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Contents

List of abbreviations and acronyms

CBAM	Carbon Border Adjustment Mechanism
CISL	Cambridge Institute for Sustainability Leadership
CSDDD	Corporate Sustainable Due Diligence Directive
DIRCO	Department of International Relations and Cooperation
DMRE	Department of Mineral Resources and Energy
DSTI	Department of Science, Technology and Innovation
DTIC	Department of Trade, Industry and Competition
EU	European Union
EVs	Electric vehicles
GDP	Gross domestic product
HySA	Hydrogen South Africa
IDP	Integrated development plan
IMF	International Monetary Fund
IPP	Independent power producer
IRP	Integrated Resource Plan
JET IP	Just Energy Transition Investment Plan
JETP	Just Energy Transition Partnership
KTPA	Kilotonnes per annum
LNG	Liquefied natural gas
MoU	Memorandum of understanding
MW	Megawatt
MWh	Megawatt-hour
NAAMSA	National Association of Automobile Manufacturers of South Africa
PEM	Proton exchange membrane

PGMs	Platinum group metals
REEs	Rare earth elements
SADC	Southern African Development Community
SANEDI	South African National Energy Development Institute
SETAs	Sector Education and Training Authorities
SLP	Social and labour plan
TVET	Technical and vocational education and training
UK	United Kingdom
US	United States

Executive summary

South Africa stands at a pivotal moment in its energy future. The government has committed to a clean-energy economy, with the Just Energy Transition Investment Plan (JET IP) setting out an ambition to reduce emissions, strengthen climate resilience and shift the country towards a more sustainable development path. South Africa is a relatively industrialised country and its mineral resources have historically been the backbone of its economy. Therefore, to achieve its energy transition goals, the country will need to do more than invest in new technologies. These goals will require the strategic use of South Africa's rich mineral resource endowments (Masutha, 2025).

Green hydrogen represents a promising minerals-based pathway to cleaner energy. A central focus of this policy brief is the role of platinum group metals (PGMs) in enabling South Africa's green hydrogen economy. PGMs are a key component in the fuel cell and electrolysis technologies required for green hydrogen production (Minerals Council South Africa, 2024). Hydrogen fuel cells generate power with water as the only by-product, making them an essential component of the energy transition from fossil fuels. Boasting approximately 80% of the world's PGMs, South Africa is strategically positioned to capitalise on the rising global demand for green hydrogen and associated technologies.

In recent years, the South African government has drafted a set of policy instruments to promote these new technologies (Bhagat & Wolf, 2021). The potential benefits of this sector extend beyond clean energy production; they include job creation in high-technology industries, investment in the local beneficiation of PGMs and broader industrialisation in the Southern African Development Community (SADC). Regional collaboration will be crucial to developing resilient supply chains for battery minerals, fuel cells and renewable energy infrastructure, supporting broader industrialisation across Southern Africa.

However, the shift also represents significant challenges. The ecological damage associated with hydrogen production infrastructure and increased PGM extraction is a major concern, particularly for coastal and mining-affected communities. In addition, the production of green hydrogen requires massive investment in renewable energy infrastructure, including solar and wind energy, before it can be considered truly 'green'. Given South Africa's ongoing energy crisis, expanding the country's electricity generation capacity is a prerequisite for scaling up green hydrogen projects.

Moving away from fossil fuels will affect large numbers of people who are currently employed along the electricity generation value chain, especially those working in coal regions. Hydrogen production is a high-technology industry. It requires specialist skills, some of which are lacking in the region. Investments in education and workforce development will be necessary to ensure that local workers can benefit from these emerging opportunities. In parallel, efforts are being made to diversify the economy in coal-dependent regions towards more labour-intensive sectors such as agriculture and tourism to create alternative employment pathways for workers who may not be absorbed by the green energy transition.

All of these initiatives require financing. South Africa will reportedly need to spend more than US$250 billion over the next 30 years to 'fund the closing of coal-fired plants and develop green alternatives' (BusinessTech, 2022). The country has secured investments through the Just Energy Transition Partnership (JETP), the first country platform of its kind (Csanadi & Helmeci, 2025). However, with the election of Donald Trump, the United States has withdrawn its support for South Africa's JETP, while actors such as the European Union have recommitted to the initiative (Csanadi & Helmeci, 2025).

These shifting dynamics highlight the geopolitical nature of energy transition partnerships and underscore that South Africa's ability to develop its mineral and hydrogen sectors will partly depend on its alignment or non-alignment with foreign partners who are also pursuing their own strategic interests. It will be essential for South Africa to focus on stable partnerships. The proposed Clean Trade and Investment Partnership between South Africa and the EU, aimed at building mutually beneficial value chains in raw materials, hydrogen and clean technology, is one such example. Partnerships with the East are also being pursued, with Japan being one possible long-term partner, providing a more balanced partnership strategy (Rubidge, 2025).

Green hydrogen development must be embedded within a broader strategy that prioritises sustainable industrialisation, social equity and environmental protection

This paper concludes by emphasising that while South Africa has a significant opportunity to build a green hydrogen economy, it should not be treated as a silver bullet for the country's economic and environmental challenges. Instead, green hydrogen development must be embedded within a broader strategy that prioritises sustainable industrialisation, social equity and environmental protection.

A just energy transition requires a balanced approach that ensures both economic benefits and social justice, particularly for mining-affected communities and workers transitioning from fossil fuel industries. Failure to implement the necessary structural reforms across energy, industrial, skills and governance systems risks deepening existing inequalities, deterring foreign investment and leaving South Africa behind in the global shift to low-carbon technologies.

1. Introduction

The vast majority of the minerals that are key to the global energy transition lie beneath the soil of our continent. These include manganese, iron ore, copper, cobalt,nickel and platinum group metals.

(Cyril Ramaphosa, President of South Africa, 2024)

This policy brief explores South Africa's ongoing efforts to transition to a clean energy economy through its Just Energy Transition Investment Plan (JET IP), which seeks to achieve a low-carbon and climate-resilient society. Given South Africa's vast mineral resources, it is favourably positioned to benefit from the growing 'green' or 'critical' minerals[1] sector in order to meet its developmental targets.

Green hydrogen presents a uniquely strategic opportunity for South Africa because it brings together two of the country's strongest imperatives: the need to accelerate a transition to clean energy and the ability to leverage its exceptional mineral resource endowment. As the JET IP outlines pathways towards a low-carbon, climate-resilient economy, green hydrogen offers one of the few technologies that can simultaneously advance decarbonisation, stimulate new industrial value chains and draw directly on South Africa's natural advantages. These include the country's abundant renewable energy potential and world-class platinum group metals (PGMs) reserves.

