required for GH_2 production. **Transmission infrastructure investment should be reassessed to align the transmission infrastructure upgrades with increased potential from GH_2.**

As mentioned in section 3, GH_2 projects can also increase electricity access for remote communities or groups currently facing electricity challenges as part of JET initiatives. Ensuring that large scale green hydrogen projects also supply electricity to nearby communities, using mini grid solutions for example, can increase supply to these groups.

7.1.2. Ports

Port infrastructure is required to support GH_2 projects with the infrastructure to move GH_2 and its products such as ammonia, and other GH_2 transport vectors onto maritime transport for the export market. Ports can also enable the development of hydrogen hubs. A number of hubs and ports have been identified to connect production, conversion, transport and export infrastructure. Three ports stand out in terms of current development and project attraction. The ports of Boegoebaai, Saldanha and Coega have been identified as key ports for development of GH_2 with Transnet already assessing port infrastructure.

- Boegoebaai: In late 2022, Transnet issued a Request for Qualification (RfQ) for the appointment of a developer to design, fund and construct a deep-water port and the necessary infrastructure in Boegoebaai. Sasol is investigating GH_2 derivative exports, together with the Northern Cape Economic Development Agency.

- Saldanha Bay: Sasol has signed an MoU with Freeport Saldanha Industrial Development Zone to facilitate a green hydrogen hub. Additionally, Sasol has signed a joint development agreement with Arcelor Mittal (AMSA) to develop carbon capture technology to produce sustainable fuels and chemicals.

- Coega: Hive Energy is currently developing a green ammonia project in the port focusing on supplying green ammonia for the clean fuel and maritime industry across the Far East and Europe.

- General ports: Transnet also released a request for information (RfI) to procure 50-80MW of renewable energy at its eight ports across the country.

As more interest and investments accrue into these and other ports in South Africa, **it is vital that port infrastructure is assessed with respect to the readiness for GH_2 integration and projects.** Importantly, **no single port should be viewed as a silver bullet export option** and the commercial cases for various exported GH_2 products, markets and value chain focuses should be tested and established across the ports of interest. In addition, port opportunities should be reviewed on the basis of economic diversification and not limited to exportation of single commodities or value chains.

7.1.3. Transport infrastructure including integration with pipelines

Pipelines are an important transport infrastructure that can be leveraged to transport GH_2 from production to consumption sites. The final cost of GH_2 to the consumer is influenced by the costs of production and the costs of transport.[9] Transport costs are sensitive to the quantity of hydrogen transported, the distance, the transport means, the form of hydrogen transported, and the availability of infrastructure. Once the GH_2 is transported, it may undergo another conversion step to process or extract GH_2 in order to meet the purity and pressure requirements of the consumer.[10] South Africa's natural gas pipeline system is composed of two networks: the Mozambique to Secunda Pipeline (MSP) and the Transnet Gas Pipeline Network (TGPN). Given the high capital costs of new pipeline construction, the blending of hydrogen with natural gas in existing pipelines has attracted a lot of attention as a low cost GH_2 integration pathway.[11]

For distances up to 2 600km, GH_2 pipeline and compressed hydrogen shipping are the cheapest options to transport hydrogen (EC, 2021). For distances above 2 600km, liquefied hydrogen or ammonia are the cheapest options. These estimates make a number of assumptions around the production costs of hydrogen, the cost of electricity, and the availability of storage mediums, to name a few variables. These assumptions and cost estimates require testing in the South African context. **It is recommended that a pre- feasibility study be undertaken to determine the suitable transport modes and their cost variance for transporting GH_2, including the costs and viability of building new hydrogen pipelines in the country.** There is potential to extend existing hydrogen pipelines (SBG Springs) and to optimise renewable energy infrastructure, grid infrastructure and pipeline infrastructure. For a new pipeline system, **it is likely that these pipelines will require additional detailed study on the best option to ensure the pipelines can be used for both natural gas and hydrogen service, and the options for the best material for the pipeline construction will be done at the time of final investment decision based on relevant engineering studies.**

7.2. Sourcing funding

Financing GH_2 projects will require innovative financing structures sourced from multiple stakeholders. Ensuring that the financing landscape incentivises investment both from local and international sources is critical. The broad principles of traditional project finance are likely to be applied, necessitating collaboration by government, international development finance institutions, multilateral financing agencies, local commercial lenders and private sector investors. Given the anticipated involvement of international OEMs, export credit agencies are another key

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[9] The investment decision into transport infrastructure has to compare the costs of producing GH2 in areas of good renewables potential and transporting the GH2 to the consumer, versus producing GH2 in close proximity to consumer demand, perhaps at lower renewable potential. GH2 can be transported via ship, pipeline, trains and trucks.

[10] The form refers to whether the hydrogen undergoes compression or liquefaction processes or is converted into another chemical for the purposes of transport. Conversion processes occur in compression or liquefaction plants, or in chemical reactors for LOHC hydrogenation, and ammonia and methanol synthesis.

[11] The blending of up to 15-20% of hydrogen within natural gas is regarded as a modest modification to existing infrastructure. If the hydrogen in the existing pipeline network (MSP and extension and TGPN) is above 15-20%, this will require new pipelines to be laid. Rather than a repurposing of existing pipelines, this will require repurposing of the pipeline network on the pipeline route.

stakeholder group in the funding universe. It will be necessary for strong relationships to be developed with the governments of developed countries who have programmes in place to support developing countries in their climate change pursuits.

Aligned to this a historic Just Energy Transition Partnership (JETP) was forged at the UNFCCC's (United Nations Framework Convention on Climate Change) 26th Conference of the Parties (COP26) between the government of South Africa and the governments of France, Germany, United Kingdom (UK), United States (US), and the European Union (EU) (forming the International Partners Group [IPG]). The JETP followed engagements between the parties on the unique economic and social challenges inherent in transitioning South Africa's fossil fuel-dependent economy in a just manner. The JETP supports South Africa in achieving the most ambitious emissions reduction range as stated in the country's updated Nationally Determined Contribution (NDC) of 420-350 megatons of carbon dioxide equivalent (MtCO2- eq) by 2030. A distinguishing feature of the JETP is the centrality and commitment of the partners to enable a 'just transition', thus recognising the direct and indirect impact that the energy transition has on livelihoods, workers, and communities. The vision and objectives of the JETP are articulated in a Political Declaration which provides that the IPG will mobilise an initial US$8.5 billion between 2023 and 2027, subject to concurrence on an investment framework. A JET investment plan (JET-IP) was subsequently developed in response to this commitment from the IPG. The initial portfolio described in this JET IP, focuses on the priorities essential for catalysing a sustained just energy transition within the next five years in order to achieve the country's economic, social, and economic outcomes over the coming decades. It also considers how best the initial IPG offer of US$8.5 billion may be utilised. Included in this JET-IP is a hydrogen economy investment plan for the period 2023 to 2027. This hydrogen investment plan aligns to this GHCS.

