The development of green hydrogen in South Africa

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SUMMARY

South Africa is the 12th largest global emitter of greenhouse gas emissions. As part of global initiatives to reduce emissions, the country also pledged alliance to this common goal via the conference of parties. Strict net-zero targets have been set globally and locally, however; it has been realized that decarbonizing the energy sector will not be sufficient to reach these targets (approximately 46% of greenhouse gas (GHG) emissions emanate from the electricity sector in South Africa). This brings about the need to evaluate other sectors, also known as the hard-to-abate sectors, for decarbonization.

It has been realized that hydrogen is currently used in some of these hard-to-abate sectors and the conversion of this to green hydrogen may contribute in significant GHG emission reduction and may further assist the globe in realizing these strict net-zero targets for 2050. Furthermore, this scenario is exacerbated by the geopolitics created by the Russia-Ukraine war.

South Africa has been identified as a potential global exporter of green hydrogen and its derivatives due to our solar and wind resource potential, abundance of land availability, good resource for platinum group metals (used as catalyst for electrolysers and fuel cell manufacturing) and use and development of Fischer tropsch technology which is used for synthetic fuels. This paper discusses the concept of green hydrogen and potential market avenues, national developments that have been made for green hydrogen, considerations for the electrical grid and considerations for a just transition in the country.

KEYWORDS

Green hydrogen; Just energy transition; Decarbonisation; Value chains.

1 INTRODUCTION

From the dawn of the industrial revolution, humans have been continuously extracting fossil fuels and extensively burning them in the pursuit of economic growth and higher standards of living. This has resulted in increased global greenhouse gas (GHG) emissions and climate change. The globe now needs to transition from these extractive carbon intensive economies to low carbon economies and technologies to curb global warming and mitigate/alleviate climate change impacts. This transition will see the implementation of technologies at a pace never experienced before. Almost half of the globes GHG emissions emanate from the electricity generation sector. However, the broader energy sector incorporates what is termed hard-to-abate sectors and the solutions to decarbonise the electricity sector is not sufficient to reach the net-zero targets required to curb global warming. Figure 1 below illustrates the global greenhouse gas emissions by sector also showing that the broader energy sector accounts for ~73% of total emissions.