Since the formation of the Union in 1910, mining has been central to South Africa's economy and state building. Post 1994, gold, PGMs, coal and chromite have remained major contributors (Antin, 2013). South Africa holds approximately 80% of the world's PGMs, primarily concentrated in the Bushveld Igneous Complex, a vast geological formation spanning the Limpopo, North West and Mpumalanga provinces. This region contains some of the richest platinum deposits and is renowned for its high-grade ore and extensive reserves, making South Africa a dominant player in the global PGM supply chain. PGMs are crucial for industries such as automotive manufacturing, hydrogen fuel production and high-tech applications.

Mining remains economically vital as it contributes about 6% to gross domestic product (GDP) and makes up 60% of export value (Mining Review Africa, 2025). The sector continues to be a significant source of employment, although mechanisation and cost pressures have led to widespread casualisation and therefore lower quality jobs (Mohamed, 2009). While few would dispute the sector's historical importance, many observers note that South African mining has been in structural decline for some time. Its share of real GDP and total employment has steadily decreased over the past three decades, and levels of fixed capital formation and exploration investment remain worryingly low (Minerals Council South Africa, 2025). This downturn has led to concerns that the sector is 'mining out' existing reserves without building a pipeline of new projects. This raises serious questions about whether the mining sector can continue to play a catalytic role in socio-economic development without undergoing substantial structural reforms, particularly in the context of the global energy transition.

Some of the challenges that South Africa's mining sector faces have to do with instability in the global commodities markets, which affects the demand for PGMs. As a result, some miners have had to scale down mining and, in some places, have been forced to suspend operations altogether. Others have had to delay their expansion due to escalating operational costs. In addition, trade-related risks posed by green industrial policy measures abroad, such as the European Union's (EU) Carbon Border Adjustment Mechanism (CBAM), may further complicate export prospects and shape the long-term competitiveness of South Africa's PGM sector. This dynamic illustrates the risky nature of a resource-driven economic development strategy.

Some of the challenges that South Africa's mining sector faces have to do with instability in the global commodities markets, which affects the demand for PGMs

South Africa's PGM sector also remains the subject of protests over unfair labour arrangements. This has undermined productivity and profitability at some mines, forcing them to close or creating strong incentives to invest in labour-saving technologies (Creamer, 2023). These protests demonstrate that mining companies have failed to secure a 'social licence to operate', as ordinary people feel excluded from the benefits of previous booms in PGM production.

Moreover, PGM mines in Limpopo have repeatedly been accused of environmental degradation, forced removals and relocation of local communities without adequate compensation (Broughton, 2022). In some places, mining has led to the desecration of ancestral graves as local communities are forced off their lands to give way to new mines (Langa and Others v Ivanplats, 2017). Policies meant to promote local development, such as social and labour plans (SLPs),[2] often fall short due to weak municipal planning, poor community engagement and elite capture. These ongoing tensions reveal the fragility of community trust and the inadequacy of benefit-sharing mechanisms in the province.

This policy brief demonstrates that despite these challenges, the global energy transition offers strategic opportunities for resource-rich African countries such as South Africa. The current global push to cut carbon emissions in the context of an unfolding energy transition process presents economic opportunities for South Africa to leverage its resource endowment and meet its developmental targets. It is reported that South Africa could secure up to 10% of the global green hydrogen export market, supported by its abundant onshore and offshore renewable energy resources (Bhagat & Wolf, 2021). These factors position the country well in the emerging green energy economy.

Looking ahead, the future of PGMs will depend heavily on two key factors: (a) technological developments in the automotive sector – particularly the shift away from internal combustion engines; and (b) the extent to which the South African government is able to develop a robust hydrogen fuel cell industry. While this presents a significant opportunity for South Africa to integrate into the hydrogen value chain, it remains uncertain whether the mining sector can reform and diversify quickly enough to seize this window.

This paper is structured as follows: after briefly outlining the methodological approach, it explores the role of PGMs in South Africa's energy transition, especially in relation to green hydrogen production. The discussion then considers the challenges associated with this transition, including socio-economic and environmental concerns. Finally, the paper concludes with recommendations on how South Africa can maximise the benefits of its mineral wealth while ensuring an equitable and sustainable energy transition.

2. Data gathering and methodological approaches

In order to examine the policy initiatives that are currently being undertaken as part of South Africa's just transition to clean energy, we reviewed a wide range of documents on South Africa's PGM mining and its potential to contribute to South Africa's new industrialisation strategy. This literature included, inter alia, government policy documents, parliamentary reports and departmental strategies. We also reviewed scholarly literature on South Africa's resources sector and its potential to contribute to a just energy transition.

In addition, we adopted a purposive sampling approach targeting policy-makers and civil servants working in government departments such as the Department of Trade, Industry and Competition (dtic) to understand what the government is doing to promote the uptake of clean energy technologies. Due to limitations in time and resources, attempts to reach out to some key stakeholders such as civil society organisations, representatives of mining companies, local communities and activists was not possible. As a result, the findings may disproportionately reflect state-driven narratives or policy perspectives and may not fully capture the range of views, concerns or contestations surrounding the green hydrogen sector's development in South Africa.

3. The energy transition and PGM fuel cell production in South Africa

South Africa's mining sector contributes up to 6% of the country's annual GDP, with PGMs accounting for a significant share of mineral exports (Mining Review Africa, 2025). To support its energy transition goals, the government, in partnership with the private sector, is promoting the development of green hydrogen production. Green hydrogen is produced from water by electrolysis, which separates hydrogen and oxygen, with water being the only by-product irrespective of how the gas is used (Hamukoshi et al., 2022). However, for hydrogen to be considered 'green', its production must be from renewable energy sources that do not contribute to carbon emissions.

PGMs are critical to the green hydrogen value chain as they serve as key catalysts in the proton exchange membrane (PEM) electrolysers used to produce hydrogen through water electrolysis, as well as in hydrogen fuel cells that generate electricity. Moreover, green hydrogen can be reconverted into clean electricity via these fuel cells, a process that once again depends on the catalytic properties of PGMs (Lawlor, 2021).

Hydrogen fuel cells can generate power and provide heating in a wide range of industrial, agricultural, commercial and residential applications

Hydrogen fuel cells can generate power and provide heating in a wide range of industrial, agricultural, commercial and residential applications. As noted by Hamukoshi et al. (2022: 13), the uses of 'green hydrogen in daily life range from powering large haulage automotive and small to large industrial applications (by utilising fuel cells or hydrogen engines)'. In addition, 'large amounts of the hydrogen produced today is consumed in ammonia plants' (ibid). Ammonia is an essential fertiliser in agricultural production and a storage medium for hydrogen due to its easy and safe handling (The Royal Society, 2020).

