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Electrolysers for green hydrogen production pilot technology assessment in South Africa

Technical cooperation outcome

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60 years

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Abbreviations

AEL	alkaline electrolysis
CO_2	carbon dioxide
CoC	centre of competence
CSIR	Centre for Scientific and Industrial Research
DMRE	Department of Mineral Resources and Energy
DSTI	Department of Science, Technology and Innovation
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
HySA	Hydrogen South Africa (strategy)
IEA	International Energy Agency
JET	Just Energy Transition
JET-IP	Just Energy Transition Implementation Plan
NACI	National Advisory Council for Innovation
NDP	National Development Plan
NSI	national system of innovation
PEM	proton exchange membrane
PGMs	platinum group metals
R&D	research and development
R&I	research and innovation
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SMMEs	small, medium and micro enterprises
STI	science, technology and innovation
TA	technology assessment

Glossary of terms

Electrolyser: A system or device that uses electricity to split water molecules into hydrogen and oxygen, thereby producing hydrogen gas as a sustainable carrier of clean energy.

Centres of competence (CoCs): Centres that perform advanced research. They possess both human and infrastructural capacities, and are linked internationally to their peers. CoCs are also highly specialized in particular fields of research and innovation.

Fuel cell: An electrochemical cell that converts the chemical energy of hydrogen and oxygen into electricity.

Green hydrogen: Hydrogen produced by splitting water into hydrogen and oxygen using renewable energy sources.

Hydrogen: An energy carrier that can be used to store, move and deliver energy produced from a variety of resources, such as natural gas, nuclear power, biomass and renewable power (e.g. solar and wind).

Proton exchange membrane (PEM): An electrochemical cell that converts chemical energy into electrical energy based on the reaction of hydrogen with oxygen or another oxidizing agent.

Technology assessment (TA): An interdisciplinary process of gathering public and expert perspectives or opinions on social, environmental and economic benefits of a technology.

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Executive summary

Technology Assessment promotes forward looking and evidence-based policies for STI

Technology assessment (TA) is a useful toolbox for assessing social, economic, environmental and even political risks and benefits of new technologies. It is an interactive and interdisciplinary process of gathering expert and public perceptions to inform policies for science, technology and innovation (STI) and promote forward looking and evidence-based governance of new and emerging technologies. Many countries, particularly developed ones, are institutionalizing TA through administrative and legislative processes.

In 2022, United Nations Trade and Development (UNCTAD) launched a pilot project to support the building of TA capabilities in Seychelles, South Africa and Zambia. The project focused on technologies in and for agriculture and energy. The UNCTAD TA methodology was developed taking into account the distinctive conditions of developing countries that have not accumulated the required human and institutional capabilities to conduct such assessments. It adopts the following approach: establishing governance structures (steering committee and expert group), identifying a specific technology for assessment, mapping stakeholders to participate in the assessment, gathering both qualitative and quantitative data from the stakeholders, and offering policy recommendations for consideration by relevant authorities.

In South Africa, the Government decided to focus its TA on electrolyser technologies, given the high level of interest in the production and commercialization of green hydrogen energy. Initially the focus was on green hydrogen, but this was refined during the assessment process to focus on electrolysers. Given the early stage of maturity of this technology, assessing its possible social and environmental impacts posed a challenge, whereas the economic impacts could be more easily explored. Stakeholders were found to be more knowledgeable about the economic impacts, but were largely unfamiliar with social and environmental impacts. A fuller assessment will therefore be needed. Over the past decade or so, the Government has developed a wide range of policies and instruments, as well as adopting several programmes dedicated to the promotion of green hydrogen. For example, in 2007, the Cabinet adopted the Hydrogen South Africa (HySA) strategy, which led to the development of a national Hydrogen Society Road Map that was approved by the Cabinet in September 2021, and in 2023 the country developed a national green hydrogen commercialization strategy.

In 2008, the Department of Science and Innovation (DSTI) established centres of competence (CoCs) to implement the HySA strategy. One of the main technologies that the HySA CoCs focus on is electrolysers to produce hydrogen, due to the country's rich endowment of platinum and renewable energies that are critical to the production of green hydrogen. Key institutions undertaking research in electrolyser and hydrogen-related technologies in the HySA strategy are the University of Cape Town, Northwest University, South Africa's national mineral research organization, MINTEK, the Council for Scientific and Industrial Research (CSIR) and the University of the Western Cape (UWC).

In addition, South Africa is actively involved in partnerships with other countries, notably Germany and Japan, that focus on research and innovation (R&I) for the development of electrolysers. There is also growing private sector interest in the development and commercial use of electrolyser technologies. For example, the South African chemicals and energy company, Sasol, and the British multinational mining company, Anglo American, are among the leading enterprises in the development and potential use of electrolysers in South Africa. The TA exercise described in this report is largely exploratory in the sense that it is the first one undertaken by the Government.[1] Conducted over a

[1] It should be noted that some academic institutions and researchers in the country conduct research on TA, indicating that there is some TA activity and capacity in the country.

period of about two years using the UNCTAD TA methodology as primary guidance, the following activities were undertaken:

(a) Review of the literature on policies for, and institutional actors in, the hydrogen economy, as well as trends in electrolyser technology R&I in the country.

(b) Designing and administering a survey questionnaire on the economic feasibility and competitiveness of South Africa in electrolyser technologies in local, regional and international markets. The survey covered 34 participants.

(c) Virtual and face-to-face interviews with more than 25 key stakeholders from the private sector, academic and policymaking groups involved in the hydrogen energy subsector, in general, and R&I on electrolysers.

(d) A virtual focus group discussion aimed at assessing the state of knowledge and public perceptions of the benefits and risks of electrolysers in South Africa. Participants included 29 individuals from various sectors.

Five key messages and recommendations emerged from the analysis of the qualitative and quantitative data collected:

Five key messages and recom-mendations emerged from the analysis.

(i) South Africa has relatively high technical potential to engage in the development and use of electrolyser technologies. It has accumulated scientific and technological capabilities in electrolysers and is participating in international partnerships in hydrogen-related research that contribute to its knowledge base for electrolyser technology development. The country needs to better coordinate its different electrolyser R&I initiatives to exploit economies of scale. Greater public-private sector partnerships and coordination may help enhance its innovativeness in electrolyser development and production.

(ii) There is uncertainty as to whether South Africa is and will become economically competitive in the regional and international markets for electrolysers. The relatively small number of respondents to the survey did not provide a strong enough basis for making an informed judgment on the country’s competitiveness in electrolyser technologies. The survey can therefore be considered as providing only preliminary evidence. Consequently, a comprehensive assessment of the competitiveness of the country in the electrolyser markets may be required.

(iii) The country has a relatively rich body of policy frameworks for hydrogen, but a poorly coordinated set of initiatives among the institutional actors. Better coordination of both policies and initiatives is critical. It is expected that the proposed Inter-Ministerial Committee on the Hydrogen Economy, approved by the Cabinet in February 2024, will improve synergies and channel resources more efficiently into electrolysers and other hydrogen production technologies.

(iv) Further work should be done to assess the environmental and social impacts (such as on women and the youth) from the development of electrolysers for green hydrogen production in South Africa. The TA showed that there was a limited understanding among the stakeholders of how electrolyser technologies would impact the natural environment and what would be their potential social benefits and risks. This may be attributed to the nascent state of electrolyser technology deployment in the country.

(v) There are lessons for institutionalizing TA in the country. While the project has built some capabilities, further development of both human and institutional capacities for comprehensive participatory TAs is needed. The DSTI may wish to document lessons learned from this exercise, and conduct benchmarking of international best practices in TA to inform a national TA strategy.

1. Introduction

The UNCTAD project on Technology Assessment in the Energy and Agricultural Sectors in Africa to Accelerate Progress on Science, Technology and Innovation, which involves South Africa, Seychelles and Zambia as pilot countries, was initiated in South Africa in 2019 following the submission of an expression of interest by the country.

In recent years, there has been a surge of policies, programmes and strategies relating to green hydrogen technologies, and some political attention to developing and commercializing it in South Africa. Since the mid-2000s various policy and programmatic initiatives have been launched to explore and promote the country's entry into the "green hydrogen economy".' In 2007, the Cabinet of the Government of the Republic of South Africa approved the national Hydrogen South Africa (HySA) strategy, which establishes the country's overall policy framework for building a hydrogen economy. To implement such an economy, the Government developed the Hydrogen Society Road Map and the Green Hydrogen Commercialisation Strategy (GHCS) among other policy instruments. Green hydrogen is also prioritized in the Just Energy Transition (JET) Partnership and the Just Energy Transition Implementation Plan 2023–2028 (JET-IP).

The various policy and programmatic initiatives on hydrogen are aimed at reducing the country's high dependence on coal, thereby spurring the transition to a low (net-zero) carbon economy, diversifying the sources of energy production to meet growing demand and address energy scarcity (manifested in load shedding and undersupply of electricity), and building national capabilities for exporting hydrogen to international markets. The country is richly endowed with input materials, such as platinum and iridium resources, which is a huge advantage for developing a sustainable hydrogen value chain. There is also increasing international demand and investment in hydrogen as an energy source.

To give practical expression to the various policy goals on the green hydrogen economy, South Africa is investing in the development of electrolyser technologies. The Department of Science and Innovation (DSTI) and other actors are supporting CoCs dedicated to R&I in electrolyser technologies. There are also private institutions that have ongoing R&I activities on electrolyser technologies. Despite these efforts, there has been no formal policy-oriented systematic and comprehensive TA of electrolysers and other hydrogen-based energy technologies. Technology assessment can be defined as a problem-oriented process that examines social, economic and environmental effects when a technology is introduced, extended or modified. It is an interactive, communicative, and scientific process that aims to contribute to forming public and political opinion on the economic, social and environmental aspects of a given technology, its risks and opportunities, as well as providing practical, pragmatic and sustainable options for appropriate policy actions. TA is therefore a useful toolbox for science, technology and

Various policy initiatives support the transition to a low carbon economy

UNCTAD's pilot project on TA is an innovative capacity-building exercise for Africa

innovation policy. So far, it is being used mainly in developed countries, and has been institutionalized in parliaments and executive branches in countries such as France, Germany, the United Kingdom of Great Britain and Northern Ireland and the United States of America, among others.