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

a) direct public funding.
b) public-private partnerships.
c) leveraging funding from developed markets specifically set aside to support the green transition in developing/carbon intensive countries.
d) leveraging funding from export credit agencies.
e) green/project bond financing; and
f) blended finance mechanisms.

Governments globally are looking to various mechanisms in order to unlock financing of GH_2 projects and accelerate development by mitigating specific investor risks, for example:

a) developing strong relationships with the governments of developed countries who have programmes in place to support developing countries in their climate change pursuits.
b) providing partial guarantees.
c) providing blended concessional finance; and/or
d) providing grants and/or subsidies to pilot projects.

Broadening relationships with the IPG in the JET partnership and establishing relationships with countries outside the IPG will be key in enabling the above relationships and sourcing the specified funding instruments above.

The development of the GH_2 will be led by private sector funding while leveraging the JET funding available for this value chain. In addition, blended finance vehicles will be pursued in order to leverage in commercial lenders to meet the capital requirements. Over the next 12 months, the dtic and the IDC will deepen the modelling around the various development scenarios in order to understand the social, environmental and economic impact - to identify whether there could be value in accelerating the development of GH_2 through specific levers, including incentives following normal government budgeting processes.

Levers introduced by other countries include;

a) 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;

b) redirecting income from carbon taxes towards green initiatives;

c) special economic zones tax incentives; and

d) Income Tax provisions and deductions.

7.3. Socio economic development and Just transition

Significant opportunity exists for economic development and social inclusion which should be pro-actively driven through the GHCS.

Gender equality and social inclusion

- The development of the hydrogen economy provides the opportunity to integrate gender equality at both an employee and ownership level.
- Women potential in GH_2 needs to be realized, and women need to be empowered to take leadership roles in green industries as entrepreneurs and / or industry professionals.

BBBEE including worker and community empowerment

- Opportunity to empower previously disadvantaged people by taking ownership in new businesses and by providing new job opportunities.
- Communities and workers can be empowered by shareholding in projects and by SMMEs contracting along the GH_2 value chain.

Skills action plan

The creation of a hydrogen economy will require a new skill sets as well as an increase in capacity of a productive workforce. Although the unavailability of skills is a risk, the ability to build the skills base to support the deployment of the initial GH_2 projects will create the potential for significant employment within the GH_2 value chain. Details of specific skills required and the associated action plan to source and build these skills are outlined in the skill action plan in the GHCS as shown in Figure 3.

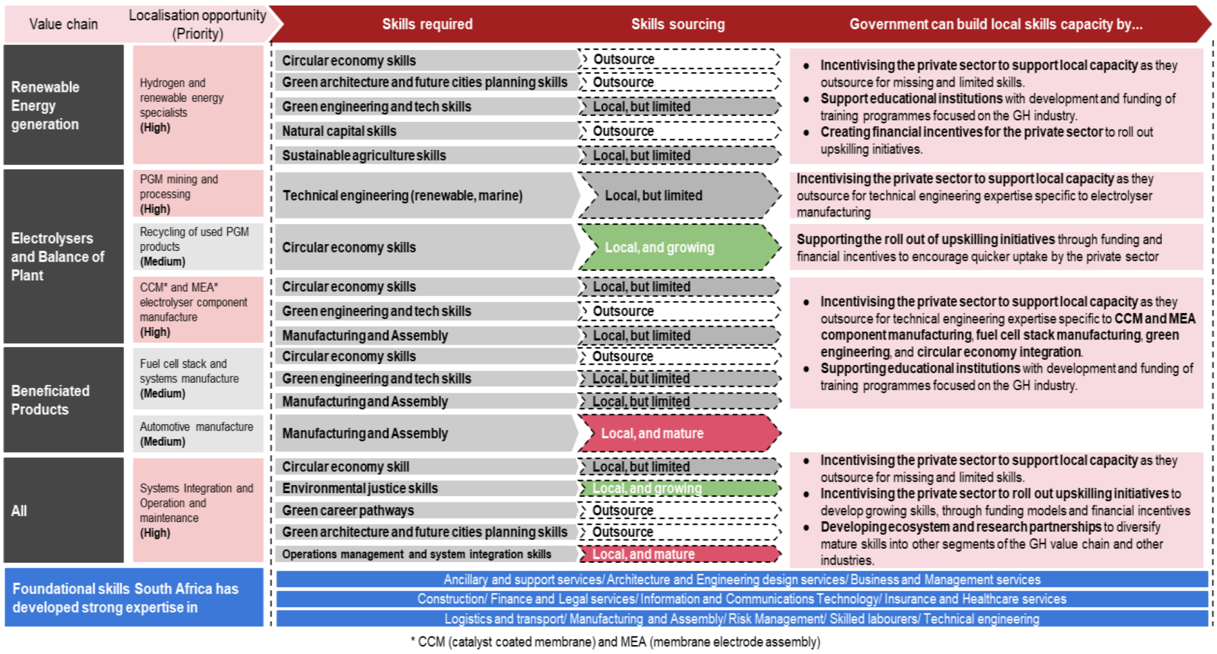

Figure 3: Skills Action Plan

Economic impact assessment

To estimate the economic impacts that will result from the implementation of the GHCS a high- level economic impact assessment (EIA) was carried out at the end of 2022. The EIA was conducted on the value chains as shown in Figure 4.

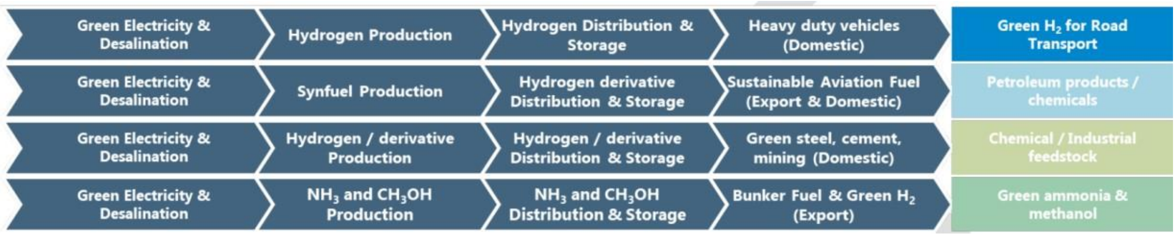

Figure 4: EIA Value Chains

According to this assessment, implementation of the GHCS will have significant positive impacts on the economy including on GDP, investment, balance of payments, tax revenue, employment, and CO_2 emissions as depicted in Figure 5. By 2030, the GHCS is projected to increase South Africa's GDP by R188 billion and by R390 billion in 2050, by producing, using, and exporting green hydrogen. The GHCS is also expected to result in reduced CO_2 emissions and increased investment, as well as support 387 thousand jobs per annum by 2030 and 368 thousand by 2050 and generate substantial tax revenue. Although the study found the GHCS would initially lead to a negative balance of payments, it is expected to improve over time as exports increase and imports of equipment and fossil fuels decrease.