Countries such as Japan and South Korea, as well as parts of Europe, have limited resources to competitively produce green hydrogen power-fuels and are likely to import them from potential producers such as South Africa. However, long-term export prospects depend on clear and sustained demand signals from major importing regions, which remain in flux as hydrogen strategies continue to evolve.

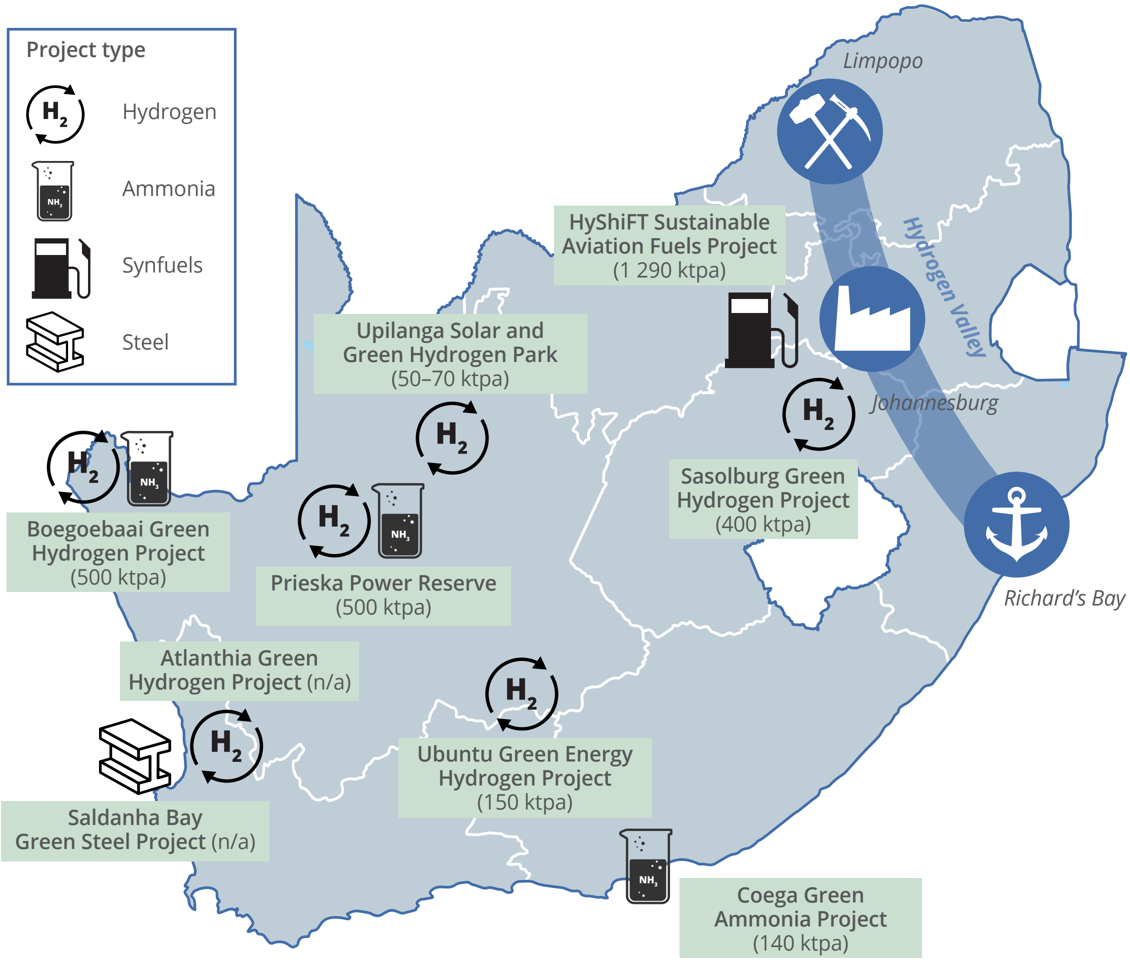
3.1. South Africa's strategic position

Given South Africa's rich PGM endowment, it is strategically positioned to be at the forefront of the emerging fuel cell technology industry. Below is a map of hydrogen production sites and associated industries across South Africa, which demonstrates the potential for green hydrogen projects to propel South Africa towards re-industrialisation during the energy transition.

The PEM technology needed for green hydrogen production is expensive and will require a large capital outlay in investments before production starts (Hamukoshi et al., 2022). To produce green hydrogen, the energy must come from green sources (solar, wind power and hydro), which South Africa currently lacks given its overreliance on fossil fuels. More importantly, green hydrogen must compete with other more affordable technologies that are already on the market, such as lithium-ion batteries. These are now relatively cheap and readily available due to efficiencies in their production. To achieve economies of scale, commercially viable quantities of green hydrogen are required for it to be a workable green alternative to fossil fuels.

Figure 1

Hydrogen production sites in South Africa



Note: 'ktpa' refers to kilotonnes per annum

Source: Kalt et al. (2023)

The setting up of industrial hubs to promote the development of the hydrogen fuel sector is critical for both downstream and upstream industries. The growth of the local hydrogen fuel cell sector is likely to boost local demand for PGMs at a time when their prices have declined sharply on global commodity markets. Furthermore, PGMs will play a key role in unlocking hydrogen's potential in the decarbonisation of transport and other industries as a new green economy emerges in South Africa.

3.2. Recent developments

Hydrogen production is not necessarily a new phenomenon in South Africa. The country accounts for around 2% of global grey hydrogen production and seeks to reach 4% of the green hydrogen market by 2050 (Salma & Tsafos, 2022). Given South Africa's experience, it intends to leverage its competitive advantages including strong renewable energy resources, ample land, established port and gas infrastructure and Sasol's Fischer–Tropsch synthesis[3] capabilities (Council for Scientific and Industrial Research, 2024).

The Department of Science, Technology and Innovation (DSTI) played a key role in setting up Hydrogen South Africa (HySA), which leads pilot projects in green hydrogen production. HySA is a long-term, 15-year programme designed to develop South African intellectual property, knowledge, human capital, products and components, and processes that can support the country's participation in the global hydrogen and fuel cell technologies market (dtic, 2022).

A Council for Scientific and Industrial Research report (2024), produced by the Labour Market Intelligence research programme, notes that South Africa plans to install at least 15 gigawatts of electrolysis capacity. This would enable the annual production of 500 kilotonnes of green hydrogen for transport, built environment, industrial and power applications, and generate an estimated 30 000 jobs per year by 2040.