In South Africa, TA has not been institutionalized, but various aspects of such a form of assessment have been used in different processes, such as in the formulation of a hydrogen roadmap and a green hydrogen commercialization strategy. In addition, different policies make implicit reference to the importance of TA, and the DSTI has conducted TA-like activities, including technology foresighting and road-mapping.

In 2021, South Africa joined a pilot African regional project on TA, which was developed and launched by UNCTAD. The project aims at supporting three participating countries, namely Seychelles, South Africa and Zambia, to engage in national processes for examining the potential social, economic, environmental and technological effects of selected new technologies that are or were being introduced or diffused in the agricultural and energy sectors of the three economies. It is a capacity-building project that enables the countries to experiment with the use of TA, since none of them have prior accumulated experience and institutional capacities for formal policy-linked TA.

South African joined the project mainly to build domestic capabilities on TA

The main reason why South Africa joined the UNCTAD TA project was to build its domestic capabilities to use TA to fast-track the implementation of various STI and STI-related policy measures. Many countries' policy and legal frameworks require their governments to make evidence-based technological choices and R&I decisions, supported through engagement with the public. For example, in South Africa, the 2019 White Paper on Science, Technology, and Innovation requires the Government to make "a significant policy shift in including civil society in STI planning at all levels, and devoting resources to supporting grassroots and … innovators".[2] It also requires the Government to institute or develop a framework for responsible R&I. Conducting participatory TA is one approach to ensuring that responsible R&I takes root in South Africa's STI system.

The DSTI coordinated the TA project, which focuses on assessing economic, social and environmental benefits and risks of adopting electrolyser technologies in South Africa. An expert group and a steering committee, bringing together stakeholders from various academic and professional backgrounds and institutional affiliations, including government departments, the private sector and science councils, were established to provide technical, intellectual and administrative support to the project (see Annex 1). The expert group and the steering committee acted as the overall TA governance team and were responsible for the selection of the energy technology to be assessed. Based on a methodology developed by UNCTAD, the TA was conducted for a period of about two years through a variety of activities in various steps. It included a review of the relevant literature and policy documents, the selection of electrolysers for green hydrogen production, a stakeholder analysis, and the collection of data via a survey questionnaire, interviews and a focus group discussion (FGD).

This report is structured as follows. Section 1 provides an overview of South Africa's development context and the energy outlook. It discusses challenges and opportunities relating to the country's energy security, as well as various national efforts aimed at transitioning to a low-carbon economy. One of the

[2] Republic of South Africa, 2019, *White Paper on Science, Technology, and Innovation: Science, Technology and Innovation Enabling Inclusive and Sustainable South African Development in a Changing World* (Department of Science and Technology, Pretoria): xii.

key findings discussed in this section is that South Africa has a wide range of technological options to overcome the challenges to its lack of energy security and meet its obligations to transition to a net-zero carbon economy. The country holds 70 per cent of global platinum deposits and over 85 per cent of global iridium deposits, which are critical for green hydrogen production.

Section 2 provides an overview of different policy frameworks and instruments, as well as programmatic initiatives that the Government has adopted or launched to harness different energy technology options. It identifies an array of policy instruments and programmes for green hydrogen in the country. There is also a growing body of academic and non-academic studies on the socioeconomic and technical aspects of building a green hydrogen economy in South Africa. Overall, green hydrogen is receiving increasing policy and research attention in the country.

Section 3 discusses electrolyser technology for harnessing green hydrogen. It focuses on the socioeconomic impacts of the technology, the different actors involved in electrolyser R&I, and how and whether the national system of innovation (NSI) as a whole creates or unlocks systemic barriers to electrolyser development and commercialization in South Africa.

Section 4 outlines the methodology, and describes the processes, instruments and activities undertaken in conducting the TA. Further, it presents a SWOT analysis, and analyses the empirical information gathered for the TA. Emphasis is placed on the design and administration of a survey questionnaire, interviews and a focus group discussion, which were the main methods for gathering and analysing both qualitative and quantitative information for the TA. It focuses on key aspects, such as stakeholders' understanding or knowledge of green hydrogen and electrolyser technologies, actors and trends in electrolyser R&I, stakeholders' perceptions of the effectiveness of current national policies and programmes for electrolysers for green hydrogen production, perceptions concerning the benefits and risks of using the technology, and proposals for maximizing benefits and reducing risks associated with the development and commercialization of electrolysers for green hydrogen production. Specific limitations of the methodology and some of the institutional challenges to the TA process are also discussed.

Sections 5 and 6 outline tentative policy recommendations and an action plan for using the TA to inform decisions on the development and application of electrolysers for green hydrogen production in South Africa, respectively. They also discuss measures that the Government and UNCTAD as well as other stakeholders should undertake to build capacity to institutionalize TA as a toolbox for technology policymaking.

2. Background

South Africa's future prospects for sustainable development depend on its ability to generate adequate, affordable and clean energy. It has therefore adopted a wide range of policies and instruments to address energy insecurity. There is a push in the country to develop domestic capabilities to enable it to become a global leader in electrolysers and green hydrogen production.

National development context and the energy challenge

South Africa is one of the most industrialized countries in Africa, and is classified as an upper middle-income economy by the World Bank and the International Monetary Fund (IMF). Its economy is more diversified than the other economies on the continent, with the main economic activities consisting of mining, tourism, manufacturing, agriculture, financial services, forestry and fisheries. However, the economy has experienced a considerable downturn over the past decade or so because of declining productivity in most of its sectors.

Real growth of South Africa's gross domestic product (GDP) averaged 1.6 per cent during the period 2011–2019, declined by 6 per cent in 2020 (with the onset of the Covid-19 pandemic), then recovered, with growth rates of 4.7 per cent in 2021, 1.9 per cent in 2022 and 0.6 per cent in 2023. It is forecast to grow by 0.9 per cent in 2024 and 1.2 per cent in 2025, according to IMF data.[3] The country has one of the highest rates of overall adult unemployment, at 32.8 per cent, and unemployment of youth (15–34 years) at about 56 per cent in 2023.[4] Poverty and socioeconomic inequalities, including limited access to amenities such as water, good health and energy are still very high 30 years after the country attained independence (or after the end of apartheid). Energy insecurity is one of the most pressing development challenges that the country faces today. It undermines the ability of the country to reverse the deepening economic decline, create jobs, spur manufacturing and attain the United Nations Sustainable Development Goals (SDGs) as well as many other national development goals.

South Africa faces a major energy crisis. Load shedding (electricity cuts or blackouts) is negatively impacting the economy. The Government's 2023 country report on progress towards the Sustainable Development Goals shows that South Africa is lagging in meeting SDG7 on affordable and clean energy.[5] The report states that, despite "advancements in renewable energy, South Africa is facing challenges in other areas related to SDG7. Particularly concerning is the regression in

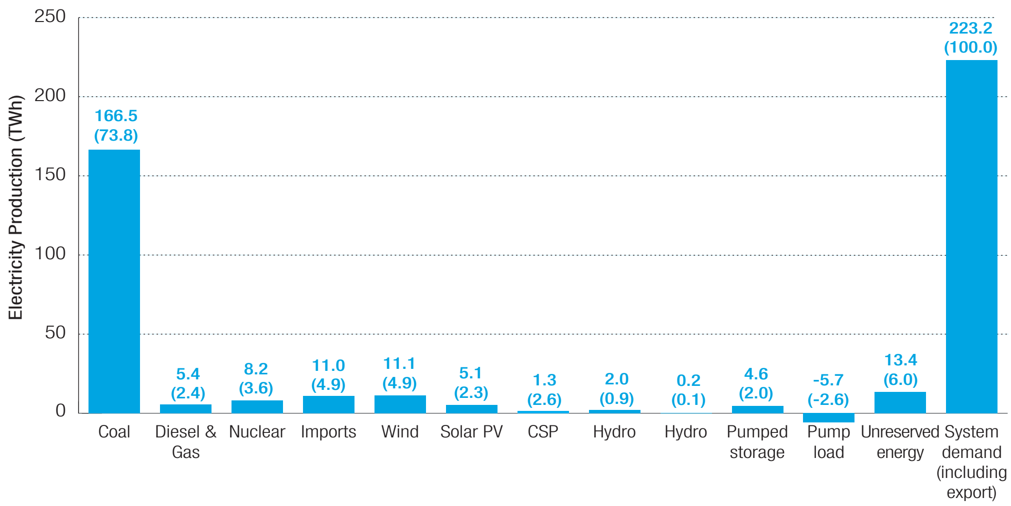
> Energy insecurity is a pressing development challenge facing the country

[3] IMF Regional Economic Outlook: Sub-Saharan Africa, April 2024 at https://www.imf.org/en/Publications/REO/SSA/Issues/2024/04/19/regional-economic-outlook-for-sub-saharan-africa-april-2024 (accessed 20 May 2024).

[4] Republic of South Africa, 2023, *Sustainable Development Goals Country Report – South Africa* (Statistics South Africa, Pretoria).

[5] Republic of South Africa, 2023, *Sustainable Development Goals Country Report – South Africa* (Statistics South Africa, Pretoria).

Figure 1.
Share of different energy sources in South Africa's energy mix, first quarter 2024 (percentage)



Source: Adapted from the Centre for Renewable and Sustainable Energy Studies (CRSES), Stellenbosch University; available at https://www.crses.sun.ac.za/sa-energy-stats/ (accessed 10 June 2024).

Notes: Figures in brackets are percentage shares; TWh stands for terawatt hours; CSP is concentrated solar power. Unserved energy = Manual Load Reduction (load shedding) + Interruptible Load Supply + Interruption of Supply.