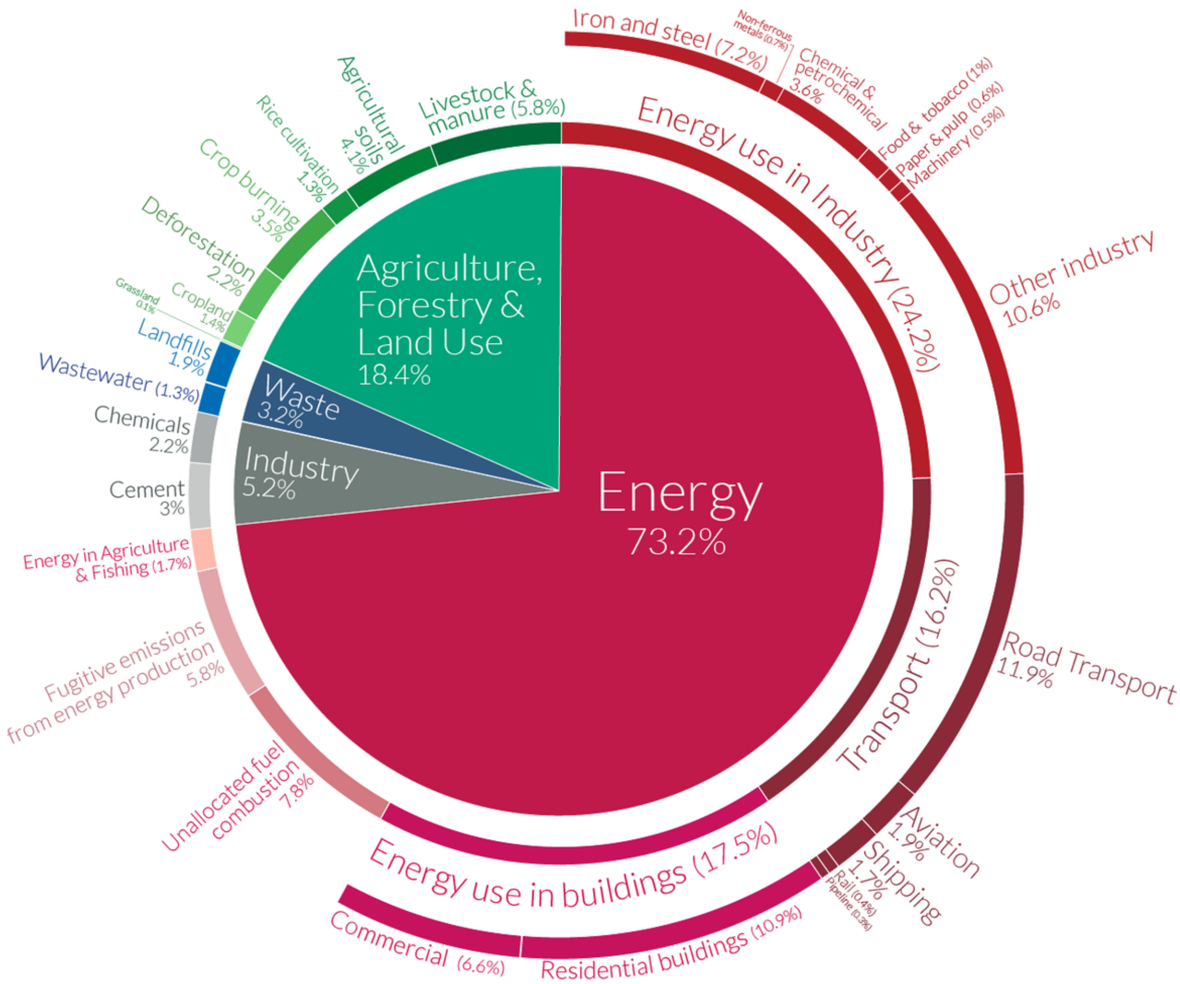


Figure 1: Global greenhouse gas emissions by sector [1]

The electricity sector can be decarbonised predominantly by the implementation and use of renewable energy such as wind and solar photovoltaic (PV). However, other interventions such as the use of green hydrogen within energy processes is required to decarbonise the hard-to-abate sectors such as shipping, steel, chemicals and to some extent, agriculture. The International Renewable Energy Agency (IRENA) predicts that ~10% of GHG emissions will be reduced by the use of green hydrogen (as described in Figure 2 below).

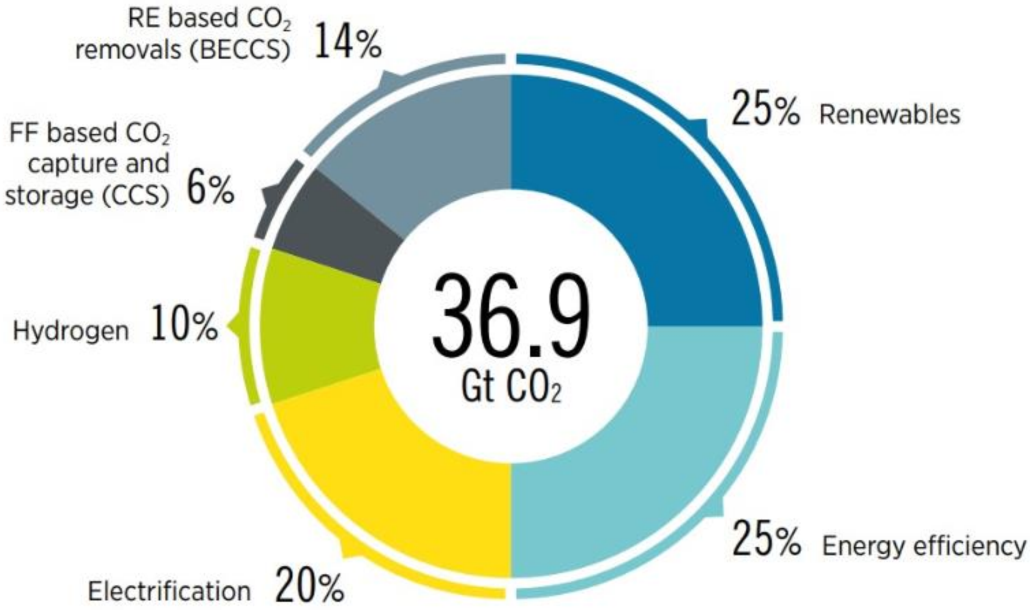


Figure 2: Technology avenues required to reach net-zero targets [2]

In South Africa, green hydrogen is becoming a key technology pathway for the development of the green economy in the country. The global North has been experiencing energy security issues relating to the Russia-Ukraine war and reduction of gas. This along with the ambitious net-zero targets being pursued has caused these countries to think about other avenues for long term energy security. The global South has better renewable resources and abundant land which can create the green energy required for the global net-zero targets. Europe has already shown their interest in procuring green energy in the form of hydrogen and/or its derivatives for this purpose. This brings about a significant opportunity for South Africa to alleviate its triple challenge of unemployment, inequality and poverty. This paper will elaborate on the developments for green hydrogen in South Africa and related considerations.