HySA has established three centres to develop the technology required to produce hydrogen from renewable energy sources and for its storage and distribution. The programme also aims to identify cost-effective and sustainable methods for integrating PGM-based components into hydrogen fuel cell and related technologies, ultimately supporting commercialisation and the development of a viable mineral beneficiation industry (dtic, 2022). The main objectives are thus to create high-technology industries based on minerals found in the country, and employment creation.

The Platinum Valley Initiative connects three hydrogen hubs in Limpopo, Gauteng and KwaZulu-Natal. This so-called 'hydrogen valley' programme is a partnership between the DSTI, the South African National Energy Development Institute (SANEDI), mining company Anglo American Platinum (now Valterra Platinum), fuel cell producer Bambili Energy and French energy company ENGIE. Together, these organisations conducted a feasibility study on the valley, which indicated that green hydrogen has the potential to support various industrial activities across the valley, including mining and mobility applications (Omarjee, 2022).

In addition, several green hydrogen and energy generation projects are being implemented throughout South Africa. The Prieska Power Reserve in the Northern Cape will produce green hydrogen and green ammonia fertiliser. Similarly, the Sasol petrochemicals company partnered with the Northern Cape government to implement the Boegoebaai green hydrogen and ammonia production plant, which is expected to produce 400 000 tonnes of hydrogen per annum.

Two other Sasol projects also form part of the Green Hydrogen National Programme. These projects are expected to produce up to five tonnes of green hydrogen a day (Omarjee, 2022).

A key part of this new green hydrogen production is that it is set to stimulate a circular economy that promotes industrial linkages and the beneficiation of minerals for the advantage of local industries, as observed by Kalt et al. (2023). These developments reflect the possibility that the growth of a new hydrogen sector could create wider connections across the mining and industrial sectors, including green ammonia fertilisers and steel production industries. These linkages, if enhanced, can expand industrial development beyond South Africa's borders.

3.3. Green hydrogen and South Africa's Just Energy Transition Investment Plan

As mentioned above, the role of PGMs in the critical components required in the global decarbonisation efforts could help South Africa to decarbonise its transport sector and other industries under its JET IP. A central aim of the JET IP is to build a long-term partnership that advances low-emission and climate-resilient development, speeds up the just transition and the decarbonisation of the electricity sector, and opens new economic opportunities, including in green hydrogen and electric vehicles (EVs) (JET IP, 2023). These objectives are also aligned to the country's National Development Plan 2030, which aims to eliminate poverty and reduce inequality by 2030, and its Industrial Policy and Strategy Review (2024: 4), which seeks to 'unleash private investment and energise the state to boost economic growth and inclusion'.

Under the JET IP, green hydrogen is listed as one of three main priority areas, and some funds have already been diverted to the hydrogen valley. Green hydrogen can be seen as a key vector not only for decarbonisation but also for economic transformation. This is particularly necessary for the hard-to-abate sectors such as heavy transport, steel and chemical industries, and fertiliser and petrochemical production (Cloete, Cohen & Uhorakeye, 2025). Green hydrogen is important for storing surplus renewable energy to ensure a variable solar and wind supply – the role in which gas is presumed to have in the transition when there is a weather lull (CISL, 2024).

In addition, coupled with South Africa's renewable energy potential, there is an opportunity to export to other regions and to access alternative markets to build supply chain resilience. Furthermore, localising green hydrogen–related manufacturing can stimulate employment and diversification in South Africa's industrial economy (Cloete, Cohen & Uhorakeye, 2025).

The country's green hydrogen ambitions will, however, not be without challenges as projects depend on physical infrastructure, regulatory readiness and energy coherence (Cloete, Cohen & Uhorakeye, 2025), and very few global projects have come to fruition. For example, the Sasol Boegoebaai hydrogen project, with an estimated R350 million (about US$18.5 million) allocated for the pilot, has not been implemented (Rubidge, 2025). Sasol announced its exit from the project to refocus on coal due to insufficient commercial viability.

Moreover, green hydrogen has high production costs and the lack of domestic demand creates significant barriers to its viability. This is further exacerbated by a lack of green finance, mostly offered in the form of loans, making it less appealing for debt-constrained states. Regarding South Africa, the International Monetary Fund (IMF) has already issued a caution on its debt situation (Fraser, 2025). Consequently, the focus has largely been on an export-led hydrogen economy, which could further destabilise South Africa's energy security and access ambitions. It is thus important to develop a sector that is geared towards domestic use and to drive regional integration.

Furthermore, due to geopolitical competition over critical battery minerals supply chains, major South African trading partners like the EU are keen to diversify its green energy sources. The EU holds the potential to become a leading market for hydrogen products produced in South Africa. To advance its climate neutrality goals, the EU's Hydrogen Production Strategy positions hydrogen as critical to reaching carbon neutrality by 2050. In pursuit of this goal, the EU has taken concrete foreign policy steps to strengthen cooperation with Southern African countries on green hydrogen and critical minerals.

Notably, the EU signed a memorandum of understanding (MoU) with Namibia in 2022 focused on green hydrogen and raw materials, and similar agreements have been concluded with Rwanda, the Democratic Republic of the Congo and Zambia (Africa Policy Research Institute, 2025). More recently, South Africa has signalled its intention to develop a critical minerals MoU with the EU, and the EU–South Africa Summit Declaration contains commitments to deepen cooperation on green hydrogen (DIRCO, 2025; European Union Council, 2025).

Leveraging these and similar agreements will be crucial to unlocking foreign investment in South Africa's emerging hydrogen economy, alongside state support for the sector. In addition, country platforms such as the South African Just Energy Transition Partnership (JETP) also offer an opportunity for climate finance to primarily attract investment (Robinson & Olver, 2025).

However, global tariff regimes may have a negative impact on both the demand and supply sides of climate-neutral technology cooperation and financing mechanisms. One such example is the anticipated introduction of CBAM on imports and other similar measures. In keeping with net-zero pledges, the EU, the United States (US) and the United Kingdom (UK) will expose more than 50% of South Africa's export value to increasing carbon tax levies (Sama Yende, 2023). According to the JET IP (2022), an estimated US$50 billion is at risk for the South African economy arising from the energy transition.

Overall, South Africa's green hydrogen ambitions reveal significant promise but also structural limitations shaped by global market dynamics, trade measures and geopolitical competition. These external pressures will influence how the sector develops, but its long-term success will depend just as much on domestic conditions. The next section turns to these internal justice dimensions, examining how green hydrogen can support or constrain fair, inclusive and locally grounded outcomes.