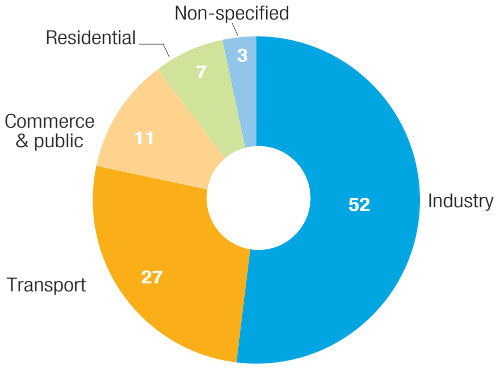
energy access, with the country reversing its near-universal access achievements reported in 2019. The percentage of the population with access to electricity dropped from 95.0% in 2019 to 89.3% in 2021. The country is also grappling with an unstable power supply, resulting in frequent power interruptions, and escalating electricity costs, posing a threat to energy security. In response to these issues, policymakers are considering ongoing interventions to address the problem of power interruptions."

South Africa's future prospects for economic and overall sustainable growth depend largely on its ability to overcome structural impediments to generating adequate, affordable and clean energy, as acknowledged in various policy documents. It also recognizes the need to diversify its sources of production of clean (low- carbon) energy. Energy is responsible for 81 per cent of South Africa's emissions, of which 45 per cent are from electricity. It is among the world's top 20 greenhouse gas (GHG) emitters and has committed to lowering its emissions under the Paris Agreement.[6] Coal is still the dominant source of electricity in the country (figure 1), although lower than in the 1990s. The Government seeks to significantly increase energy supply to meet demand while increasing the share of gas and renewables in the energy mix.

Figure 2 shows that industrial demand for energy is in excess of 50 per cent of the total. Further, according to the Department of Mineral Resources and Energy, the total nominal generating capacity of the electric public utility, Eskom, as at March 2019 amounted to 44 gigawatts (GWs), but due to operational challenges of reduced energy availability from its ageing power generating fleet, it has failed to meet demand.

[6] https://www.worldbank.org/en/news/press-release/2023/10/25/south-africa-afe-world-bank-backs-reforms-to-advance-energy-security-and-low-carbon-transition.

Figure 2.
Energy demand in South Africa, by sector, 2018 (percentage)



Source: Department of Mineral Resources and Energy, *The South African Energy Sector Report 2021*: 21;. available at: https://www.dmre.gov.za/Portals/0/Energy_Website/files/media/explained/2021-South-African-Energy-Sector-Report.pdf.

There has been progress in the introduction and diffusion of renewable energies in the country over the past decade. According to the South African Renewable Energy Masterplan (draft July 2023),[7] in South Africa in 2021, a kilowatt hour (kWh) of solar PV cost 0.375 rand and a kilowatt hour (kWh) of wind energy cost 0.344 rand. It is estimated that in 2022, 2.1 GW of renewable energy was added to the already 3.9 GW reported in 2018. And, overall, the costs of renewable energy technologies have declined over the past few years.

Overview of South Africa's energy policies and other instruments

South Africa has adopted a wide range of policies and instruments to address the various socioeconomic challenges, including policies to tackle energy insecurity. The country's overall development policy framework is the national development plan (NDP) – Vision 2030 – which was adopted in 2012 and lays out the country's energy goals or aspirations.[8] It states: "South Africa should invest in and help exploit the wide range of opportunities for low-carbon energy from hydroelectric and other clean energy sources in southern Africa." The NDP also sets several energy targets that should be achieved by 2030, including: (a) producing sufficient energy while reducing carbon emissions per unit of power by about one third, and (b) procuring at least 20,000 megawatts (MWs) of renewable electricity, importing electricity from the region, decommissioning 11,000 MWs of ageing coal-fired power stations and increasing investments aimed at improving energy efficiency.

Energy policies are also articulated in various policy documents, regulations, plans and strategies, including the 1998 White Paper on Energy Policy, the 2003 White Paper on Renewable Energy Policy, the 2006 Electricity Regulation Act, the 2007 Hydrogen South Africa (HySA) strategy, the 2008 National Energy Act, the 2011 Minerals Beneficiation Strategy, the 2016 Integrated Energy Plan, the 2019 Integrated Resources Plan, the 2019 White Paper on Science,

Energy policies are articulated in various policy documents, regulations, plans and strategies

7 Republic of South Africa, 2023, South African Renewable Energy Masterplan (draft), An industrial and inclusive development plan for the renewable energy and storage value chains by 2030 (Pretoria), available at https://www.dmr.gov.za/Portals/0/Resources/Renewable%20Energy%20Masterplan%20(SAREM)/South%20African%20Renewable%20Energy%20Masterplan%20(SAREM)%20Draft%20III.pdf.

8 Republic of South Africa, 2012, *National Development Plan 2030: Our Future – Make it Work* (Pretoria), available at https://www.gov.za/sites/default/files/gcis_document/201409/ndp-2030-our-future-make-it-workr.pdf.

Technology, and Innovation, and the 2021 National Industrial Policy Framework. There are also various fiscal (economic), voluntary or soft (e.g. public-private partnerships) and regulatory initiatives in place. An example of a policy instrument is the 2023 Just Energy Transition Implementation Plan (JET-IP 2023–2027).

The 1998 White Paper on Energy Policy outlines the following policy objectives: (a) promote access to affordable energy services for disadvantaged households, small businesses, small farms and community services; (b) improve energy governance; (c) enhance the management of energy-related environmental and health impacts; and (d) diversify both supply sources and primary energy carriers. These policy objectives are to be achieved by deploying various instruments, including a National Electrification Fund and forming public-private partnerships.

The 2003 White Paper on Renewable Energy focuses on enlarging the country's capabilities for developing renewable energy technologies. Its objectives include strengthening R&I in renewable energy and promoting its widespread diffusion and use. The main instruments for implementing the policy framework are outlined in the Integrated Resource Plan (IRP 2010) adopted by the Cabinet in May 2011. The IRP sets an ambitious target of 17,800 MWs of renewable energy to be achieved by 2030.[9]

South Africa aspires to become a global leader in electrolysers

The 2007 National Hydrogen and Fuel Cell Technologies Research, Development, and Innovation Strategy, adopted by the Cabinet and launched as Hydrogen South Africa (HySA),[10] sets the overall policy framework for investments in R&I in green hydrogen. The HySA strategy is premised on the rationale that South Africa possesses 80 per cent of the world's reserves of platinum group metals (PGMs), the demand for which is likely to increase as a result of local and global investments in electrocatalysts. This gives the country a strong basis for engaging in green hydrogen and fuel cell technology development. Indeed, the country aspires to become one of the global leaders in electrolysers for green hydrogen production. One of the objectives of HySA is to promote research and development (R&D) that would enable South Africa to achieve a target of 25 per cent of the global market share of hydrogen and fuel cells.

The 2010 Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), covering a mix of key energy policy instruments, was developed by the Department of Energy (now called DMRE), the National Treasury and the Development Bank of Southern Africa to implement provisions of the 1998 White Paper on Energy Policy of South Africa. It aims to make urgent interventions to overcome the electricity or power generation shortages that the country has been facing since around 2007. The programme's objective is to attract or promote private sector investment in new electricity generation capacity, and help diversify the country's energy mix.

The 2019 White Paper on Science, Technology, and Innovation[11] does not have explicit policy goals and specific instruments for promoting energy security in the country. However, it makes general reference to increasing R&D and innovation in the circular economy, including supporting the transition to renewable low-carbon energy technologies.

The 2019 Integrated Resource Plan (IRP2019)[12] is another key policy framework for energy security in South Africa.

[9] Republic of South Africa, 2024, Integrated Resources Plan (IRP) 2023 (Department of Mineral Resources and Energy, Pretoria).

[10] Republic of South Africa, 2007, National Hydrogen and Fuel Cell Technologies Research, Development, and Innovation Strategy (Department of Science and Technology, Pretoria).

[11] Republic of South Africa, 2019, White Paper on Science, Technology and Innovation Science: Technology and Innovation Enabling Inclusive and Sustainable South African Development in a Changing World (Department of Science and Technology, Pretoria).

[12] Republic of South Africa,2019, *Integrated Resource Plan (IRP2019)* (Department of Energy, Pretoria).

Developed under the leadership of the Department of Energy (now called DMRE), the IRP2019 is a plan for electricity infrastructure development. It aims at promoting the production of electricity based on least-cost electricity supply and demand balance. The plan also takes into account environmental and water sustainability considerations to minimize carbon emissions and wastage of water. It makes specific reference to HySA by stating: "South Africa's specific focus on the hydrogen economy and the progress achieved by the hydrogen initiative (or HySA) based at the University of the Western Cape, should be supported with more research and the chance for practical application within the power system."[13] In addition, it promotes the consolidation of various energy policies and initiatives; as stated in the plan: "For coherent policy development in support of the development of a just transition plan, consolidate into a single team the various initiatives being undertaken on just transition."[14]

The Just Energy Transition Partnership (JETP) and the JET Implementation Plan (JET-IP) 2023–2027 articulate key energy policies. The JETP is a policy mix comprising concessional loans, grants, blended finance and public-private partnerships (PPPs) aimed at steering South Africa's energy sector, in particular, and economy in general, to a low carbon status. France, Germany, the United Kingdom, the United States, and the European Union, as well as the United Nations Development Programme (UNDP), the World Bank and other multilateral banks have partnered with South Africa to support the implementation of South Africa's revised Nationally Determined Contribution (NDC) under the Paris Agreement. The updated NDC outlines key challenges in implementing the country's 2021–2025 and 2026–2030 NDCs, describing issues relating to the management of the energy transition in the power sector and its social and economic implications, particularly in the coal-producing provinces or regions of the country.