2 POWER TO X

As mentioned above, there are various hard-to-abate sectors that require decarbonisation in order to reach net-zero targets. The green hydrogen value chain is vast and wide as hydrogen can be used in many processes. The term power to X is used to describe the various avenues for green hydrogen and its based on the fact that green electricity/power is used to make hydrogen and further hydrogen derivatives (referred to as X). The technology used to produce the power in this process determines the colour of hydrogen. The top 3 colours considered are: green indicating renewable energy, grey indicating coal-fired power, blue indicating natural gas with carbon capture.

The value chains for green hydrogen is illustrated in Figure 3 and the end-use applications for green hydrogen is listed in Figure 4. Hydrogen use in processes is not a new concept, many companies thrive on this in their current operations albeit grey hydrogen. These companies include Sasol, PetroSA, Linde, etc. The only “new” part of the value chain is the green electricity and the subsequent electrolysis of water.

South Africa has the benefit from the experience and use of Sasol's Fischer tropsch technology which is used for the production of synthetic fuels and required for green hydrogen value chain for green fuels.

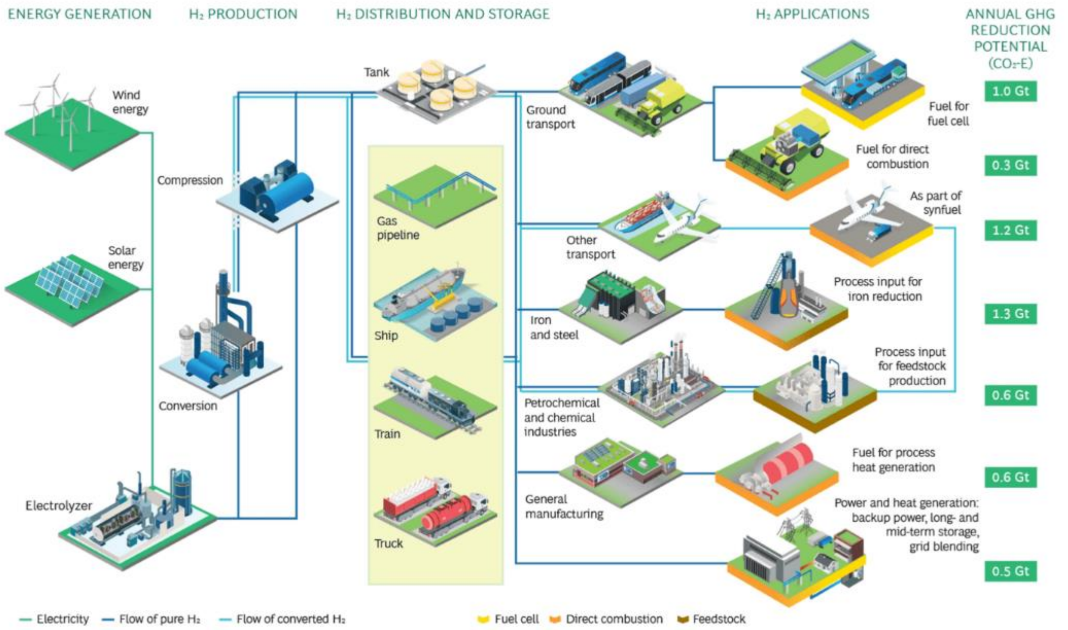


Figure 3: Value chains for green hydrogen [3]