	2030	2040	2050
Gross domestic product (GDP)	R188 billion	R298 billion	R390 billion
Jobs Supported	387 774	423 090	367 912
Accumulated CO2 emissions reduction	67 mt	225 mt	493 mt
Fixed Investment	R 730 billion	R 1.4 trillion	R2 trillion
Tax Revenue	R29 billion	R34 billion	R32 billion
Balance of Payments	(R26 billion)	R18 billion	R64 billion
Green H_2 volumes	1,6 mt GH_2	3 mt GH_2	4 mt GH_2

Figure 5: High level estimation of the socio-economic benefits of the GHCS

7.4. Job creation potential

Based on the targeted production volumes in the GHCS, the EIA also assessed the jobs created for each of the value stream that are shown in Figure 4. This is show in Figure 6. The ammonia export market will be the major contributor to job creation.

Figure 6: Jobs created per value stream

Additionally, in December 2022 the South African Institute of International Affairs launched the South African Green Hydrogen TVET Ecosystem Just Transition Strategic Framework report. This study assessed the job creation potential of fuel cells and electrolyser manufacturing in South Africa. This report concludes that **18 800** new TVET jobs will be created in the fuel-cell and electrolyser manufacturing sector by 2050. This report also states that there is potential to transition workers who work on the production of catalytic converters and other ICE vehicle parts to electrolysers and fuel cells. However, this will require reskilling and upskilling. Examples of required skills in the production of fuel cell and electrolyser equipment include:

- new technical skills
- occupational health and safety related to working with a volatile gas like hydrogen and related applications;
- digital/ICT skills;
- tools to operate lab equipment; or working with CNC systems; and
- soft skills, including communication, teamwork, problem solving, emotional intelligence and critical thinking. (SAIIA, 2022)

7.5. Role of Government in policy and regulations

Clear and stable regulation pertaining to hydrogen is essential in order to deliver certainty to developers and investors so projects and applications can be implemented with reduced risk. Clear regulation will also foster investor confidence and financing. South Africa's current regulatory framework can be leveraged to support the development of a national-level GH_2 industry. It will be a significant body of work to develop a regulatory framework that:

- Defines what constitutes a GH_2 project across the value chain to provide regulatory clarity to current and potential investors into South African GH_2 projects. This would also involve what is defined by the term "green"[12] in GH_2.
- The South African Bureau of Standards (SABS) has commenced with hydrogen standards

[12] This could quantify the CO2 emissions of the process or set a cap on CO2 emissions in the definition. Further, the approach could also look at whether to consider the life cycle emissions of production in the definition.

development aligned to ISO/TC 197 hydrogen technologies standards.

- Clarifies the classification of hydrogen as a gas or energy source for the purpose of regulation, and the implication of the chosen classification.
- Provides regulatory clarity and approaches to the compression, storage and transport of GH_2 and beneficiated products such as green ammonia.
- Ensures the safety of the community and industry at all times. Sasol produces about 2 mtpa of grey hydrogen and has developed safety standards which can be referenced for developing national green hydrogen safety standards.
- Aligns, and is supported by South Africa's existing energy planning policies such as the Integrated Resource Plan (IRP) and Integrated Energy Plan (IEP)
- Synchronises with South Africa's decarbonisation and just transition ambitions, through NDC contributions, mitigation pathways and JT policies.
- Removes investment barriers and supports the investment in South Africa's GH_2 economy.
- Is flexible and responsive to the dynamic nature of GH_2 developments as they evolve from a technology, techno-economic, policy, regulatory, finance and investment perspective.

It is imperative that the specific government department actions proposed in the GHCS action plans be included in department APPs to ensure implementation and monitoring of government actions.

7.6. Incentives

Key regulatory incentives could be considered to accelerate the development of South Africa's domestic and export markets. Some of the key incentives have been outlined below.[13]

7.6.1. Domestic market incentives

A progressively increasing carbon price alongside stimulus packages provided by government will provide essential confidence for investment in infrastructure and research, development and demonstration of GH_2 technologies. Carbon pricing mechanisms coupled with effective revenue recycling mechanisms that support investment in clean energy options will be a key enabler to drive GH_2 production forward. The cost of GH_2 production could be lowered by reducing the taxes and fees within the GH_2 value chain. Lowering corporate, business and sales taxes on GH_2 could also improve the economics and accelerate investment on projects. Stakeholders have repeatedly highlighted the fact that South Africa's licencing and authorisation processes are long and complex and delay project implementation. In order to expedite the authorisation and licensing processes, the need exists to introduce a single "one-stop" mechanism to facilitate all the licensing and authorisation processes required as part of implementing a GH_2 project.

Hydrogen powered vehicles might play a significant role in climate change mitigation within the transport sector and the development of the GH_2 economy. In order to accelerate the market penetration of heavy-duty fuel cell vehicles, a supportive national framework and financial incentives will be needed. Various financial and non-financial incentives from direct purchase grants to tax and registration fee exemptions and zero VAT can encourage the deployment of these vehicles. The implementation of zero-emission vehicles targets could also create the initial demand for GH_2 refuelling stations which are pre-conditions for making heavy duty fuel cell vehicles a viable option for mining and logistics companies.