The JET-IP 2023–2027 is a comprehensive plan developed under the leadership of the Presidential Climate Commission (PCC). It is "a roadmap that enables South Africa to take targeted and aligned strides towards meeting its decarbonisation commitments in a manner that will deliver just outcomes for the people affected by the energy transition and that contributes to inclusive economic growth, energy security, and employment. It confirms that the South African JET will be managed at a pace, scale, and cost that is consistent with the country's socio-economic development path, needs, and affordability."[15] The core priority areas of JET-IP include skills development (strengthening education and training in green innovation and entrepreneurship), improving access to and production of electricity (e.g. large-scale and distributed renewable energy generation), supporting the Mpumalanga Just Transition (community-driven projects that shift peoples' reliance on coal value chains, for example), production of new low-energy vehicles (e.g. incentives to the automobile industry to invest in decarbonizing the transport sector), and promoting green hydrogen (e.g. rolling out an engagement strategy on the socioeconomic benefits of the green hydrogen industry, and responding to local concerns with concrete benefits, as well as fast-tracking R&D funding for innovation to enhance the country's competitiveness).

Another important policy initiative is the 2023 Green Hydrogen Commercialisation Strategy (GHCS)[16] that was developed under the leadership of the Department of Trade, Industry and Competition (DTIC). Its objectives include: (a) securing and

The JET-IP 2023–2027 provides a roadmap for meeting decarbonisation commitments

[13] Republic of South Africa, 2019, *Integrated Resource Plan (IRP2019)* (Department of Energy, Pretoria): 14.
[14] Republic of South Africa, 2019, *Integrated Resource Plan (IRP2019)* (Department of Energy, Pretoria): 45.
[15] Republic of South Africa, 2023, Just Energy Transition Implementation Plan 2023–2027 (The Presidency, Pretoria): 28.
[16] Republic of South Africa, 2023, Green Hydrogen Commercialization Strategy for South Africa (Department of Trade, Industry and Competitiveness, Pretoria).

expanding South Africa' global green hydrogen market; (b) introducing policy and regulatory frameworks to expand domestic demand for green hydrogen; (c) supporting R&D in hydrogen-powered mobility applications with a specific focus on heavy duty fuel cell vehicles; (d) attracting foreign direct investment; and (e) fostering green hydrogen exports through tax incentives, grant schemes and reduced import surcharges on technology options. The GHCS also promotes electrolyser technology development. For example, it states: "The most sustainable and priority production method is through electrolysis of water using renewable energy to split the water molecule into hydrogen and oxygen. Countries with favourable renewable energy locations are likely to become net exporters of GH [green hydrogen] or related GH vectors, such as ammonia, and those that do not have such favourable conditions are likely to become net importers. This will prompt a global market for GH that will unlock new trade relationships and opportunities."[17]

Overall, South Africa has a wide range of policies and instruments for building its energy security base (table 1), many of which focus on green hydrogen. Despite these initiatives, the country is experiencing an unprecedented energy crisis that is spurring deindustrialization, exacerbating unemployment and impeding its efforts to attain the Sustainable Development Goals.

Table 1:
Overview of selected policies and instruments relating to green hydrogen

	Description	Objectives	Relevance to hydrogen
The 1998 White Paper on Energy Policy	Framework for regulating energy supply and demand	Ensure energy access and security of supply –through integrated energy planning, governance, stimulate economic development and manage energy environmental impacts.	Hydrogen insignificantly cited as a future source of renewable energy in the country
2003 White Paper on Renewable Energy Policy	Strategic intend of renewable energy	Set and outline targets (by 2013) for renewable energy in power generation and non-electric applications	Hydrogen insignificantly cited as a future source of renewable energy in the country
Hydrogen South Africa (HySA) Strategy, 2007	A detailed 15-year programme	Beneficiation of PGM's and capacity development through 3 competence centres: HySA Infrastructure, Systems and Catalysis	The central policy for hydrogen development and pathways for South Africa
2008 National Energy Act	Legal framework to govern investments, energy supply and demand	Promote energy mix, ensure energy access and security of supply - through integrated energy planning and governance	Hydrogen cited as a future source of renewable energy for South Africa
The minerals beneficiation strategy, 2011	Strategy for downstream beneficiation of minerals in the country	Promote downstream mineral beneficiation. In particular, platinum group metals and other precious metals	Potential for fuel cell production in South Africa
National development plan,2012	Reduced poverty and inequality by 2030	Promote diversification of energy generation and energy infrastructure development.	Mitigate and address climate change impacts through the green transport strategy and application of hydrogen fuel cell technology
Integrated Energy Plan, 2016,	Framework for integrated energy planning	Guide South Africa's integrated energy planning and mix based on future demand scenarios based on climate change caps and costs.	Hydrogen planning in the context of the overall energy plan of the country
White paper on science technology & innovation 2019	Broad policy intent on various aspects of NSI	National system of innovation enhancement though emphasizing inclusivity, transformation, and partnerships	Increase investment in high-end infrastructure to support innovation and develop new industries and products e.g., hydrogen fuel cells
The National Industrial Policy Framework, 2021	Broad industrial development policy framework	Promote and support for fuel-cell industry development through a climate compatible industrial development policy roadmap	Green industry investments detailed in The Industrial Policy Action Plan, 2021
DMRE, Integrated Resource Plan, 2023	Forecast (2050) and integrated energy development plan for South Africa	Promote renewable energy, drive diversification of technologies – including low carbon emission and promoted energy mix. Outline timelines to decommission ESKOM coal power stations.	Hydrogen cited as an area for R&D and for its potential role to store energy
Green Hydrogen Commercialization Strategy for SA	Gives effect to the 2007 Hydrogen South Africa Strategy	Prepare the country for a hydrogen economy that has the upside potential to create 370 000 jobs add 3.6% to RSA GDP by 2050.	To add additional renewable energy generation capacity and promote South Africa as a major producer and exporter of green hydrogen

Source: UNCTAD.

[17] Republic of South Africa, 2023, Green Hydrogen Commercialization Strategy for South Africa (Pretoria): 8.

Electrolyser technology research and development in the National System of Innovation

South Africa's NSI consists of public and private organizations involved in R&I, policy bodies and initiatives, funding agencies, civil society organizations, and businesses comprising both small and medium-sized enterprises (SMEs) and large companies. Key public agencies include science councils (such as the CSIR and MINTEK), funding bodies (such as the National Research Foundation and the Technology Innovation Agency), 26 public universities, 50 technical and vocational education and training (TVET) colleges, the National Advisory Council for Innovation (NACI), the DSTI, the Department for Trade, Industry and Competition (DITC), the Department of Mineral Resources and Energy (DMRE), and many other government departments dealing with electricity, agriculture, water, forestry and fisheries. All these entities influence the country's energy policies and R&I activities in green hydrogen.

There is scant information on the participation of small, medium and micro enterprises (SMMEs) in the energy sector, but in general it is expected that their participation will increase through the REIPPPP, coordinated through the DMRE. However, at present, most SMMEs lack the requisite capabilities to participate in the REIPPP. Various efforts are under way to overcome this challenge by strengthening their capabilities to participate through the REIPPP and other programmes, such as the Energy Industry Support Programme (EISP) of the CSIR Energy Research Centre, which aims at providing technical assistance for this purpose.[18] The overall aim of the programme is to empower SMMEs with the skills and financial resources, including through the provision of technical incubation services, to enable them to effectively engage in energy production and distribution.

The Innovation Hub is also supporting SMMEs to participate in the energy sector. By December 2023, the Hub was incubating at least 19 SMMEs in the development and distribution of renewable energy technologies. Its Climate Innovation Centre South Africa (CICSA) incubation programme, with the support of the Gauteng Growth and Development Agency (GGDA), is nurturing SMMEs to participate in different parts of the energy sector value chain.

International partners, such as the European Union, the International Renewable Energy Agency and the World Bank, as well as bilateral partners, such as the governments of China, Germany, the Kingdom of the Netherlands, the Russian Federation and the United Kingdom, are also participants in South Africa's NSI and energy sector. Some of them already have (or are actively seeking) strategic partnerships with South Africa in the development of a green hydrogen economy and renewable energy technologies. For example, the European Union and the World Bank are major partners in the JETP, providing technical and financial support to the JET-IP. Meanwhile, Germany and the Kingdom of the Netherlands have established bilateral cooperation initiatives with South Africa to develop green hydrogen technologies, such as cooperation between South African and German researchers on electrolyser technologies.

Many programmes support building SMME capabilities in the energy sector

Another element worth analysing within the context of the NSI is R&I in energy. Data sourced from PatSeer,[19] a comprehensive global patent research platform, reveal that South Africa has produced 50 patents on electrolysis since 1962, of which there are currently 12 active patents, either applied for or granted, in electrolyser technologies.

[18] https://www.csir.co.za/csir-energy-industry-support-programme.
[19] https://patseer.com.

The 2020 NSI Review called for radical institutional reconfiguration

The country's NSI is itself changing. Reviews of the NSI for 2017 and 2020 show that it has certain structural weaknesses that should be addressed to spur R&I. The 2017 NSI review concluded, inter alia, that linkages between the public and private sectors were weak, that R&I did not focus adequately on addressing societal challenges faced by the poor, that there were policy incoherencies and weak policy implementation, as well as poor coordination and interaction among different departments, causing the NSI to underperform.[20] The 2020 NSI Review, titled A New Pathway 2030: Catalysing South Africa's NSI for Urgent Scaled Social and Economic Impact – A Review of South Africa's Higher Education, Science, Technology and Innovation Institutional Landscape (HESTIIL), found the NSI to be dysfunctional.[21] It called for radical reconfiguration of the institutional set-up. The review noted that, while the NSI had expanded in terms of the number of actors, there were weak linkages and underperformance of many of the public sector organizations involved.

Overall, the energy sector in South Africa has a diverse range of public and private sector actors with varying roles and capabilities. As shown in table 2 below, there are overlapping mandates and potentially diverse interests in the hydrogen economy.