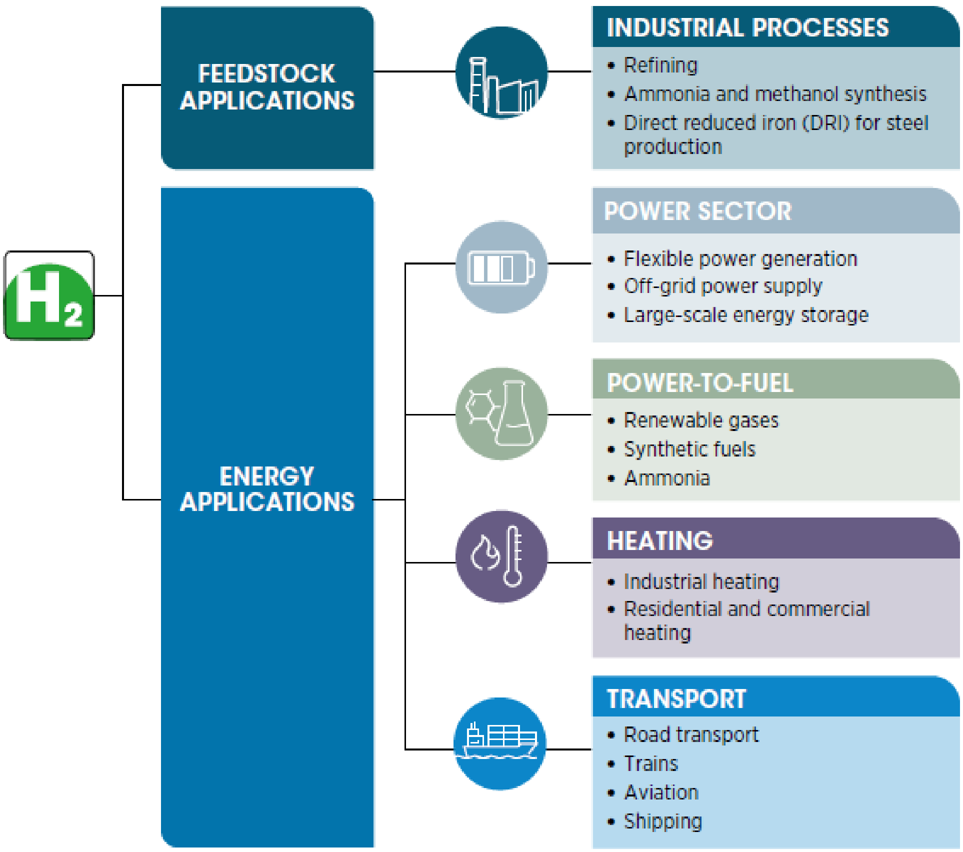


Figure 4: End-use applications for green hydrogen and its derivatives [4]

2.1 Economics of green hydrogen

Although there are various possibilities and sectors for green hydrogen use, it may not always be feasible for the end-user. Currently, the major producer's of hydrogen produce grey hydrogen at an average of ~$2/kg. This value is calculated using the levelized cost of hydrogen equation which takes into account various factors such as capital investments, operations and maintenance costs, lifespan of equipment, weighted average cost of capital and estimated production over the lifespan, amongst others.

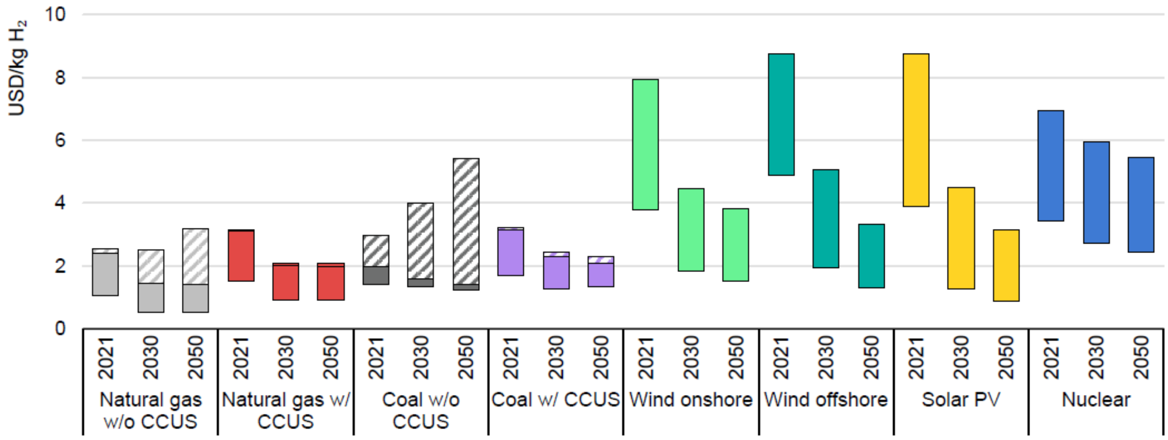


Figure 5: Current and future levelized cost of hydrogen production per generation technology [5]

As can be seen from Figure 5, currently, green hydrogen is considered too expensive, however, policy makers and developmental financiers globally are working on possible enablers, subsidies and incentives. Due to the numerous end-use applications, the policy drivers will need to span across many sectors in order to achieve. Europe and USA have derived specific policy documents to direct the market on some of their requirements for green hydrogen production. There are already open markets ready to accept bids for the export of green hydrogen to the global north i.e. H2 Global, however, some of the requirements stipulated are too strict for South Africa to meet at this point in time. The other mechanism being formulated and moulded to become a significant incentive to lower the price of green hydrogen and its derivatives is Carbon Border Adjustment Mechanism (CBAM).