7.6.2. Export market incentives

The development and location of GH_2 projects within SEZs will be a key enabler to support South Africa's GH_2 economy. In terms of section 21(1) of the SEZ Act, the Minister of Trade and Industry may determine and implement support measures, including incentive schemes, for operators and businesses operating within Special Economic Zones. This provision can be used as a basis to provide tailored support mechanisms for GH_2 projects within SEZs. New and existing incentive mechanisms outlined above can be introduced in GH_2 projects within SEZs or applied to REDZs. Many countries have also introduced Guarantees of Origin (GO) systems. The GO system can create a credit-based chain of custody that provides hydrogen consumers with certainty pertaining to the green nature of the hydrogen. South Africa would have to ensure that a GO System aligns with import countries. The state has an important role to play in bilateral engagements with key trade partners and potential consumers of South African GH_2 and beneficiated products. The Government should identify trade partners for the GH_2 economy and strategically understand what is required from these markets for market entry. Another opportunity arises with existing regional and bilateral agreements that are close to review. These reviews provide an opportunity to enhance the trade of sustainable goods, with a particular focus on sustainable energy products to enhance demand for GH_2 and GH_2 beneficiated products.

These efforts will require a strong and concerted effort across multiple dimensions. A South

[13] The regulatory discussion is not aimed at outlining a comprehensive regulatory framework for South Africa, but rather outlines high-level regulatory support mechanisms that can support South Africa's GH2 economy. Here, innovative and alternate approaches for GH development may also be considered. For example, the book and claim system can be used both domestically and internationally as a carbon offset mechanism to channel investments towards GH2 projects.

African Government champion to drive these engagements and development should be formed and can leverage the existing structures that exist with the Green Hydrogen Panel.

7.7. Skills Development

Ensuring skills development for a successful GH_2 economy is a key enabler in driving the commercialisation plan. Potential job losses and social impacts of decarbonising South Africa's economy should be addressed through skills development in the renewable energy and GH_2 sectors. Decarbonisation of heavy industry using GH_2 directly protects jobs in these industries and presents opportunity for new jobs The upskilling of workers to enable a functioning GH_2 sector will be key. New skills will include:

- **Green career pathways** - assessing the main opportunities for green careers in the local context, while investing in reskilling and upskilling initiatives to meet the current and future green skills gap.
- **Natural capital skills** - protecting and monitoring the earth's natural resources including environmentalists, hydrologists, and biochemists.
- **Green engineering and tech skills** - design and maintenance of solar panels, wind turbines, electrolysers, and other green technologies.
- **Green architecture and future cities planning skills** - constructing and integrating green buildings and green spaces into future cities.
- **Sustainable agriculture skills** - implementing digital solutions in agriculture such as organic farming, urban farming, and precision agriculture; all enabled through data, drone, and DNA technology.
- **Environmental justice skills** - managing the intersection of human rights and environmental rights to ensure that a just transition is possible, and diversity, equity, and inclusion forms a strong foundation for participation in the green economy for all.
- **Circular economy skills** - building processes and industries that fit into circular economy principles to support development of a green transition.
- **Operation management and system integration skills** - integrating the nodes of green economic development to be aligned and think as "one".

All skills training should have 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 institutions. Government will also have to balance the need to outsource GH_2 value chain expertise to expedite GH_2 project development and local skills proliferation against local capacity building.

8. Strategic implementation

8.1. The role of Government and the private sector

Stronger partnerships will need to be built between Government, the private sector and civil society to create an enabling environment. Implementation should also drive international partnerships while protecting national interest.

Government's role is to create a conducive investment environment to attract investment into this industry. This will entail:

- Position of 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.
- Drive the implementation of infrastructure by partnering with the private sector. This will include port, rail, pipeline and electrical transmission and re-fuelling infrastructure.
- The Department of Science and Innovation is to monitor global developments and opportunities for innovation in a drive to commercialise home grown technologies and improve cost effectiveness of GH_2.

Details of the proposed responsibilities of specific government departments are listed in Annexure A.

The role of the private sector will include the initiation, development and execution of green hydrogen projects along the value chain for domestic consumption and export. This will include:
- Applying project development best practices to successfully de-risk projects;
- Be open to crowding in funding and to partnerships;
- Increase project pipeline in tranches;
- Be flexible to changing market needs;
- Source funding for projects and
- Show that South Africa is action oriented and deliver tangible results on projects.

8.2. Capturing the export market

Analysis of global net exporters has been completed using the 1.9 mtpa scenario or about 7% of the global import market as a SA base. If technology and learning rates advance significantly to bring GH_2 costs down to 2050 the production of grey hydrogen could be entirely constituted of GH_2. Based on the estimates, South Africa has the potential for close to 7% market share. South Africa will likely compete directly with Morocco, Russia, Chile and the UAE, and at more than 15% with Saudi Arabia and Australia. **Southern Africa, mainly Namibia and South Africa, could tap into a 10–22 mtpa of hydrogen equivalent export market.**

Without support, South Africa faces a trade disadvantage compared to other countries to compete in markets such as Japan and South Korea. This is due to closer geographical proximity allowing for lower transport costs, early mover advantage, and the already strong established relationships. Forecasts predict a South African price evolution from approximately $4/kg in 2025, to $3/kg in 2030, to $2.5/kg in 2035, to $1.5/kg in 2040, to $1/kg in 2050. Although South Africa is forecast to be one of the lowest cost producers of GH_2, the competitor countries will be able to reach low-cost production before South Africa. South Africa will differentiate itself by using proprietary Fisher Tropsch technology to target export of sustainable aviation fuel and will manufacture electrolysers and fuel cells using PGMs available locally. Additionally, South African projects will benefit from additional Government support in the form of incentives in the short term to reach lowest cost of production sooner than projected in order to be globally competitive.

South Africa can benefit from the fact that importing countries may seek to diversify supplies of energy, and South Africa could target GH_2 sales to East Asian markets. Blue hydrogen will compete with GH_2 in the Japanese market, as Japan has already commenced importing blue ammonia. Many global GH_2 value chain participants are already active in South Africa and are investigating participation in the GH_2 value chain in South Africa. South Africa's primary market will most likely be the EU and the United Kingdom. There are significant initiatives already undertaken by the EU to enable and facilitate GH_2 imports, including with South Africa. The European Union, notably Germany, have already introduced policy and have indicated a willingness to pay a premium price through the implementation of long-term (10 year) supply agreements to stimulate GH_2, ammonia and Power-to-X market development. Namibia, due to its historical ties to Germany also has an opportunity to collaborate with South Africa. However, there is a risk that the EU delegated acts (RED II) are too onerous for developing nations on the renewable energy and sustainable carbon sourcing requirements for green hydrogen which needs to be addressed by projects intending to export to the EU.

The following strategic objectives should be considered in pursuit of South Africa's GH_2 export market ambitions:

- Export Markets: secure long-term global market share and competitive trade position by strategically positioning South Africa as a preferred and reliable provider to key markets, specifically EU/UK, Japan and South Korea 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 to comprehensively understand global demand by country and the extent to which South Africa can increase market share.