Table 2:
Mapping of key energy sector stakeholders and actors in South Africa's National System of Innovation

Government	State owned enterprises	Private companies	Academia and R&D	Other
▪ **Depart of Science and Innovation (DSI)** – *research and innovation, renewable energy and South African hydrogen strategy* ▪ **Mineral Resources and Energy (DMRE)** – *energy policy, energy mix, renewables and planning* ▪ **Department of Electricity (DE)**, -*energy supply* ▪ **Trade, Industry and Competition (the dtic)** –*develop manufacturing, green industries and foster trade and foreign direct investment* ▪ **Depart of Transport (DoT)** –*targets and meet green transport intent* ▪ **Department of Public Works and Infrastructure** –*utilising green technologies in buildings and infrastructure* ▪ **Department of Public Enterprises (DPE)** – *SOE shareholder, governance and oversight* ▪ **National Treasury** –*national fiscs, budgets, procurement and control* ▪ **Department of Forestry, Fisheries and the Environment (DFFE)** –*sustainability and environment management* ▪ **Provincial Governments:** key Gauteng, KZN, Limpopo, Northern and Western Cape –*by-laws, procurement and infrastructure*	▪ **ESKOM** –*power generation, distribution, export and procurement from independent power producers* ▪ **National Energy Regulator of South Africa (NERSA)** -*licence and regulate energy sector, infrastructure and tariffs* ▪ **PetroSA** –*gas and hydrocarbon exploration, acquisition, development and marketing* ▪ **Transnet** –*road, rail and port infrastructure. Green energy use and application* ▪ **Central Energy Fund (CEF)** –*security of supply and exploration, acquisition, development and marketing* ▪ **Industrial Development Corporation (IDC)** – *industrial development funding*	▪ **SASOL** -*energy and petrol capital company and develop hydrogen-based infrastructure.* ▪ **Anglo American, Impala Platinum, Isondo Precious Metals and other mining companies** – *security of supply, application develop hydrogen-based infrastructure* ▪ **Independent Power Producers (IPP)** –*energy generation* ▪ Mulilo energy holding ▪ **Refineries; Total energies, Shell Hydrogen, Astron refinery, BP, Busmark**, -*Green energy use and application* ▪ **Bambili Energy, KPMG, TongaatHulett, Africa H2 Project, CHEM Energy South Africa, Hydrox Holdings, Afrox, Air Liquide, ArcelorMittal** -*security of supply, application develop hydrogen-based infrastructure*	▪ **South African National Energy Development Institute (SANEDI)** – *Energy R&D and in green energy application* ▪ **North-West University,** *HySA Infrastructure, energy R&D, innovation and capacity development* ▪ **University of Cape Town & ESRG** - HySA Catalysis, *energy R&D, innovation and capacity development* ▪ **University of Pretoria** - *energy R&D, innovation and capacity development* ▪ **University of Witwatersrand** - *energy R&D, innovation and capacity development* ▪ **University of Western Cape** -HySA Systems, *energy R&D, innovation and capacity development* ▪ **CSIR** - *HySA Infrastructure, energy R&D, innovation and capacity development* ▪ **MINTEK** -HySA Catalysis, *energy R&D, innovation and capacity development* ▪ Public funded R&D institutions ▪ HySA Infrastructure Centre of Competence	▪ Africa Climate Foundation, ▪ Responsible care, ▪ Chemical and allied industries association ▪ RMI ▪ South African Institute of International Affairs (SAIIA) – UK Partnering for Accelerated Climate Transitions (UK PACT) ▪ Poelano High School ▪ Global Hydrogen Council

Source: UNCTAD.

[20] Republic of South Africa, 2017, Research and Innovation for Socio-economic Impact Now! A review of the South Africa Science, Technology, and Innovation Institutional Landscape (Department of Science and Technology, Pretoria).

[21] See: https://www.dst.gov.za/images/2021/Higher%20Education,%20Science,%20Technology%20and%20Innovation%20Institutional%20Landscape%20Review%20Report.pdf.

As noted earlier, South Africa has a relatively long history of working on green hydrogen, having launched a variety of programmatic and policy initiatives in this area starting in 2007 when the Cabinet adopted the HySA Strategy. HySA envisages that the country will be able to produce about 2 per cent of global green hydrogen for local consumption and 1 per cent for export. The Government plans to achieve 10 GW of electrolysis capacity in the Northern Cape region by 2030 and 15 GW by 2040.

The DSTI, in partnership with private companies Anglo American, Bambili Energy and ENGIE, is establishing a hydrogen valley around Johannesburg, Mogalakwena and Durban. The selection of the corridor from Durban to Mogalakwena was based on the potential to switch many of the industrial, mobility and building activities to hydrogen fuel.

Under HySA, the Hydrogen South Africa Public Awareness, Demonstration and Education Platform (HySA PADEP) was established to market hydrogen technology locally and internationally. As its name implies, the HySA PADEP programme seeks to raise public awareness of the country's hydrogen economy and activities. It is linked to the three CoCs located at University of the Western Cape, University of Cape Town, and Northwest University, respectively. These universities co-host those centres with some of the science councils. Table 3 provides an overview of the centres and their areas of focus.

HySA is a key policy document for national hydrogen development

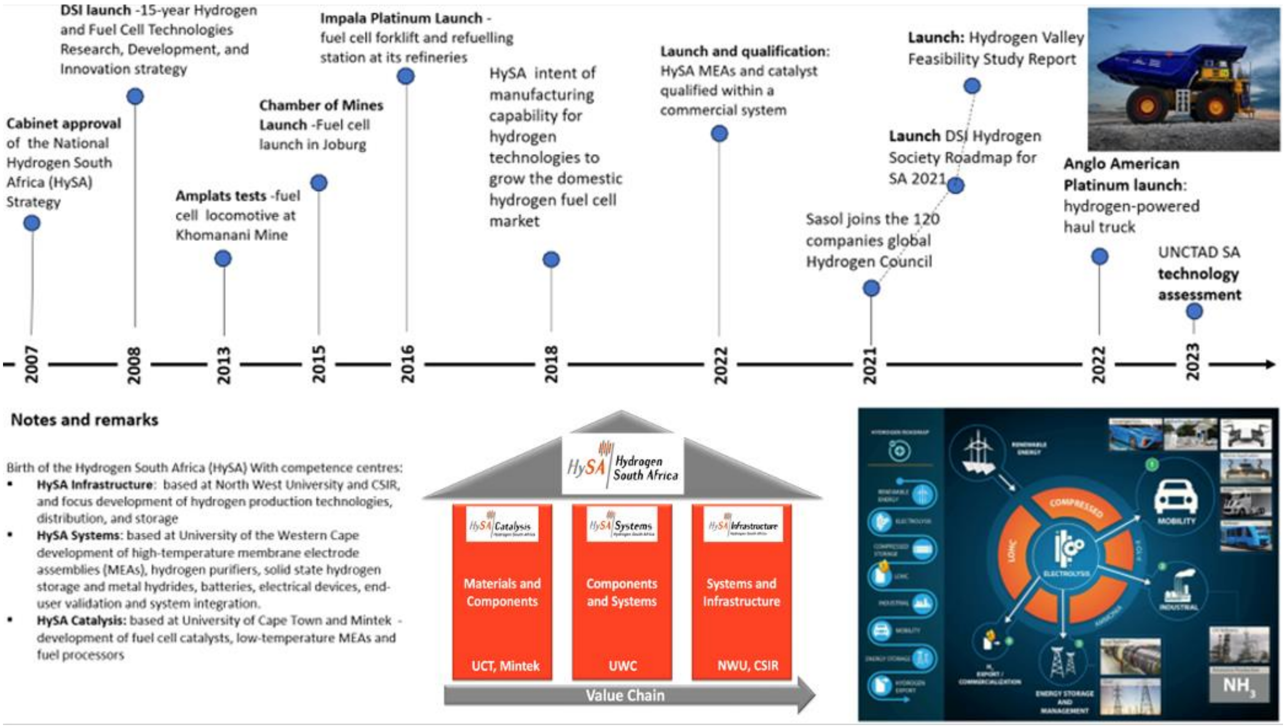
Table 3: Designated HySA centres of competence

Centre of Competence	Host	Focus area
HySA Systems	University of the Western Cape	Systems integration and technology validation
HySA Catalysis	University of Cape Town and MINTEK	Catalysis (development of catalytic components for proton exchange membrane electrolysers and fuel cells)
HySA Infrastructure	Northwest University and the CSIR	Infrastructure (hydrogen production, storage and delivery/transportation)

Source: https://www.hysasystems.com/.

There are also several private sector initiatives. These include Anglo American Platinum, BMW Group and Sasol South Africa, which are piloting hydrogen vehicles, and Phelan Green Energy's green hydrogen project, which aims to establish a state-of-the-art green hydrogen-ammonia plant in the Western Cape. Sasol already produces about 2 per cent of global hydrogen supply using coal gasification facilities. Meanwhile, PetroSA uses hydrogen in its gas-to-liquids refinery. Figure 3 provides an overview of the different initiatives and milestones in hydrogen policy and R&I in South Africa.

Figure 3:
Major green hydrogen-related initiatives in South Africa: Milestones and journey from 2007



Source: UNCTAD.

In summary, South Africa has several initiatives on hydrogen energy, with the majority focusing on "grey hydrogen" (see 2.4 below). The country has adopted a relatively rich array of policies to promote green hydrogen, with deliberate or explicit government policies and strategies to enhance the country's entry into the hydrogen economy on a competitive basis. These efforts are largely driven by South Africa's need to decarbonize, meet its sustainability goals and exploit opportunities related to beneficiation (or further local processing) of platinum group metals.

Table 2 presents a mapping of influential actors in the South African hydrogen economy based on a 2022 study.[22] It shows that both public and private sector actors, as well as the international community, are increasingly influencing investment decisions in hydrogen in the country. The South African Government, through its relevant departments, is a leading actor in establishing the policy environment for the hydrogen economy and making investments in relevant knowledge production (see also figure 3).