3 DRIVERS IN SOUTH AFRICA

South Africa has realised the need for the green hydrogen market in 2007 when Department of Science and Innovation (DSI) had started its research, development and innovation plan for this. The DSI invested in many initiatives, with the main one being Hydrogen South Africa (HySA), to inform the country's objectives and stimulate the development of a hydrogen ecosystem. The DSI then published the Hydrogen Society Roadmap in 2021 [6] and this along with other related policy detailed in Figure 6 forms the initialisation of the enabling environment for green hydrogen development in the country. Global changes such as the geopolitics of energy and the global North energy crisis has brought about an intended focus on hydrogen trade and this is detailed in the Green Hydrogen Commercialisation Strategy.

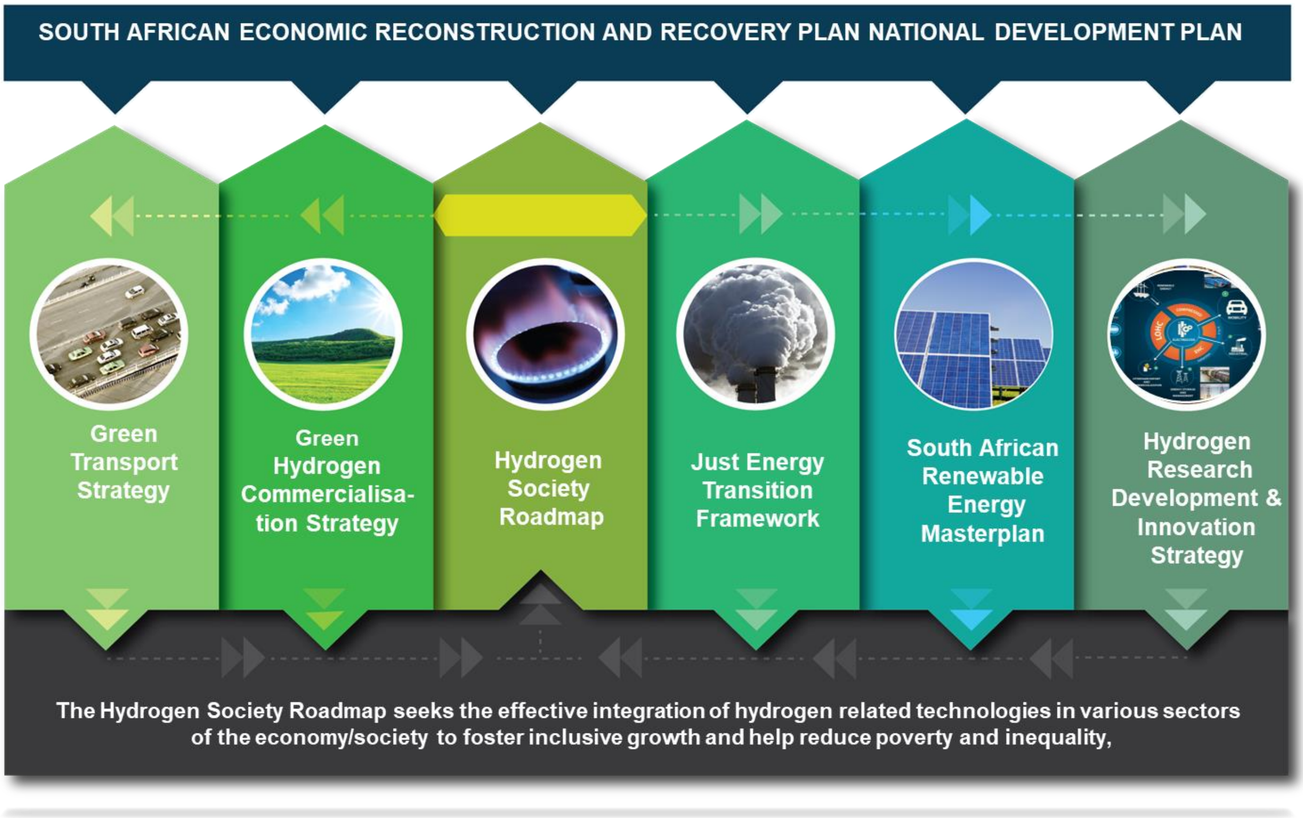
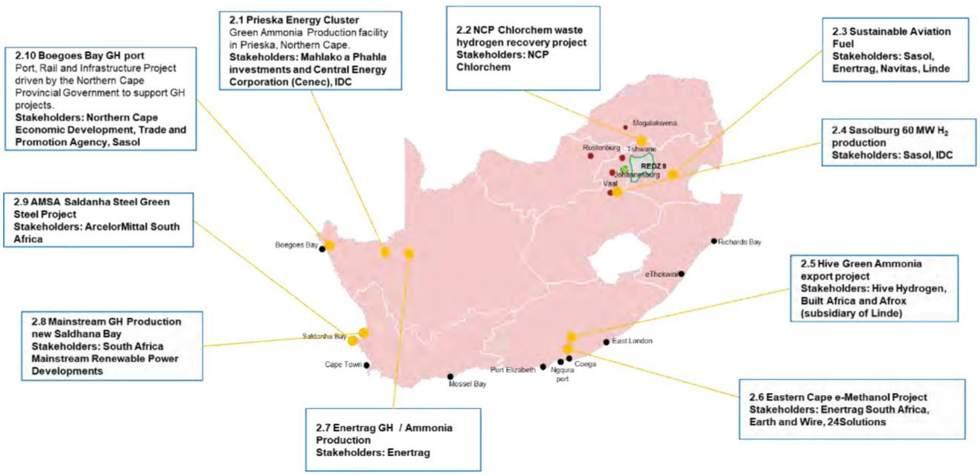