4. A just approach to localising green hydrogen

As outlined, the rising demand for minerals offers Africa both opportunities and risks. Africa is part of a global value chain for green and transition minerals and this role is concentrated in exploration, extraction and some processing where the risks of mining are more prevalent in the form of environmental and human rights risks (African Development Bank, 2023). The time-sensitive nature of the green transition also places the continent in a precarious position. In many contexts, the mining of critical and transitional minerals has already intensified existing social and environmental harms associated with the extractive sector. For example, the mining of lithium, which is crucial for the battery supply chain, includes potential impacts such as the local pollution of soil, air and water, the disposal of toxic residuals, the intensive use of water and energy, work and environmental risks, child labour and sexual abuse, and corruption and armed conflict (Global Witness, 2023).

To ensure that the energy transition in South Africa is truly ‘just’, it must be approached in a way that reflects the country’s unique structural conditions, most notably, its deep reliance on coal, persistently high unemployment and extreme socio-economic inequality. Green hydrogen, like other low-carbon sectors, cannot be pursued in isolation from the broader developmental imperative to create a more socially inclusive and environmentally sustainable economy. In this context, South Africa’s Just Transition Framework emphasises the need for more than shifting energy sources; it requires attention to three key dimensions of justice:

- Procedural justice, which calls for inclusive and transparent decision-making processes that give affected communities a real voice;
- Distributive justice, which concerns how the costs and benefits of the transition are shared, particularly in coal-dependent regions; and
- Restorative justice, which demands efforts to repair past harms caused by extractive industries and ensure that new sectors do not reproduce the same patterns of exclusion.

These justice concerns are equally relevant to the future of mining in South Africa, particularly in relation to the governance of critical minerals. Without strong safeguards and intentional policy design, the development of the green hydrogen sector risks reinforcing many of the same inequalities that have long characterised South Africa’s mining economy.

Taken together, these concerns suggest that the key questions around green hydrogen in South Africa are not only technical or financial but also deeply bound up with justice. The subsections that follow therefore examine the major barriers to a just green hydrogen transition: structural risks in sectors such as automotive manufacturing and coal; distributional and labour-market challenges including skills gaps and uneven regional impacts; infrastructural and resource constraints around energy and water systems; and political economy dynamics related to export orientation, financing, and the social licence to operate.

4.1. Disruption of the automotive sector

The JET IP identifies that the automobile and coal sectors are likely going to be affected by the energy transition. South Africa's auto industry is mostly export-led, relying on exports to the EU and US markets. Both these regions have committed to accelerate the phasing out of internal combustion engine vehicles by 2030. And, while South Africa has made the same time frame commitment, its auto industry is confronted with significant challenges in its ability to transition and compete in an EV sector that is dominated by countries like China. Although EVs have the potential to cut emissions and reduce grid pressure when paired with clean charging infrastructure, South Africa's domestic adoption rate remains slow. Despite a rise in EV and hybrid purchases in 2024, the total number on the road is still only around 15 000 (Bubear, 2025).

South Africa's auto industry is mostly export-led, relying on exports to the EU and US markets

Currently, the automotive sector is one of the country's largest economic sectors, contributing 4.3% to the country's GDP. The industry is also South Africa's fifth-largest export sector, accounting for 18.1% of total exports and employing over 110 000 people (Augustine, 2024). South Africa's move from fossil fuel–based automobiles is tied to Global North automakers that dominate local assembly (Chege, 2021).

The industry is mostly centred around Tshwane, eThekwini, Nelson Mandela Bay and Buffalo City in the Gauteng, KwaZulu-Natal and Eastern Cape provinces (Maseko et al., 2020). Automakers such as Ford, Toyota and Volkswagen manufacture models for both the domestic and European markets, with the UK and the EU consuming about 46% of its exports (Reuters, 2024).

The production of EVs involves far fewer inputs than their petroleum-based counterparts. As a result, limited jobs are likely to be created through the development of infrastructure for charging and other activities such as the safe disposal and recycling of used batteries. The petrol stations that will be replaced by charging stations will also be impacted, with most of the low-income workers likely to lose their jobs.

The Nelson Mandela Bay and Buffalo City areas in the Eastern Cape province will face the harshest impact should the industry be unable to develop alternative production clusters and transition to assembling EVs (Dludla, 2025). Informal-sector suppliers and taxi operators will also need to eventually transition to EVs, which will necessitate further government support. There is thus a need for safeguards to protect the sector from the potential shocks generated by the energy transition.

However, there are opportunities to stimulate broader economic activities in the EV market. The South African government has taken necessary steps to enact policies that will support EV production while also improving its market share (Reuters, 2024). The National Association of Automobile Manufacturers (NAAMSA) has also made policy suggestions to the government that aim to stimulate local demand through, for example, import duties (NAAMSA, 2023).

More opportunities are highlighted in the dtic's (2021) draft *Auto Green Paper on the Advancement of New Energy Vehicles in South Africa*. Key government interventions to promote this sector include tax reforms to stimulate greater domestic demand for EVs as well as an EV industrialisation strategy, which will guide the transition. Early momentum is being seen in this regard.

South Africa has already taken some measures in this direction, including a 150% tax incentive for EV and hydrogen vehicle production in an effort to reduce emissions and to secure the country's position in a largely competitive global automotive context (van Diemen, 2025). To achieve this, R964 million has been allocated to support the transition in the medium term. This time frame coincides with the ban of combustion engines in markets like the EU.

In 2024, Eskom launched its EV infrastructure pilot project by acquiring EVs and installing charging stations nationwide. This initiative forms part of the national utility's long-term distribution strategy to fully electrify its fleet of approximately 13 000 vehicles by 2040 (Kemp, 2024). Eskom's inclusion of both utility and passenger EVs reflects a dual focus on operational decarbonisation and expanding equitable access to low-emissions transport, which is important to address South Africa's equitable access to public transport.

4.2. Disruption of the coal sector

South Africa is heavily dependent on its coal sector for energy and employment. About 83% of electricity generation comes from coal, ranking at the highest share in the world (Cole, Canpolat & Sijapati, 2025). The transition from a largely fossil fuel–based economy towards a green hydrogen economy will have a significant impact on coal mine workers. It is estimated that about 15 coal mines are expected to close by 2030 and another 23 by 2040. These closures not only threaten the wages of workers but also the country's economic stability. Mine workers are paid higher than the average municipal worker; therefore, the loss of well-paying jobs will deepen local poverty and inequality, especially in coal-producing areas already facing 33–42% unemployment (Cole, Canpolat & Sijapati, 2025). While renewable energy generation offers alternative opportunities, it typically requires different skills compared to coal generation and typically in other regions.