Technologies for green hydrogen and electrolysis

Decarbonizing the global economy is crucial, given available evidence indicating that emissions of carbon dioxide (CO_2) and other GHGs (such as methane) have to be drastically reduced in a very short period of time to contain the negative effects of climate change. Electrifying industrial processes and transport is clearly the first option in decarbonization efforts. However certain processes are not suitable for direct electrification, for example in industries

[22] Brot für die Welt/Heinrich-Böll-Stiftung, 2022, Green Hydrogen: Key success criteria for sustainable trade and production: A synthesis based on consultation in Africa and Latin America, available at: https://www.boell.de/en/2022/11/10/green-hydrogen-key-ressource-criteria-sustainable-trade-production.

that require high temperatures, such as the iron and steel and chemical industries, and in heavy and long-distance transport. In these cases, hydrogen is an important energy carrier. Today, around 70 Mts of hydrogen are used globally (e.g. in the chemical industry), sourced largely from processing fossil fuels, mainly natural gas (76 per cent), and a much smaller share from coal (23 per cent) (IEA, 2019: 37).

Thus, hydrogen technology in industry and the transport sector is not in itself a sustainable energy source. Indeed, global production of conventional and polluting hydrogen, also known as "grey hydrogen", is responsible for 830 MtCO_2-equivalent of emissions (i.e. 830 million tons of carbon dioxide) per year. Therefore, it is necessary not only to substitute today's hydrogen production with more environment-friendly technologies, but also increasing amounts have to be produced, for example for use in the iron, steel and chemical industries and for low-emission fuels for transport, so as not to further damage ecosystems by emitting additional GHGs.

The best option for sustainably producing hydrogen is through electrolysis, which has been a well-known technology for around two centuries. Water is split into oxygen and hydrogen by applying an electric current. However, if the electricity used comes from fossil sources, it is not an environmentally sustainable technology. It can only be classified as such if the electricity is drawn from renewable energies, such as hydro, wind, solar or geothermal power. In addition to this "green hydrogen" (GH2), other "colours" of hydrogen are being considered as relevant options to reduce the carbon footprint of industries and the transport sector. The most relevant of these alternatives is "blue hydrogen" (BH2), which uses fossil fuels (mostly natural gas), but, unlike grey hydrogen, the CO_2 emissions generated are captured, used and/or stored (e.g. in caverns or exploited gas fields). The extent to which blue hydrogen can be regarded as ecologically compatible depends, among other things, on the percentages of CO_2 that can be sequestrated and permanently stored, and whether and to what extent gas leakage along the process can be avoided.

A third "colour" of hydrogen is "pink hydrogen" (PH2), basically following the GH2 model, with the difference that the electricity for electrolysis is generated by nuclear power, rather than wind, solar or geothermal energies. France is the leading country promoting PH2 as a sustainability technology, but South Africa and Argentina (with an own nuclear power sector) could also assess it as an opportunity. Only recently, "white hydrogen" (WH2) has been included on the international energy agenda, following discoveries of significant reservoirs of natural hydrogen in countries like Albania and Mali. White hydrogen is naturally occurring like oil and gas, generated by continuous geochemical reactions in hard rock. Whether and when this WH2 may be commercially used is to a large extent uncertain, and still requires a great deal of basic and applied research.

> There are different colours of hydrogen - green, blue, grey, pink and white

Recent years have witnessed varying periods of interest in hydrogen, but none have resulted in a sustained and substantial increase in investment beyond the mentioned industries (IEA, 2019). What sets the current trend apart is the extensive exploration of potentially new applications for hydrogen and for its production through low-emission processes, giving it greater prominence in mainstream discussions on alternative energies globally. Various nations and companies are beginning to recognize its potentially valuable role in the future of energy production (IEA, 2019). At the country level, there were 41 national hydrogen strategies documented by November 2023 (World Energy Council, 2023).

> Electrolysis is the best bet for sustainably producing hydrogen

Based on the analysis of current policies and announcements by governments, the International Energy Agency (IEA) estimates that demand for hydrogen could reach 115 Mt–130 Mt by 2030. Recently, however, the international discourse on hydrogen has met with increasing scepticism. Some of the concerns expressed seem well-founded. For instance, the IEA's *Global Hydrogen Review* stated that the "pipeline of announced projects for the production of low-emission hydrogen accounts for up to 38 Mt by 2030" (IEA, 2023: 50). However, and in most cases, non-binding memorandums of understanding have been signed, and a final investment decision has been made for only 4 per cent of the projects.

For South Africa, assessing the potential of electrolysers has two different dimensions:

- The country has declared its commitment to decarbonize its current emissions-intensive energy system, while recognizing the need to achieve higher levels of energy security and avoid load-shedding, which is heavily affecting the economic and social sustainability of the country.
- Since 2007–2008, South Africa has launched strategies that have aimed at making the country a competitive supplier of hydrogen-related technologies (electrolysers and fuel cells). A core comparative advantage that the country seeks to exploit is its very high share of critical materials for electrolysis, mainly platinum and iridium (around 75 per cent of estimated global reserves), which are required in the PEM technology of electrolyser manufacturing.

Increased demand for platinum and iridium could boost employment in mining

If global electrolyser capacities are scaled up to the levels forecast by international organizations like the IEA and the International Renewable Energy Agency (IRENA), the demand for platinum and iridium might increase significantly. This could raise employment in the mining of both metals in South Africa. More importantly, South Africa might get a foot in the door of the global technology industries that use these metals as inputs, and thus increase its value added and employment in an upcoming core technology area.

There are three electrolyser technologies which can be used to produce GH2 and PH2: alkaline electrolysis (AEL), PEM electrolysis, and solid oxide electrolysis cells (SOECs).

- AEL is a mature technology that has already been commercialized. It has been used since the 1920s, in particular for hydrogen production in the fertilizer and chlorine industries, and in many countries with huge hydropower potential. It is characterized by relatively low capital costs compared to other electrolyser technologies as it does not require the use of precious metals, such as platinum and iridium.
- PEM electrolyser systems were first introduced in the 1960s. They use pure water as an electrolyte solution, and so avoid recovery and recycling of the potassium hydroxide electrolyte solution that is necessary with AEL. One disadvantage is that they require expensive electrode catalysts (platinum, iridium) and membrane materials. Their lifetime is currently shorter than that of AEL, and their overall costs are currently higher than those of AEL. Moreover, they have been less widely deployed.
- SOECs are the least developed electrolysis technology. They operate at high temperatures and with a high degree of electrical efficiency. And because they use steam for electrolysis, they need a heat source.

3. Methodology and rationale for the choice of technology

South Africa conducted its technology assessment through a structured process guided by a seven-step methodology developed by UNCTAD and tested during the project. The steering committee and expert group established for the TA selected the technology based on the potential for South Africa to develop strong technological capabilities and manufacturing capacity in electrolysers and green hydrogen. Given their nascent status, the assessment could help fill gaps in what was known about the economic, social and environmental implications.

Methodology

This TA exercise was guided by a methodology developed by UNCTAD.[23] The first step involved a preparatory phase of establishing a governance structure comprising a steering committee and an expert advisory group. The steering committee comprised representatives from the Department of Science and Innovation, the South African National Energy Development Institute (SANEDI), the Agriculture Research Council (ARC), academia and the private sector. Its overall remit was, inter alia, to provide policy and administrative oversight for the TA, identify and appoint an expert advisory group, set priorities for the TA (including developing criteria for the selection of the technologies to be assessed), select the technologies to be assessed, and communicate the TA process to the wider public. The representative from the DSTI chaired the steering committee.

The expert group was appointed by the DSTI with responsibilities for implementing the TA, which involved participating in data collection and capacity-building workshops, providing technical advice to the steering committee, and producing the TA report. However, the expert group did not fully function as had been anticipated, and UNCTAD had to recruit independent local consultants to implement the TA under the guidance of the DSTI and the steering committee.

Prior to the establishment of the steering committee and expert group, UNCTAD organized a training workshop in August 2022 for all three countries participating in the pilot African regional project on TA – Seychelles, South Africa and Zambia. The purpose of the workshop was to help the countries' teams develop a good understanding of TA processes, including advising the key stakeholders in the three participating countries on how best to organize the TA processes and the respective roles of the steering committee and expert group.

The steering committee and the expert group for the South Africa TA held six meetings between September 2022 and October 2023. These meetings,

The TA was guided by a new UNCTAD guiding methodology

[23] UNCTAD, 2022, *Technology Assessment in Developing Countries: A Proposed Methodology* (United Nations Trade and Development, Geneva).

guided by the UNCTAD TA methodology, focused on setting priorities for the TA and identifying key policies, regulations and strategies to be reviewed, selecting the technology to be assessed, mapping stakeholders, and considering different parts of the TA report that would be prepared. In addition to these six meetings, at least two virtual regional meetings and an in-person regional workshop in May 2023 were organized by UNCTAD to enable the three countries participating in the African regional project to share experiences to improve their TA processes.

A mapping exercise identified the main stakeholders to engage

The second step after the establishment of the steering committee and the expert group involved a review of the literature on South Africa's energy outlook or mix and related policies and instruments. The review focused on both implicit and explicit policy frameworks to identify the country's wide range of policies, some of which are explicitly dedicated to promoting green hydrogen. It informed subsequent steps of the TA, particularly the selection of the technologies to be assessed, the mapping of key stakeholders and actors in the energy sector, in general, and the green hydrogen economy in particular.

The steering committee and the expert group selected the technology to be assessed in a transparent process. Each of the committee and expert group members was asked to propose or nominate a specific energy technology that would be considered for the TA. Five technologies (energy storage, artificial intelligence, green hydrogen, agrivoltaics and floating photovoltaic solar panels) were nominated for the TA. Members of the expert group and steering committee then voted on which of these technologies should be selected, and they chose green hydrogen. Further deliberations led to the final selection of electrolyser technologies for green hydrogen production as the technology to be assessed.