Figure 6: South African policy drivers for the development of the green hydrogen market (Source: DSI)

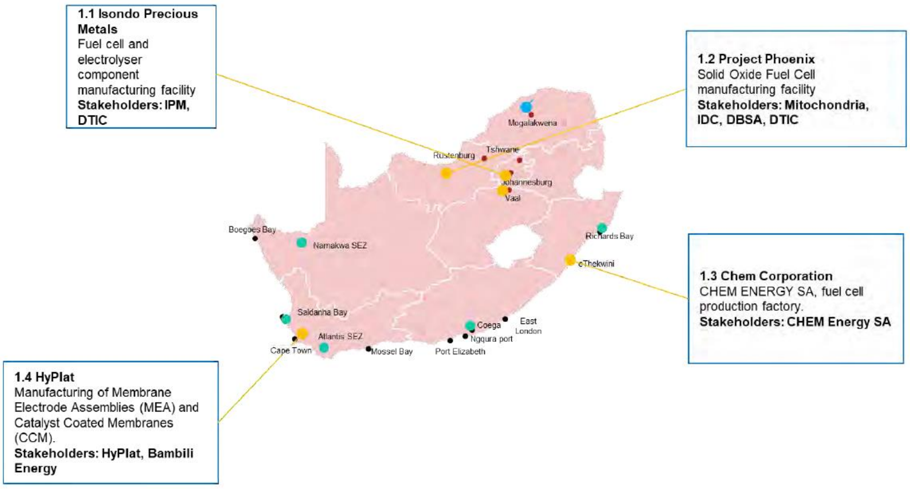
The South African Just Energy Transition Investment Plan (JETIP) presented at the conference of parties (COP) in 2022 details the investment requirements for the country to decarbonise and reach its very ambitious net-zero targets. This plan stipulates that the country needs R1.5tn to decarbonise and modernise the electricity grid, new energy vehicle sector and development of green hydrogen. Approximately 22% of R1.5tn is allocated for green hydrogen, predominantly towards feasibility and pre-feasibility of related projects [7]. This is a significant enabler for the market and depicts significant opportunity for economic growth and socio-economic benefits. However, the practicality of the development of a sustainable ecosystem must be considered. Skills required for this is immense and if not given the attention required, can hinder on the success of these plans. Enablers for the demand side, especially local demand, is still required. The current prices are too high and mechanisms such as carbon tax, carbon credits and subsidies will be required to stimulate local demand for green hydrogen.