The private and the public sector will need to play a role in mitigating these effects. For example, mining companies' SLP budgets can provide support for human resource and local economic development. The 33 coal mines analysed by Cole, Canpolat and Sijapati (2025) have a collective budget of R4.7 billion (approximately US$260 million) for training, retrenchment support and community projects. This budget can be allocated towards portable skills training, adult education, bursaries and internships aimed at re-employability post mine closure. However, the authors find that despite these commitments, the current level of training is far below what is needed for a genuinely 'just' energy transition. To increase efficiency, SLP spend will have to be integrated with local government planning, notably with municipality-based integrated development plans (IDPs).

There are also initiatives in alternative energy that can provide opportunities for the provinces to transition in a more equitable manner. Hydrogène de France (HDF Energy) has announced plans to develop one of Africa's largest green hydrogen power projects in Mpumalanga. The French company intends to invest US$3 billion into the province, installing 1 500 megawatts (MW) of solar photovoltaic alongside 3 500 megawatt-hours (MWh) of hydrogen storage. Of the 20 potential green hydrogen projects identified nationally, three are planned for Mpumalanga. As an independent power producer (IPP), HDF Energy is enabled through Eskom's land-lease agreements with IPPs for the commercial use of land parcels near two of its coal-fired power stations in the province (Molelekwa, 2024). These initiatives may help Mpumalanga offset a portion of the employment losses in the province and contribute to a more balanced sharing of the transition's impacts.

4.3. Addressing the skills gap

Harnessing green hydrogen's economic and environmental benefits will require a skilled workforce. Various policy measures, including the JET IP, emphasise the crucial role of skills development in facilitating a just energy transition. South Africa's technical and vocational education and training (TVET) sector plays a major role in the development of a skilled workforce.[4]

A report by the Labour Market Intelligence research programme noted that 27 occupational qualifications funded by various Sector Education and Training Authorities (SETAs) have been identified as critical for the hydrogen economy (Bakharia, 2024). The report also cited the higher education minister, who observed that unlike in countries such as Germany and given the sector's early stage in South Africa, opportunities for green hydrogen–specific work-based learning remain limited.

Various policy measures, including the JET IP, emphasise the crucial role of skills development in facilitating a just energy transition

However, some progress has been made. South Africa has already introduced several initiatives to support the green hydrogen economy, including the introduction of pedagogy and training in renewable energy technology at the national certificate level. The DSTI has collaborated with the Energy and Water Sector Education Training Authority and other partners to launch hydrogen fuel cell–related training programmes. These programmes will promote greater participation of locals through employment opportunities across the emerging green hydrogen fuel sector. The ramping up of PGM production is also likely to create new employment and economic opportunities among local communities, especially in the Limpopo province.

The dtic is also working with universities and other partners to promote the beneficiation of platinum for catalysts that can be used in hydrogen fuel cells. According to an interview with a dtic staff member[5] (interviewed online on 27 May 2024):

> *The department is promoting the] development of skills base for the development of beneficiation of platinum-to-platinum catalysts – technology that uses platinum to generate reactions. It has looked at an infrastructure that would be required for a hydrogen economy, types of fuel stations, and technology to refuel and is collaborating with the University of Cape Town and Northwest University.*

The dtic official noted that fuel cell technology is now available but has yet to be fully commercialised. The technology is already present in the market, with several entities coming to South Africa to assemble fuel cells. Further interviews with dtic staff highlighted the department's commitment to strengthening links between PGM mining, beneficiation and the expansion of the local manufacturing industry:

> *[The government is also promoting the commercialisation of new technologies such as the Mintek PEM.[6] However, it has been affected by some delays as Mintek tries to find a partner to work with in order to produce the technology using local inputs. Moreover, some partners in the fuel cell sector have been willing to come on board – using catalysts imported from China. In general, there is growing interest from the private sector as several companies are coming to assemble the fuel cells in South Africa.*

However, more needs to be done. Greater coordination between the Department of Higher Education and Training and the recently launched Just Transition Labour Research Centre is important. More funding should be provided to prioritise skills development for the green hydrogen economy to ensure that green hydrogen opportunities do not only benefit a few but also the broader population and especially those previously marginalised under the apartheid regime.

4.4. Structural barriers to green hydrogen production

For value creation to improve Africa's comparative advantage in transitional mineral supply chains, the insufficient stock of infrastructure in the form of power, water and transport services will need significant improvement. Over 640 million Africans have no access to electricity, representing a rate approximately 40% lower than the global average (Empower Africa, 2025). Most of the world's mineral beneficiation capacity is in countries with abundant and low-cost energy, including natural gas and hydropower, making South Africa's ongoing energy crisis a major constraint (African Climate Foundation, 2022).

One of the key challenges is South Africa's electricity grid limitations. South Africa has been plagued by insufficient capacity and outdated technology to maintain and expand its grid. The current grid infrastructure is based in hubs like the Gauteng province, where industrial demand is located. This means that renewable energy generated in high-resource areas like the Northern Cape cannot be transmitted efficiently or in sufficient quantities due to inadequate or outdated transmission infrastructure (Cloete, Cohen & Uhorakeye, 2025).

The current grid infrastructure was designed to flow into coalfields in Mpumalanga for bi-directional purposes or long-distance flows. Consequently, there are insufficient transmission lines and substations connecting the Northern and Western Cape to national demand centres and industrial zones (Burger, 2025).

Grid limitations directly restrict green hydrogen development. The process of electrolysis is very energy intensive and requires a continuous, reliable supply of power. Investors are reluctant to commit capital where there are risks in transmission access and grid reliability. Cloete, Cohen and Uhorakeye (2025) argue that most green hydrogen production sites should be located near renewable energy power plants to reduce electricity costs. In addition, without solving the grid challenges, excess power will be difficult to export. In this context, power producers may be forced to curtail output – leading to higher cost per unit.

Securing financing for South Africa's electricity grid has proven a persistent challenge. However, the country now stands to benefit from the EU's Global Gateway initiative, which offers blended finance and technical support for renewable energy and port infrastructure development. Regionally, South Africa could partner with neighbour Namibia on high-voltage grid interconnectors to enable large-scale green hydrogen production, even as both nations vie for export markets (Rubidge, 2025). In this endeavour, the African Development Bank – already prioritising cross-border infrastructure – could play a catalytic role in co-financing and facilitating cooperation on such projects (Rubidge, 2025).

The Department of Mineral Resources and Energy (DMRE) has also adopted various measures aimed at improving energy reliability at mine sites and generally across the grid. This is being done by lifting the licensing threshold for IPPs. For example, mining company Seriti is diversifying its energy supply by deploying wind and solar projects to ensure a reliable source of energy for the mining sites in Mpumalanga and in Grootegeluk, Limpopo (Nhede, 2023).