8.3. Domestic market - price trajectory and penetration of industry

In GH_2 production, electricity accounts for 60-70% of costs, and the costs of electrolysers and balance of plant account for 30-40% of costs. Currently the production cost of GH_2 is not cost competitive with other hydrocarbon-based fuels. Carbon taxes can aid in reducing the cost differential between GH_2 and incumbent fossil fuels. While the declining cost of GH_2 production coupled with increasing carbon taxes is predicted to achieve GH_2 price parity from 2025 to 2027, this doesn't account for the overall higher cost of energy to end-users or capital costs of transitioning energy assets. A more realistic or market view of achieving local price parity may therefore be closer to 2030. Declining GH_2 prices will unlock opportunities across key sectors to decarbonise industry.

Consideration could be given to tax and other incentives to accelerate investments in, particularly, decarbonisation of export value chains to ensure that regulations in place in export markets do not inhibit the export of South African goods.

Noting the above considerations, and adopting the more aggressive demand view the key drivers of future South African demand between 2023 and 2050 are forecast to be:

- 2023-2025: Road transport, primarily Fuel Cell Vehicles (FCVs), including chiefly Heavy-Duty Vehicles (HDVs). Mobility represents a significant opportunity for South Africa, but this will be sequenced based on economic viability, which will be dictated by volume and carbon emissions. Mining represents the best early adopter of hydrogen for mobility, followed by heavy duty logistics (trucks and buses).

- 2023-2025: Refining and processing, which consumes significant amounts of hydrogen for the production of petroleum products and chemicals. Many refining and process plants that currently consume or produce grey or blue hydrogen have active projects to switch to GH_2.

- 2025-2030: Chemical and Industry, notably the non-ferrous metals, green steel, and cement sectors, which will need to decarbonize to remain globally competitive.

- 2028-2030: Green ammonia and methanol, which will replace current production from grey and blue hydrogen and add new production from new use cases.

- +2030: Power Storage and Balancing, which will see GH_2 being used for long duration storage based on daily, monthly, and cross-seasonal balancing requirements. With greater renewable energy penetration into the global energy system, the need for hydrogen as a means to store curtailed/surplus renewable energy is anticipated to increase.

To achieve ambitious domestic demand in the >3mtpa range, will require supportive policies and incentives. This will require specific coordination and interventions between the public and private sector. **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 market demand.**

The strategic objective that should be considered in pursuit of South Africa's GH_2 Strategic vision outlined above is to stimulate the domestic demand for GH_2, by demonstrating the feasibility of GH_2 applications in hard-to-abate sectors such as non-ferrous metals, green steel, sustainable aviation fuel, fertiliser and cement in order to foster short term pilot projects and long-term commercialisation.

8.4. Equipment manufacturing

Establishing local industrial capability and equipment manufacturing is a key enabler of longer- term competitive advantage and the following strategic objectives should be considered:

- Support initiatives and intellectual property for local GH_2 production and inputs such as electrolysers, catalysts, fuel cells and the integral components that comprise these. These components include membrane electrode assembly (MEA), and catalyst coated membranes (CCM) for example.
- Understand the potential for industrialization of the renewable energy manufacturing supply chain through an aggressive GH_2 strategy. This should involve alignment of the masterplans in process in the renewable energy, steel and automotive sectors as well as relevant Phakisa processes (e.g. oceans).
- Create partnerships and joint ventures to secure investment, technology partnerships, and long term demand off-take agreements.

8.5. Catalytic project development and successive ramp up

Establishing such a new long-term industrial capability will require staged, pragmatic and ambitious policy and government support aligned to support private sector driven investment in infrastructure. This will have to occur in a context where South Africa faces challenges related to low economic growth, electricity supply and a constrained fiscal space with competing priorities and the technology surrounding GH_2 production, use, transport, and storage is still maturing and competitiveness and cost-parity with incumbent fossil-based routes has yet to materialise.

Formulating a roadmap is a crucial step in order to plan future pathways and ensure that a holistic approach is adopted. The roadmap provides a level of market certainty and buy in from multiple stakeholders towards achieving certain milestones and development of the value chain for both export and domestic markets. The roadmaps are distinguished into short term (2023-2027) and longer-term objectives (2023-2050) for the purposes of the commercialisation strategy. Responsibilities are allocated by segmenting actions identified for the public sector and the private sector within each time frame. The roadmaps are followed by the indicative short-term funding requirements.

Based on the above elements of the value chain, the total cost to the end user of the GH_2 is approximated as the sum of the component costs along the value chain pathway. This cost will vary based on the form of GH_2 required in the end use and conversion processes required, and the method of transport. **On the basis of a scenario of 1.9 Mt GH_2 for export and 1.9 Mt GH_2 for domestic consumption to 2050, significant investments in estimated installed capacity for renewable energy and electrolysers are required.** It is estimated that a combination of 56 GW of solar and 24 GW of wind will be required as an electricity input, combined with an aggregate electrolyser capacity of 41 GW to meet the demand anticipated in this scenario.

Long term growth aspirations could exceed 7mtpa of production by 2050. This potential ramp up, associated costs and CO_2 displaced is shown in Figure 7.

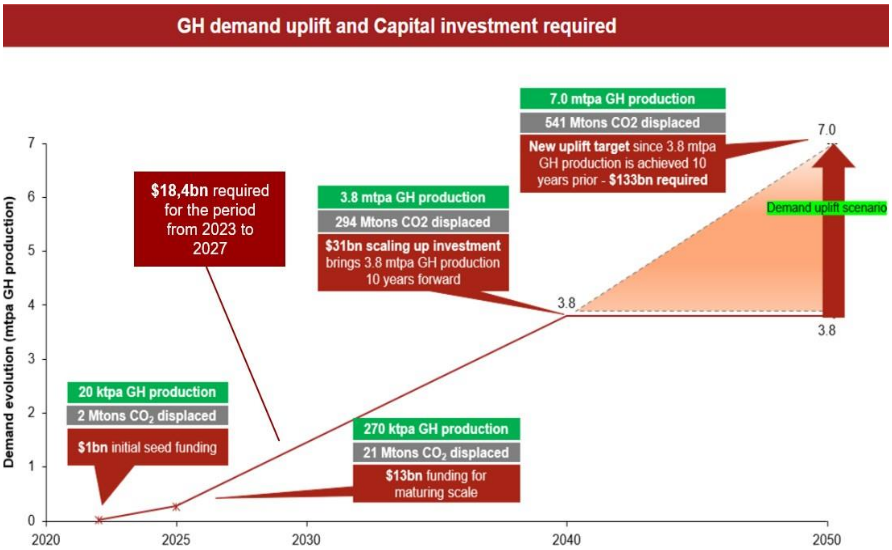

Figure 7: GH2 demand uplift and capital investment required.