3.1 Green hydrogen commercialisation strategy (draft) [8]

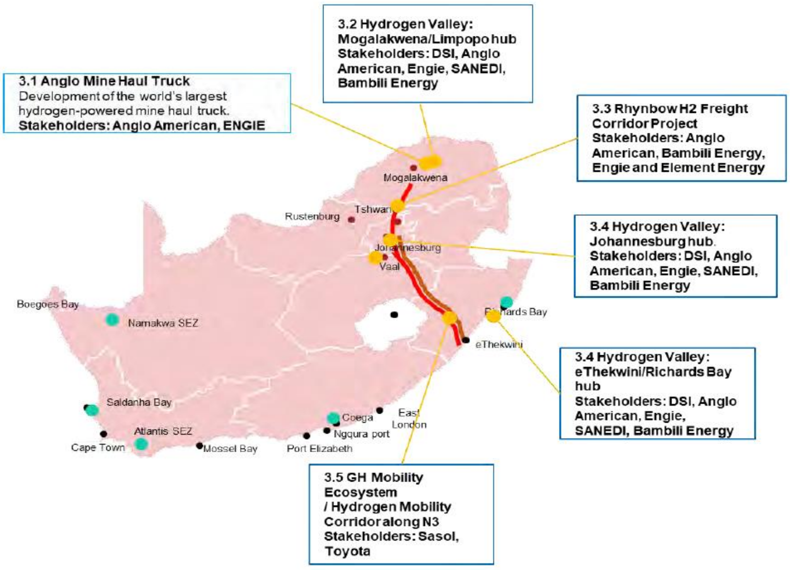
As mentioned above, a draft green hydrogen commercialisation strategy has been published by the Industrial Development Corporation (IDC) in a consortium driven by Department of Trade Industry and Competition (DTIC). This document estimates the export and local market potentials along with the expected benefits for the country. Various catalytic projects have been announced and these are illustrated in Figure 7 below. Most (if not all) of these projects have been registered as Strategic Integrated Projects (SIPs) with Infrastructure South Africa (ISA) in the Presidency.



(a) Green hydrogen, chemicals and green steel [8]



(b) Manufacturing [8]



(c) Mobility [8]

Figure 7: Catalytic projects highlighted in draft green hydrogen commercialisation strategy [8]

The strategy highlights the need for at least 100GW of dedicated renewable energy capacity based on at least 3.8mt per annum of hydrogen production from 2040. Various target markets have been identified and the catalytic projects highlighted in Figure 7 above are meant to catalyse the process for creation of the ecosystems required as well as to provide a first mover advantage. These aspirations are envisaged to produce approximately 650 000 jobs and will be targeted at closing the inequality gaps.

4 OTHER CONSIDERATIONS

The aspirations for the development of the green hydrogen ecosystem have been expressed by both public and private sector of the country. Some activities are quite advanced and are already attracting off-take and investment. However, it is still a need to understand the practicality of these projects and aspirations. There are many factors that may impede the success of these plans and this section highlights some of those considerations.

4.1 Electricity grid and energy storage

The connection of the renewable energy plants required for the electricity production in the green hydrogen value chains is prudent to ensure that the country can produce hydrogen at competitive prices required by the market. However, recent developments have shown that the grid capacity available in the best renewable resource areas i.e. Northern Cape for solar and Western Cape for wind is limited to none. The consequence of this was made evident when 3.2GW of wind capacity was declined for connection to the transmission grid in the Cape in the most recent bid window of the renewable energy independent power producer programme (REIPPPP). Furthermore, there are concerns around water use for green hydrogen production has been considered and most of the larger production plants are therefore envisaged near the coastlines to include desalination of water from the sea. This exacerbates the need for the grid capacity to be available near these areas. The latest Eskom Transmission Development Plan (TDP) [9] indicates that the upgrade of this corridor of transmission grid to create an increased grid capacity of ~58GW more will take approx. 7-10 years if no significant hurdles are met. This capacity alone will still not be enough for the 100GW vision and technically was calculated using the expected electricity demand growth for the current ways of living (not directly accounting for green hydrogen electricity demand). This is a concern and a consideration that needs to be taken into account when pursuing the green hydrogen dreams of the country.

Certain end-use applications for green hydrogen derivates require constant electricity supply and this can also be said for alkaline electrolysers as intermittent operation can lead to reduced lifespan due to mechanical stress and thermal cycling. This then highlights the need for energy storage applications and there are various types of energy storage applications that can be adapted depending on the end-use applications. Figure 8 below illustrates the different energy storage technologies that can be adopted for different end-use applications as envisaged by Australia.