Focusing on project-specific-generating capacity, which is a feature of many national plans to improve domestic downstream capacity, may, however, lead to widening inequalities for host communities that are likely to absorb the social and environmental costs. Heavily investing in energy sources like liquefied natural gas (LNG), diesel and heavy fuel oil will further exacerbate environmental costs, and hydrocarbon-based energy infrastructure should be avoided.

Securing alignment between South Africa's energy policy and its green hydrogen ambitions requires the draft Integrated Resource Plan (IRP) 2023 to embed renewables, green hydrogen production and battery storage as core components. The current IRP places heavy emphasis on hydrocarbons and excludes green hydrogen as a baseload option, while also omitting any phase-in targets essential for meeting decarbonisation commitments (Just Share, 2024). To enable a green hydrogen economy, South Africa must dramatically scale up renewable generation and integrate robust grid storage and EV charging infrastructure – an imperative that demands a marked departure from conventional fossil fuel–centric planning. Incorporating clear decarbonisation objectives and technology diversification into the IRP is critical to support both hydrogen and transport sector transitions.

Another challenge is the development of green hydrogen pipelines. Most existing gas infrastructure cannot transport pure hydrogen without considerable modification, meaning that green hydrogen will require new or heavily upgraded infrastructure (McGregor & Young, 2025). South Africa's gas infrastructure is already limited, which strengthens the case for new investment; however, expanding infrastructure carries the risk of becoming a stranded asset under the climate neutrality commitments the country has adopted (CISL, 2024).

South Africa also faces significant water infrastructure challenges, which pose a constraint for green hydrogen production because electrolysis is highly water dependent. The process requires splitting water into hydrogen and oxygen using electricity (Cloete, Cohen & Uhorakeye, 2025), and large-scale production needs industrial volumes of clean, demineralised water.

Given the country's broader water scarcity, this becomes a strategic restriction that must be integrated into project planning and national policy. This is especially difficult in provinces such as the Northern Cape and Western Cape, which are among the driest in the country and therefore least suited to supplying the volumes of water required for electrolysers. In effect, South Africa's energy geography and water geography do not align.

South Africa also faces significant water infrastructure challenges, which pose a constraint for green hydrogen production because electrolysis is highly water dependent

A policy environment that promotes coordinated, multi-scalar infrastructure planning would not only strengthen domestic energy security but it would also enable South Africa to emerge as a credible and competitive actor in the global hydrogen economy, to ensure public acceptance and a resilient value chain (Cloete, Cohen & Uhorakeye, 2025).

4.5. Balancing foreign and domestic needs

It is worth noting here that some critics of South Africa's emerging green hydrogen sector have argued that the country must focus on addressing current energy shortages and expand access to energy before pursuing its ambitious green energy transition strategy. They argue that the green hydrogen sector is not going to benefit locals but is instead designed to meet the energy needs of the EU and private investors who have been actively lobbying the South African government to promote the sector through grants and policy advice. According to Kalt et al. (2023):

> *In the context of the severe energy crisis, energy justice activists primarily critique that green hydrogen creates electricity distribution conflicts if energy resources are diverted away from the people. This would lead to a two-tier energy system, in which stable, low-cost and clean electricity is made available for green hydrogen exports, while the*

majority of South Africans do not benefit, instead relying on an unstable, expensive and polluting national power system.

The above argument highlights some of the contradictions that South Africa is confronted by in its energy transition strategy which seeks to, on the one hand, decouple South Africa's economy from fossil fuels, while, on the other hand, divert scarce energy resources to the production of green hydrogen for export. According to Young and McGregor (2024), green hydrogen currently costs between US$5 and US$8 (about R89–143) per kilogram, making it about five times more expensive than fossil fuel–derived hydrogen and three to five times costlier than oil. If green hydrogen is to be cost effective enough to compete with fossil fuels, the industry will need government subsidies and incentives for manufacturers.

At present, most domestic initiatives, including Hydrox Holdings, Bambili Energy and HySA, remain at the feasibility stage and there is currently no commercial-scale production of fuel cells or electrolysers in South Africa (Rubidge, 2025). Scaling up manufacturing capacity will require substantial investment, particularly in building a local electrolyser supply base to support the development of the broader value chain.

Progress has been constrained by the lack of dedicated programmes to support domestic suppliers and by challenges in attracting foreign manufacturers with sufficient incentives to establish local production. In this context, off-take agreements with international and local buyers are especially important to provide market certainty and to ensure confirmed buyers by 2030, which would help de-risk early-stage investment and accelerate industrial development (Rubidge, 2025).

Furthermore, South Africa risks being caught up in the ongoing geopolitical competition over the control of green minerals supply chains between China and Western countries. China currently controls most of the mining and processing of key critical minerals value chains (copper, cobalt, lithium, manganese, graphite, nickel and some rare earth elements (REEs)) including the production of EVs (Benabdallah, 2024). The over US$8 billion in loans and grants extended to South Africa by Western countries to promote its energy transition can be seen as a geopolitical response to Chinese dominance in the EV sector (Lenferna, 2023). Given this dynamic, South Africa should strategically position itself in an impartial manner.

Critical mineral extraction represents an area where African countries may be well positioned to adopt a more non-aligned approach, working with whichever partners offer the best terms for investment, value addition and skills transfer. This could enable a more strategic engagement with global actors and ensure that African minerals serve African development.

However, it remains to be seen whether African countries will be able to leverage this moment to advance their own development agendas. Until recently, the discourse has largely centred on how the EU and the US can secure access to African minerals to reduce dependence on China, rather than on how African countries can extract greater value or shape the terms of engagement. A lack of coordinated African agency has contributed to this imbalance. Despite this, the release of the African Union's African Green Minerals Strategy marks a critical step towards asserting a more unified and proactive position (Bega, 2025).

4.6. Eroding social licence to operate

Green hydrogen diplomacy has largely centred on a 'win-win approach', yet it has tended to exclude community voices from key decision-making processes and overlook many of the impacts discussed above (groundWork, 2025). There are also serious local consequences linked to increased production. One major concern is that green hydrogen is likely to intensify PGM mining, which is already shifting towards open-cast methods due to the rising costs associated with shaft mining. Although more cost effective, open-cast mining is environmentally disruptive (Rock, 2024).

Challenges around the social licence to operate have also affected the implementation of SLPs. A lack of social acceptance can lead to community conflicts, strikes and protests, resulting in supply chain disruptions and affecting mineral demand (Mueller et al., 2022). In fulfilling SLP commitments, companies often assume responsibilities that should fall to the state, such as providing social investment funded through public revenues. This becomes even more problematic when mines close, raising concerns about long-term state planning, continued dependence on minerals and the lack of economic diversification.