The focus was specifically on proton exchange membrane (PEM) electrolyser technology, which relies on platinum and iridium resources as inputs (see section 2.4). The early stage of maturity of this technology posed a challenge in assessing its social and environmental impacts. On the other hand, stakeholders were found to be more knowledgeable about the economic impacts.

After this final selection,[24] a mapping of stakeholders and actors was undertaken in order to identify key actors in R&I, policymaking, commercialization, and other activities in electrolysers for green hydrogen production. The mapping exercise identified the main stakeholders from among the private sector, universities, government departments, State-owned enterprises, international development partners and foreign companies. Each of these groups have different interests in the green hydrogen economy.

To gather empirical data, a questionnaire was designed and administered,[25] which focused on the following aspects:

- South Africa's competitiveness as provider of hydrogen products on local, regional and international markets; whether South Africa may be subcontracted by international providers of hydrogen products; and the competitive advantages of South Africa in the international electrolyser market.
- Disadvantages or challenges for South Africa in the international electrolyser market.
- Ways and means of strengthening the country's capabilities in R&I in electrolyser technologies; and socio-technical impacts of electrolyser technologies in the country.

The questionnaire was sent to the steering committee, expert group and many stakeholders that had been identified

[24] Initially, the UNCTAD TA project had planned to assess a technology within the agricultural sector, but abandoned the idea due to organizational challenges.
[25] The questionnaire is presented in annex 2.

during the mapping exercise. The survey was also administered to local and international executives, researchers, experts and academics at the Fourth International Conference on Electrolysis held in August 2023 in Sun City,[26] and later at the Science Forum South Africa (SFSA) held in December 2023 in Pretoria (see annex 2 for the survey questions).

In addition, interviews with key stakeholders were conducted to gather further evidence. Respondents were identified from the stakeholders and actors mapping exercise. The interviews aimed at gathering views or perceptions on South Africa's competitiveness in the electrolyser market, the effectiveness of the NSI, and the policy framework in promoting electrolysers for green hydrogen production, as well as social and environmental impacts of green hydrogen, in general, and electrolyser technologies in particular. The interviews also sought views on the kinds of policy interventions that the Government of South Africa should institute in order to harness electrolyser technologies in sustainable ways to address local socioeconomic challenges (such as unemployment and energy insecurity) and improve its international competitiveness in electrolyser production and the green hydrogen economy.

To obtain additional data, a virtual focus group discussion with actors and stakeholders was held in February 2024. The discussion addressed perceptions of the state of knowledge of electrolyser technologies and green hydrogen, challenges and opportunities from local and international commercialization of the technologies, risks, costs and benefits of electrolyser technologies, and envisioning South African participation and competitiveness in the green hydrogen market in the long term.

Rationale for selecting electrolyser technologies for the technology assessment

As noted earlier, electrolysers for green hydrogen production were selected for the TA by the steering committee and the expert group after considering other energy technologies that had been proposed by members of the two groups. Each of the nominated energy technologies had been evaluated based on specific criteria, such as the level of policy and political interest or attention it was receiving in the country, newness or maturity of the technology in the energy mix, potential for social resistance to the technology, the DSTI's programmatic R&I investment priorities, and the potential of the technology to contribute to the JET.

Electrolysers for green hydrogen production was selected because of the potential for this technology to contribute to South Africa's goals of attaining net-zero carbon status by the 2050 target. But also after considering the country's accumulated expertise in Fischer-Tropsch technology,[27] availability of PGMs (used in the manufacture of membranes and catalysts in electrolysers), abundant sun and wind energy resources, and the availability of land on which to establish industrial scale energy plants. South Africa can also be a substantial exporter of green ammonia (a carrier of green hydrogen) to Europe and East Asia.

Furthermore, it was noted during the interviews, and stated in various policy documents such as the JET-IP and the Green Hydrogen Commercialization Strategy, that there is a potential local and global market for green hydrogen, and that South Africa is already developing

A survey and multiple interviews provided empirical data for evaluation

Electrolyser technology was selected based on national priorities, expertise and resources

[26] See https://International Conference on Electrolysis 2023 | engineering.nwu.ac.za.

[27] South Africa has acquired highly developed expertise in Fischer-Tropsch technology, currently applied in coal liquefaction, especially by the global chemicals and energy company, Sasol. This technology can assist the transition to a hydrogen economy, as a company like Sasol has the expertise to handle large volumes of a difficult element such as H2. Also, for developing fuels based on hydrogen (e.g. sustainable aviation fuels) this expertise in process engineering is clearly an asset.

Three types of electrolyser technologies can be deployed

bilateral cooperation arrangements with several countries (e.g. Germany and the Kingdom of the Netherlands) to work on this form of energy technology. South Africa also has the added advantage of a long coastline with a well-developed port infrastructure. This could be leveraged through trade and strategic partnerships with countries such as Japan, and those in other parts of Asia and Europe that might be interested in importing green hydrogen.

Additionally, South Africa already possesses significant knowledge in some of its universities and science councils, as well as intellectual property and expertise, in hydrogen and fuel cell technology production. Moreover, the country has an established manufacturing industry, expertise in the production of synthetic fuels, and a large labour force that is “completely trainable” according to the country’s Green Hydrogen Commercialisation Strategy. Sasol, and the national oil company, PetroSA, have expertise and infrastructure that could be used in production, storage and transport of green hydrogen. Sasol is already producing brown hydrogen from coal. While brown hydrogen is not environmentally friendly, it can be combined with carbon capture storage to reduce carbon emissions.

Another important reason for selecting this technology is that local production of green hydrogen would offer employment opportunities in the country. It is estimated that the hydrogen economy has the potential to add 3.6 per cent to the country’s GDP and create approximately 370,000 jobs by 2050.[28]

Another reason why the steering committee and the expert group decided to focus on electrolyser technologies is because they are a promising option for carbon-free hydrogen production from renewable and nuclear resources. Water electrolysis is one of the best methods for green hydrogen production. Electrolysers can range from small-sized equipment for small-scale hydrogen production, to large-scale production facilities that could be renewable electrolysers on GHG-emitting forms of electricity production.[29] Three types of electrolyser technologies can be deployed in green hydrogen production, each with its own advantages and disadvantages, as summarized in table 4 (Roos et al., 2022).

[28] EISA Africa, April 13, 2023.

[29] Fuel Cells & Electrolysers | Isondo Precious Metals, available at https://www.isondopm.com/fuel-cells-and-electrolysers/.

Table 4:
Electrolyser technologies compared: Advantages and disadvantages

	AEL	PEM electrolysis	SOEC
Advantages	• Well-established technology • Non-PGM catalysts • Long-term stability • Relatively low-cost • Stacks in the MW range • Cost-effective	• High current densities • High voltage efficiency • High-pressure operation which can save hydrogen compression costs • Good partial load range • Rapid system response • Compact system design • High gas purity • Dynamic operation	• Efficiency up to 100 per cent • Non-PGM catalysts • Possibilities for heat integration and heavy industries • Possibilities for Co-CO_2 and water electrolysis • High temperature and pressure operation
Disadvantages	• Low current densities • Limited load flexibility and low dynamic operation • Low operational pressures • Corrosive liquid electrolysis	• High cost of components because of need for PGMs and titanium • Acidic corrosive environment	• Laboratory stage • Bulky system design

Source: UNCTAD, based on Carmo et al., 2013 and Chatenet et al., 2022.

It is apparent that the different electrolyser technologies have varying niches and uses. South Africa's competitive advantage for becoming a key player in the export of green hydrogen is based on its relatively large abundance of PGMs; but only PEM electrolysis actually makes use of PGM materials (platinum and iridium) as catalysts that drive the generation of oxygen and hydrogen in the PEM electrolyser. The other electrolyser technologies (alkaline and SOEC) may assist with decarbonizing other sectors of South Africa's energy economy, for example in heavy industry.

4. Empirical findings

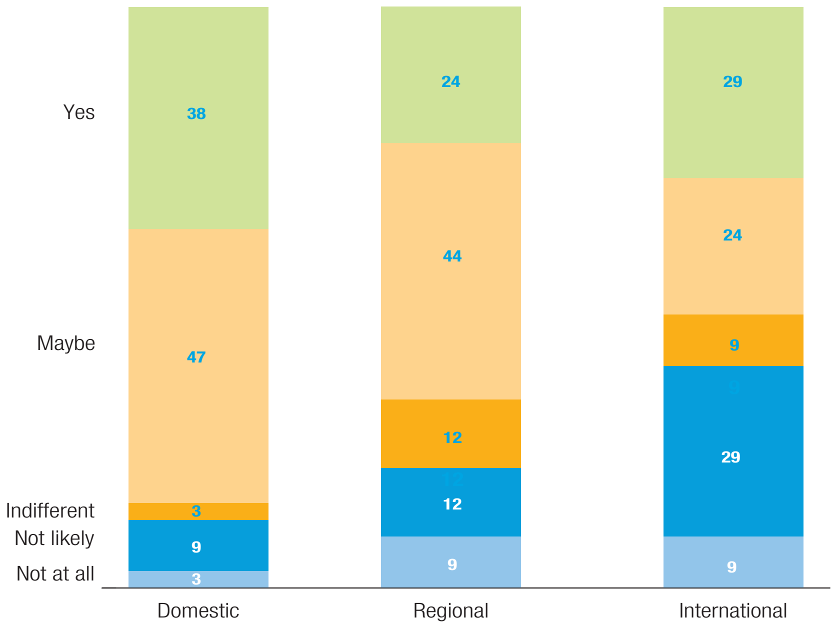
Empirical evidence on electrolysers and green hydrogen came from a survey, interviews and focus group discussions. Stakeholders had views on the economic implications, but these were not decisive as views varied greatly and there was no consensus. Evidence on social implications was very weak as most stakeholders had no views on this. Environmental implications were also not strongly identified, except concern surrounding water availability for green hydrogen production. However, evidence was gathered on the state of domestic electrolyser capabilities, and major challenges to domestic development of electrolysers at a globally competitive level. The findings point to the need for additional investigatory work.