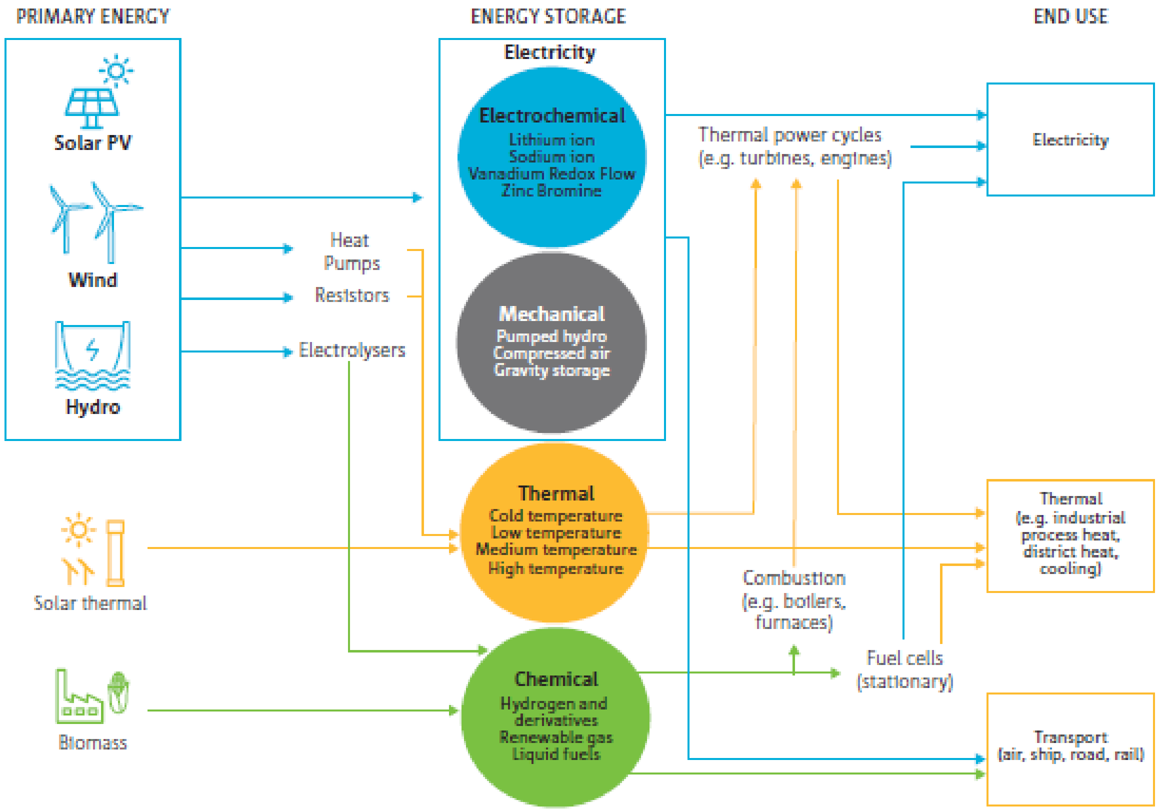


Figure 8: Energy storage technologies and end-use applications (Australia's energy storage roadmap) [10]

4.2 EU requirements

The European Union (EU) has made it very clear that they will require green hydrogen and/or its derivatives to reach its very ambitious net-zero GHG emission reduction targets. This is evident by the H2Global bidding process that was released in December 2022 worth €900m. However, some stringent requirements have been stipulated for one to succeed. The concerning requirements for South Africa is related to the additionality clause as well as the temporal and geographical correlation clause.

At this point in time with the current South African conditions, especially the energy crisis, it will immediately exclude our participation. However, it is something to consider when planning for the green hydrogen future of the country.

4.3 Other considerations

Other considerations include:

- Land required for the value chains required for hydrogen and its derivatives. Competing land interests should be considered as well as the environmental impacts.
- Cost assumptions being made due to technology improvements and decreasing costs. These projects are meant to materialise post 2030 and some of the assumptions for costing includes an expected cost reduction due to technology improvements and increased demand. This is an important aspect and consideration especially for potential investors and policy makers.

- Skills required for the ecosystem development. There is significant potential for green hydrogen value chains to create jobs and close the inequality gap, however, proper planning and prioritisation of activities is required for this to come to fruition. Many skills development activities need to be pursued and some of these can take years.
- Manufacturing and reindustrialisation. The country is on a strong mission to reindustrialise to create more employment and diversify the economy. There are targets towards fuel-cell production for vehicles and behind the meter energy storage in place. The commercialisation strategy also mentions the potential to manufacture electrolysers. These manufacturing targets are being pursued mainly due to the platinum group metals reserves in the country.

5 CONCLUSION

South Africa has numerous plans to becoming a significant player in the green hydrogen markets which is required to decarbonise hard-to-abate sectors to reach net-zero greenhouse gas emission reduction targets globally. This is evident in various enabling policies and plans. The country has unique advantages such as solar and wind resource potential, abundance of land availability, good resource for platinum group metals (used as catalyst for electrolysers and fuel cell manufacturing) and use and development of Fischer tropsch technology which is used for synthetic fuels production.

This paper discusses the concept of green hydrogen and potential market avenues, national developments that have been made for green hydrogen, considerations for the electrical grid and considerations for a just transition in the country. The country has enormous potential to create a local and global green hydrogen economy associated with notable job creation and potential to close the equality gaps. However, to ensure success various hurdles need to be considered and ironed out. The ecosystem needs to be built and enabling mechanisms such as carbon pricing and related policy developments, skills development, unlocking of grid capacity and financing which are required for success.

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