- \$1bn investment could expedite GH_2 export of 20 ktpa.
- Within three to five years, several GH_2 projects, both export and local, will come online

increasing GH_2 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 $164bn by 2040.
- Between 2040 and 2050, South Africa can aggressively pursue deeper decarbonisation by seeking a GH_2 demand uplift to 7 mtpa. This will displace 541 Mtons of CO_2 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.

8.5.1. Tracking key South African projects to date

There has been a surge of interest in GH_2 projects in the country given the need to test commercial cases across the value chain. In December 2022, Minister of Public Works and Infrastructure, gazetted the nine projects that have received Strategic Integrated Projects, which are indicated in Figure 7.

These projects[14] target different portions of the value chain, along with targeted and early-win downstream applications such as mobility (heavy duty), beneficiated GH_2 products (e.g. ammonia, sustainable aviation fuel), and GH_2 production.

[14] A more comprehensive list of South African projects is indicated in Appendix C along with geographical descriptions of projects and investment requirements to increase production.

ANNEXURE TO INFRASTRUCTURE PROJECTS GAZETTE NOVEMBER 2022

1. A total of 9 projects included in the programme have been successfully registered with Infrastructure South Africa (ISA).

2. Projects registered with ISA will receive their SIP letters immediately after the Gazette is published, which include:

    a. The Prieska Power Reserve in the Northern Cape
    b. The Ubuntu Green Energy Hydrogen Project in Northern Cape
    c. Boegoebaai Green Hydrogen Development Programme in the Northern Cape
    d. Atlanthia Green Hydrogen in the Western Cape
    e. Upilanga Solar and Green Hydrogen Park in the Northern Cape
    f. Sasolburg Green Hydrogen Programme in the Free State
    g. SASOL HySHiFT (Secunda) in Mpumalanga
    h. HIVE Ammonia in the Eastern Cape
    i. Hydrogen Valley Programme of Anglo-American and their JV Partners (9 projects) along the Limpopo, Gauteng to KwaZulu-Natal Corridor

3. Projects awaiting final project information before registration with ISA can proceed, include the following:

    a. Mainstream Renewable Energy Hydrogen in the Western Cape
    b. AMSA Saldanha Steel Hydrogen project in the Western Cape
    c. Enertrag Postmasburg Project. (Ammonia) in the Northern Cape
    d. HDF Energy Renewable Energy, IPM 1 in Mpumalanga
    e. Enertrag Indigen Project (e-methanol) in the Eastern Cape
    f. Isondo Fuel Cell MEAs Manufacturing in Gauteng
    g. Isondo / NCP Vehicles in Gauteng
    h. Saldanha Bay Green Hydrogen Project
    i. Project Phoenix Fuel Cell Manufacturing in Free State
    j. Cape Stack in the Western Cape
    k. Bambili Hyplat Fuel Cell Manufacturing

4. Note that all projects registered with ISA will receive official SIP letters once Project Plans are submitted and adopted by the SIP Steering Committee, which sits on a quarterly basis.
5. Additional Green Hydrogen projects will receive SIP status once registered with ISA.

Figure 7: Strategic integrated projects (SIP)

Table 1. Strategic Integrated Projects (SIP) gazetted in December 2022

#	Location	Project	Status	Description	Stakeholders
1	Mpumalanga, Secunda	Sasol HySHiFT	Cooperation agreement announced.	Sasol intends on developing a sustainable aviation fuel production demonstration facility, based on GH, at its Secunda operations, in Mpumalanga to be bid in the first round of the H2Global auction programme.	Sasol, Enertrag, Navitas, Linde
2	Northern Cape, Prieska	Prieska Energy Cluster	Feasibility study and scoping (2025 commission date)	The project targets the production of green hydrogen and ammonia from 2025. This entails the development of Green Ammonia Production facility in Prieska, Northern Cape. The Project will inject R6.3 billion in capital investments in the first phase, with an additional R48 billion in investments during the expansion phase. The first phase of the Project, which will be located 10km outside Prieska in the Northern Cape, South Africa, will result in the production of 70,000 tons/annum of green ammonia with a GH content of approximately 12,350 tons.	Mahlako a Phahla investments, Central Energy Corporation (Cenec) and IDC.
3	Northern Cape, Boegoebaai	Boegoebaai GH Port	Feasibility study (memorandum of agreement signed)	Port, Rail and Infrastructure Project driven by the Northern Cape Provincial Government. The port has a capital value of approximately R13 billion and is underpinned by the export of mining commodities. 60,000 hectares of well irradiated land adjacent to the site would	Northern Cape Economic Development, Trade and Promotion Agency, Sasol

#	Location	Project	Status	Description	Stakeholders
				support a 30 GW solar and wind farm (6 times SA's current installed renewable energy capacity) and support 5 GWs of electrolysers	
4	Northern Cape	Ubuntu GH Project	GH beneficiation feasibility study/Unknown	20MW GH production project in the Northern Cape	Ubuntu Green Energy
5	Saldanha Bay Industrial Development Zone (SBIDZ), Western Cape	Atlanthia Green Hydrogen	Pre-feasibility conducted	Atlanthia will produce green hydrogen and ammonia GH2 and GNH3. Solar, wind and battery storage will supply electricity to the hydrogen electrolysis (20MW), desalination, air separation and green ammonia forming processes, via the production of GH2 and green nitrogen. Their pre-feasibility study completed in 2021 indicated economic viability for export and favourable local conditions for the adoption of GH2/GNH3 in South Africa's hard-to-abate clean fuels and chemicals sectors.	Atlanthia (Pty) Ltd
6	Upington, Northern Cape	Upilanga Solar and Green Hydrogen Park	Bankable Feasibility Study	Upilanga Green Hydrogen Valley is a green Power-to-X (P2X) project. Phase 1 of the project consists of a 400MW Integrated CSP+PV Power Plant (ICPH) with 12 hours of Thermal Energy Storage (TES) and a 500MW Electrolyser area for the production of Green Hydrogen and possibly derivatives (Green Ammonia, Green Methanol) Part of the phase 1 roll	Emvelo Energia, Upilanga Green H2 and DBSA.