Mitigating the negative effects on communities is essential not only for securing a social licence but also for meeting EU sustainability requirements, such as those established through the Corporate Sustainability Due Diligence Directive (CSDDD) enacted in 2024. Germany's National Hydrogen Strategy similarly emphasises that hydrogen demand must not compromise environmental objectives and calls for imports to align with broader energy, social and ecological transformation goals (Rubidge, 2025).

Another critical issue requiring greater attention is water scarcity, given the substantial water requirements of green hydrogen production (Beswick et al., 2021). This could place additional pressure on already-water-stressed areas, with potentially severe consequences under climate change. Desalination presents one possible solution. Although costly and energy intensive, it typically accounts for only a small proportion of total hydrogen production costs – estimated at around 1% (Infrastructure News, 2023). Some experts argue that green hydrogen production could ultimately support water resilience, as the sector is better placed to absorb desalination costs than industries such as agriculture. The Eastern Cape province's Coega Special Economic Zone, for instance, already has salt production facilities that discharge desalinated water, which could be repurposed for local use (Dyantyi-Gwanya et al., 2025).

Alongside environmental standards, the equitable distribution of benefits across the green hydrogen value chain is crucial. One approach could involve allocating a portion of desalinated water for community use, thereby supporting social development while enhancing project legitimacy (Rubidge, 2025).

5. Discussion and conclusion

South Africa's green hydrogen ambitions sit at the intersection of opportunity and constraint. The analysis above has shown that the sector could revive elements of South Africa's industrial base, stimulate new technological capabilities and provide stabilising demand for PGMs at a time of market weakness. Yet the transition is emerging within an economy marked by persistent energy insecurity, infrastructure deficits, uneven institutional capacity and longstanding social and environmental tensions in mining regions. These conditions will shape the pace of the transition as well as who stands to benefit from it.

A central theme running through this paper is that green hydrogen cannot be separated from the broader structural features of South Africa's economy. The declining competitiveness of the PGM sector, the vulnerability of export-led industries such as automotive manufacturing, and the looming displacement that coal-dependent regions face all show that the transition will produce uneven impacts. The challenge is therefore not simply technological deployment but also ensuring that green hydrogen contributes to a socially inclusive, regionally integrated and environmentally responsible development pathway.

5.1. A regional approach

In the context of rising geopolitical and geo-economic tensions, regional integration is important for ensuring resilient green supply chains. Under the Southern African Development Community's (SADC) industrialisation strategy, the sharing of infrastructure is seen as crucial to regional integration and development. With its advanced industry and research and development facilities, South Africa can become a regional industrial and knowledge hub that promotes the industrialisation of the SADC region on the back of mineral beneficiation. Furthermore, the transportation of green hydrogen from South Africa's shores can enhance the nascent hydrogen sector in Namibia, where facilities and some infrastructure could be shared (Rubidge, 2025).

However, there are still major policy barriers to building truly integrated regional mineral value chains. While African countries often engage regionally, they continue to act nationally. Many national policies aimed at supporting in-country value addition, such as export restrictions, end up undermining cross-border collaboration (Parker, 2025). Overcoming these tensions between national industrial policy and regional coordination will be essential to unlocking the full potential of regional mineral-led industrialisation.

5.2. Industrial opportunities and economic pressures

Green hydrogen offers an important, although not guaranteed, buffer for PGM producers facing low prices, restructuring and stalled investment. New hydrogen projects along the hydrogen valley and in neighbouring states could support PGM demand and open new industrial linkages, including green ammonia and green steel. Yet South Africa's higher energy costs relative to competitors such as Russia and China continue to undermine its position in global markets. Without reliable, affordable renewable energy – and the grid capacity to transmit it – these opportunities will remain limited.

5.3. Labour market and just transition considerations

The just energy transition will create winners and losers across sectors. The auto sector faces declining demand for internal combustion engine vehicles in export markets, while coal regions will be forced to deal with large-scale job losses as mines close. Green hydrogen and related industries will not absorb these displaced workers in large numbers due to their capital- and skills-intensive nature. Reskilling, targeted social protection and alignment between SLP commitments and local government planning will therefore be essential to avoid deepening existing inequality.

5.4. Governance, environmental risk and social licence

As shown in section 4.6, social acceptance remains a critical constraint. Communities have experienced long histories of exclusion, uneven benefit sharing and environmental harm from mining. Without meaningful consultation, clear rules for land access and stronger institutional oversight, new hydrogen-linked mining activities may reproduce these tensions. Water scarcity is another major challenge, particularly given the substantial volumes required for electrolysis. While desalination offers options, its integration into local planning must be done carefully to avoid further burdening already-water-stressed areas.

5.5. The cost of inaction

If South Africa does not resolve its structural limitations – particularly grid expansion, regulatory coherence, water planning and institutional capacity – the country risks missing the current global window for green hydrogen and wider clean energy industrialisation. The consequences would include further job losses in declining sectors, reduced competitiveness in global markets and diminished fiscal and developmental space. Conversely, if these barriers are addressed, green hydrogen could support a more diversified industrial base, strengthen regional integration and contribute to a more equitable energy transition.

Overall, this policy brief demonstrates that green hydrogen is neither a panacea nor an inevitable outcome. It is a strategic opportunity that will require deliberate governance, stable policy direction and sustained investment in skills, infrastructure and community engagement. South Africa’s mineral endowment gives it a clear advantage, but converting this potential into broad-based development will depend on aligning industrial goals with social and environmental justice, strengthening institutions and ensuring that the transition does not replicate past patterns of exclusion. Only under these conditions can green hydrogen support a genuinely just and sustainable energy transition.

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Endnotes

1 It is important to consider how the South African government defines critical minerals. While international discourse tends to emphasise minerals that are essential for low-carbon technologies such as lithium, cobalt and rare earth elements (REEs), South Africa's own classification includes coal (Department of Mineral Resources and Energy, 2025). This is not merely a semantic distinction; it reflects how different countries understand the role of their mining sectors in the just energy transition and raises important questions about how criticality is framed in relation to national development priorities.

2 SLPs are regulatory tools that specify a mining company's responsibilities for socio-economic development and labour-related support in host communities.

3 Sasol's Fischer–Tropsch synthesis capabilities refer to its expertise in converting coal, natural gas or biomass into synthetic fuels and chemicals through the Fischer–Tropsch process.

4 For a comprehensive review of the role of the TVET system in developing the skills necessary for South Africa's green hydrogen sector, see the synthesis report from the South African Institute of International Affairs: **https://saiia.org.za/research/the-south-african-green-hydrogen-tvet-ecosystem-just-transition-strategic-framework/**

5 The names of informants have been hidden to protect their identities.

6 Mintek is a government-owned national mineral research organisation that supports the South African minerals industry.

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