#	Location	Project	Status	Description	Stakeholders
				out incorporates a 10-20MW Green H2 pilot demonstration.	
7	Free State	Sasolburg Green Hydrogen Programme	Sasol has signed a long-term contract for the supply of 69 MW of renewable energy	The Msenge project is one of several similar projects on which Sasol is focusing to complement its overall renewable energy programme procurement process. Msenge will come online in early 2024, subject to final regulatory and financial approvals.	Sasol, IDC
8	Eastern Cape	Hive energy Green Ammonia	The first phase of the plant is expected to be concluded in 2025	Hive Hydrogen has announced an investment of over $6 billion in green ammonia in South Africa. Hive has established a $4.6bn Green Ammonia Plant in the Eastern Cape. Targeted markets include agricultural, chemical, mining and maritime shipping.	Hive Energy/Built Africa
9	Limpopo, KZN and Gauteng corridors	Hydrogen Valley Feasibility Investigation - Johannesburg Hub	Various stages of feasibility	The Hydrogen Valley Programme consist of nine projects that assess the feasibility of developing corridors between the hubs of KZN, Gauteng and Limpopo. Various production and applications are being tested for their feasibility including feedstock switching, ethylene production, heavy duty vehicles, mining trucks, and buses	DSI, Anglo American, Engie, SANEDI, Bambili Energy

8.5.2. Showcasing projects

Green Ammonia Production for Export

Hive Energy and Built Africa are developing a $4.6bn Green Ammonia Plant. The plant will have a dedicated power supply at the Coega Special Economic Zone, alongside the Port of Ngqura. The plant will produce approximately 780,000 tons per year of green ammonia for the export market. This project is working together with Cerebos in a mutually beneficial way, which entails Cerebos providing the project with desalinated, demineralized water while the project will supply green energy to Cerebos.

Green Steel Production

ArcelorMittal South Africa (AMSA) is investigating the viability of restarting the Saldhana Bay operations to produce green steel with green hydrogen. AMSA plans to be the first African green flat steel producer using green hydrogen by producing direct reduced iron (DRI) via the Midrex facility at its Saldanha Works.

Fuel Cell Manufacturing

Mitochondria Energy is planning to build a hydrogen fuel cell manufacturing facility in the Vaal Special Economic Zone (SEZ) in partnership with the IDC, DTIC and DBSA. Mitochondria's plans involve developing manufacturing capacity to build units totalling 250 MW a year, with plans to eventually ramp up to 1 000 MW a year, dependent on demand at the time.

Sustainable Aviation Fuel

Sasol as part of a consortium known as HyShiFT, is developing a sustainable aviation fuel (SAF) project in Secunda. Other partners in the consortium include German-based renewable energy company Enertrag and chemicals company Linde. The project entails using green hydrogen and sustainable carbon to produce SAF for the export market.

8.6. Regional integration and supporting the development of hydrogen hubs and valleys

The concept of a hydrogen hub has become a popular policy and planning tool in order to ignite the GH_2 industry. It is important to note that provincial government efforts have played a strong role in highlighting and identifying opportunities for development in the GH_2 value chain and potential hubs. Here, it is vital that national level plans and strategies align with provincial plans in order to identify synergies and avoid duplication. The Northern Cape, Western Cape, Eastern Cape, eThekwini regions and Gauteng regions have all embarked on ambitious plans to develop GH_2 within their provinces.

It is important to create focus and prioritisation in the initial design and planning of these hubs. This has also been identified by international OEM's as well as in the literature review as global best practice. It is therefore proposed that the identified locations in the GHCS be promoted for longer term development as the GH_2 sector develops in South Africa.

Regional GH_2 integration in Africa

GH_2 has the potential to enable African countries to become more energy independent and promote zero-carbon industrialization. Additionally, the development of the GH_2 economy in Africa will create both economic growth and new jobs, as well as help to enable and accelerate the deployment of renewable energy across the continent, a necessary step to increase energy access and affordability.

Africa has immense renewable energy endowments and is equipped to take full advantage of the hydrogen opportunity. It is estimated that Africa's exports of GH_2 and derivatives could reach 20-40 mtpa by 2050 (AGHA, 2022). The northern and southern regions of Africa, due to the excellent renewable energy resources, could emerge as key export hubs. While in Eastern and Western Africa, solar and wind profiles are less optimised for exports and these regions are more likely to be focussed on domestic demand. Realising these ambitions will require collaboration between African nations.

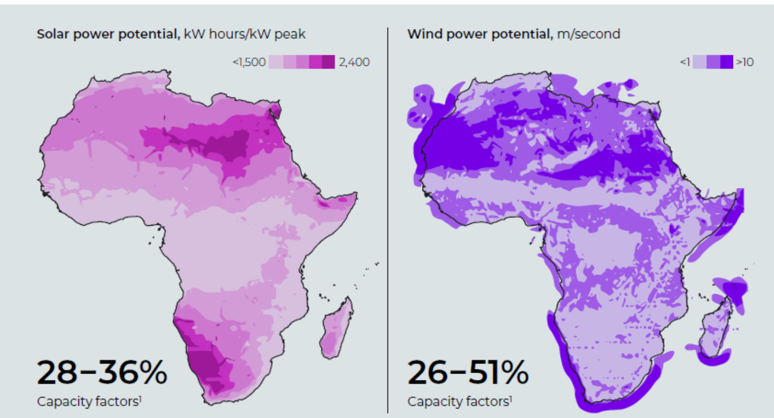

Figure 2 : Africa's renewable energy endowments source AGHA, 2022.

The President has championed an African-focused Green Hydrogen development plan, focused on unlocking opportunity in the first phase along the south-western seaboard, incorporating South Africa, Namibia and Angola, with a view to this forming the core of a southern African export hub of green hydrogen.

The African Green Hydrogen Alliance (AGHA) was formed in May 2022 and consists of the following members Egypt, Kenya, Morocco, Mauritania, Namibia, Ethiopia, Angola and South Africa.

There is potential for this type of intra-government forum or entity to drive the African GH_2 opportunity. In parallel a local DFI could be nominated to drive co-ordinated project development efforts across the region.

8.7. Short term funding plan (2023-2027)

Securing international support and financing through bi-lateral and commercial arrangements where developed nations need to secure long-term security of GH_2 supply will be key to the country securing an early mover market position. This will have to be supported by South Africa's need to drive economic recovery through green economic infrastructure that will also address the triple challenges. Based on the projected production targets, required projects and the roadmap actions, investment needs for the period from 2023-2027 is summarised below. It is envisaged that most of the projects will be private sector driven with the exception of the port development and infrastructure which will be public sector driven.

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

9. Public Consultation and Social Acceptance

The GHCS was approved by Cabinet in November 2022 for release to the public for comments. The period for comments was closed on 31 March 2023. The PCC also provided comments to the GH_2 section of the JET-IP. The GHCS was presented to NEDLAC on 24 August 2023. The GHCS was updated with inputs from public comments, PCC comments on the JET-IP and presentation at NEDLAC. A summary of the comments and how the concerns were addressed is shown below.

Theme	Concern Raised	How concerns are addressed
Energy Security	GH_2 should not compete with South Africa's energy crisis. Eradicating energy poverty is a more pressing priority.	GHCS updated to provide assurance that GH_2 can help alleviate the electricity crisis by feeding power into the grid, feeding power into micro grids for the community and by grid infrastructure upgrades allowing other RE projects to feed into the grid.
Funding	GH_2 should not direct critical grant funding away from the energy crisis and other pressing issues.	GH_2 implementation plan does not seek to obtain grants from the IPG offer already earmarked for other sectors. Grant funding will be sourced from dedicated global funds mandated for supporting GH_2 initiatives on a global level.
Workforce skills	Insufficient local workforce skills to deliver the pipeline of projects.	GHCS provides a reskilling framework that will be developed into a skills development plan.
Transparency	Governance that provides transparency on progress and fund use is required.	GH_2 implementation dashboard will be developed and made publicly available.
Infrastructure	Lack of coordination on infrastructure build for GH_2	New governance structures will be set up that will allow improved coordination between government entities and private sector

10. Conclusion

The GHCS presents a strong business case for South Africa to develop a GH_2 industry that will support both economic and social ambitions for the country. In order for the 2050 vision to materialise the defined action in the GHCS will need to have a prioritised implementation with focus on the following actions:

- Clear policy support from Government including implementing regulatory changes as defined in the GHCS action plan.
- Development of the different scenarios for funding, taking account of JET-IP and private sector funding, to determine the extent of public incentives required at the appropriate time to support the short and medium term ramp up of this new industry, and decarbonisation of heavy industries and agriculture, leading to the achievement of the GHCS 2050 targets.
- Establishing a regulatory and market framework around new11 GH2 manufacturing, production, use, transport and storage to drive investment in South Africa's GH_2 economy.

- Establish bilateral engagements and agreements between South Africa and key international consumers.
- Mobilise a task team to investigate the social, economic and environmental impact of various scenarios and determine the value that could be derived by acceleration of GH_2 value chain. This would include an assessment of the enabling levers including tax incentives, grant schemes and reduced import surcharges on technology options, production incentives and demand stimulation incentives to support the short-term objectives of the GHCS.
- Assessment of the current infrastructure requirements in terms of transmission grid, renewable energy, transport infrastructure (pipelines, ports, roads, rail) and the investments required in order to support the development of the value chain and ensure that private projects are able to access key infrastructure. Specifically undertake a pre-feasibility study on potential new GH_2 pipelines.
- Developing and securing funding instruments and disbursing specific funds such as international grants, specific hydrogen concessional funds and pricing subsidies to support the current catalytic projects and potentially newly initiated projects.
- Support of the development of the projects that have been granted SIP status as Gazetted in December 2022 towards reaching final investment decisions.
- Initiate and develop additional projects aligned to the medium term ramp up targets of the industry.
- Support the development of the identified GH_2 hubs and valleys to ensure accelerated impact in developing the new GH_2 industry and associated green industries.
- Analyse and plan for a Just Transition, ensuring appropriate public and social dialogue and understanding.
- Engage in a social dialogue between workers and their unions, employers, government and communities in order to ensure that GH2 development contributes to climate change mitigation as well as adaptation. Ensure appropriate training and skills development programmes to limit job losses and support employment as industry sectors decarbonise.

It is anticipated that a series of business plans and implementation plans will be periodically released with specific responsibilities identified in order to address resource availability with both public and private sector backed initiatives. Annual feedback will be provided to Cabinet on progress achieved and interventions recommended to accelerate development of the GH_2 value chain.

The National Green Hydrogen Commercialisation Strategy will build on momentum of HySA programme and the Hydrogen Society Roadmap to position South Africa as a global player in GH_2, green chemicals and green manufacturing. The development of this new GH_2 industry will support South Africa's Economic Reconstruction and Recovery Plan. Implementation of the action plans should ensure a Just Transition tackling skills development, job creation, 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.

Annexure A: Proposed responsibilities of the different government departments

The Presidency	• Prioritise an in-depth analysis of required GH2 regulatory framework. • 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 GH_2 • Fast track project regulatory approvals with support from the ISA office • Prioritise support of project applications to the H2 Global organization
The dtic	• Attract investment into establishing equipment manufacturing facilities specifically for electrolysers, 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) • Develop and introduce GH2 Standards and specifications. • Design and introduce a Guarantees of Origin system to install investor confidence in key import nodes.
DIRCO	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 GH_2. The current EU directives allow use of CO2 only to 2036 b) Modify the current rules for emission allocation to allow for flexibility and use of existing facilities c) Lobby to allow for a longer transition period to sustainable carbon use in the production of hydrocarbon fuels. Facilitate bilateral government to government agreements relating to off take of GH2 derivatives
The DMRE	• 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. • Consider the role of the section 19(1)(f) of the National Energy Act in respect of incentives to promote the production, consumption, investment, research and development of renewable energy and green hydrogen
The DFFE	• Advocacy for policies and support at global level, especially UNFCCC, to support GH2 development in RSA • Critical enablement of projects through timely environmental approvals. • Monitoring of carbon emissions within hard-to-abate sectors and oversight of outcomes from GH development to support achievement of NDC commitments • Waste management regulation
The DoT	• Create an enabling environment for the deployment of GH2 mobility technologies and related infrastructure • Leverage the green transport strategy to drive the development of the GH2 sector
National Treasury	• Evaluate allocations for future budget support • Manage JET-IP funding requests and enablement
The DSI	• Drive innovation, RD&I and skills development • Together with dtic, support commercialisation of innovative products, processes and services that will reduce costs and enhance competitiveness of SA component production • Assist with management of patents and licenses, both local and foreign • Co-ordinate research on critical mineral value chains • Research and insights into chemical value chains to support sustainability and global competitiveness
The DHET	• Align to the identified skills and action plan in this commercialisation strategy • Co-create technical training courses to develop future skills requirement to support GH2 and associated value chains • Focus on systems and design thinking to under-pin inter-related nature of GH2 development • Co-ordinate funding and support for university programmes • Support and coordinate skills development in industry • Bring SETA funding at industry level • Funding support for GH2 PhD projects, programmes and scholarships