Survey findings and emerging issues

A total of 34 out of over 50 individuals completed the survey's six questions (see Annex 2). The first question was about whether South Africa could be a competitive provider of electrolyser technologies on local, regional and international markets by 2030. Overall, most respondents did not expect or consider the country to become competitive in such markets (figure 4). Less than half of the respondents, or 38 per cent, thought that South Africa would be able to competitively commercialize electrolyser technology locally by 2030, and about 29 per cent thought the country would be competitive in the global or international electrolyser market. A large number of respondents were unsure or could not confidently state whether the country would be competitive at all in both local and external markets.

> Respondents were uncertain whether the country can competitively commercialize local electrolyser technology

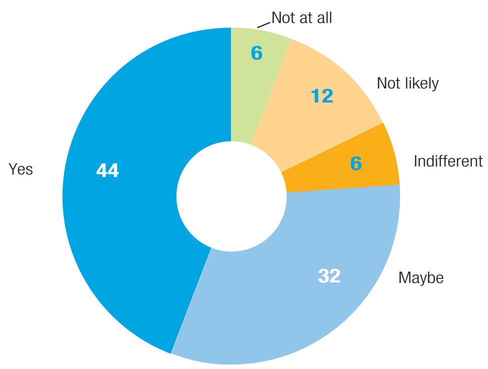
Figure 4:
Perceptions of South Africa's competitiveness in domestic, regional and international markets for electrolyser technologies (percentage of respondents)



Source: UNCTAD and DSTI Survey results.

The second question asked respondents whether South Africa might be subcontracted by international providers of electrolysers. About 44 per cent held the view that international manufacturers may subcontract the country to produce electrolyser technologies while about 32 per cent were unsure (figure 5).

Figure 5:
Views on the potential for the subcontracting of electrolyser technology production to South Africa (percentage of respondents)

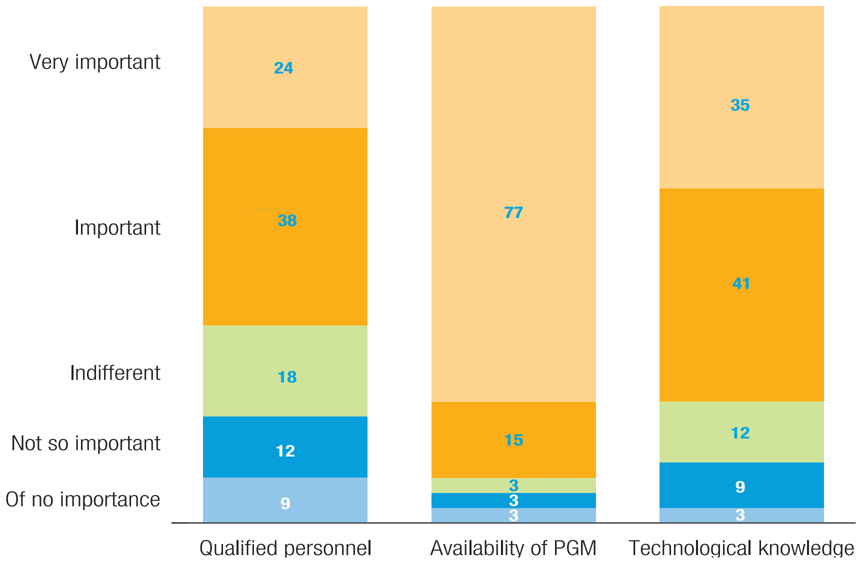


Source: UNCTAD and DSTI Survey results.

The third question asked participants for their views or perceptions about South Africa's main competitive advantages in the international electrolyser market. Overall, the general view was that the country has natural, scientific and technological opportunities to enter that market (Figure 6). According to the survey, 92 per cent of respondents believed that South Africa's PGM deposits provided it with an important or very important comparative advantage, while 76 per cent and 62 per cent of the respondents stated that technological knowledge and highly qualified personnel, respectively, are important or very important comparative advantages for the country.

The country has natural, scientific and technological opportunities to enter global electrolysers market

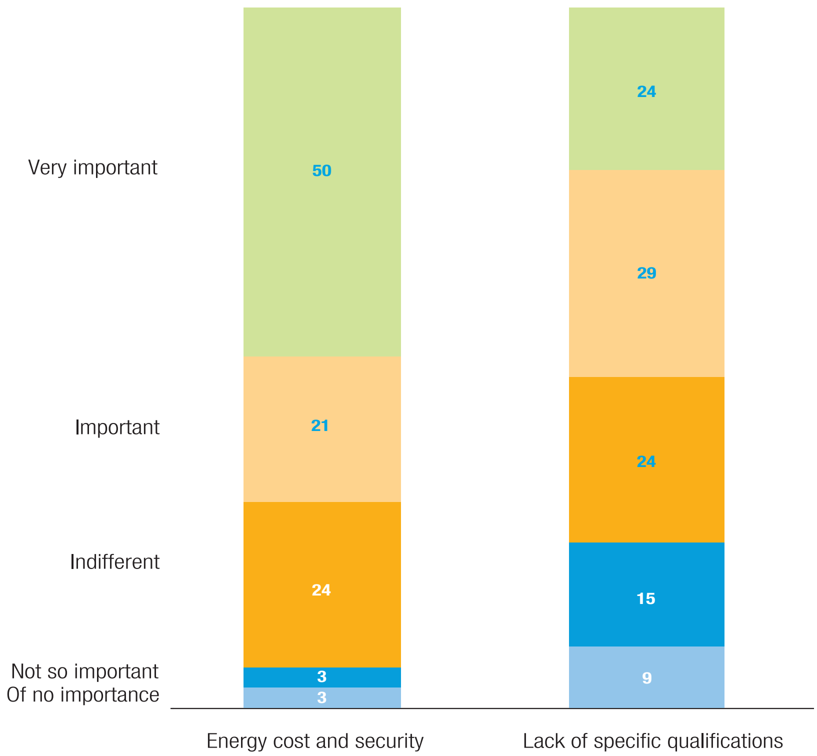
Figure 6:
South Africa's comparative advantages in electrolysers (percentage of respondents)



Source: UNCTAD and DSTI Survey results.
Note: PGM is platinum group metals

Regarding the fourth question, relating to South Africa's main disadvantages in international electrolyser markets, 71 per cent of the respondents considered energy costs and security as an important or very important disadvantage. Similarly, more than half of the respondents, or 53 per cent, indicated lack of specific qualifications as an important or very important disadvantage (figure 7).

Figure 7:
South Africa's main disadvantages in international electrolyser markets (percentage of respondents)

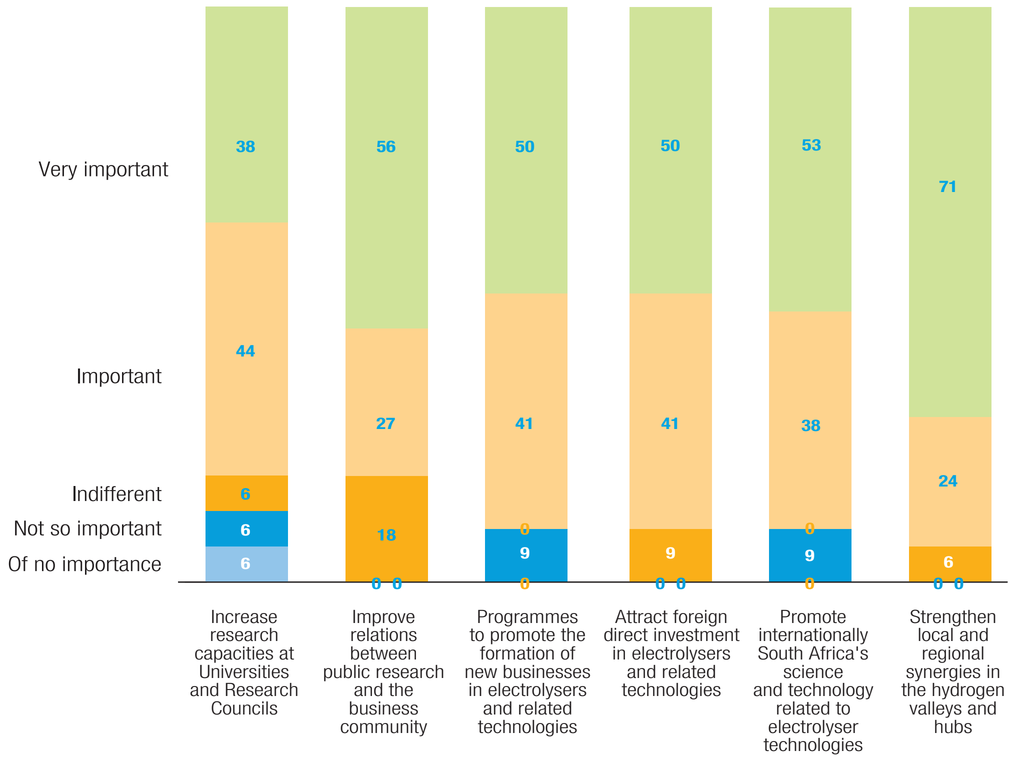


Source: UNCTAD and DSTI Survey results.

Most respondents saw diverse measures as important to strengthen capabilities in electrolysers

The survey also sought respondents' opinion on what should be done to strengthen the country's R&I capabilities in electrolyser technologies. More specifically, they were asked the question: "What should be done to strengthen knowledge creation and applications related to electrolyser technologies in South Africa?" While 38 per cent of the respondents stated that increasing research capacities at universities and science councils was very important, 56 per cent considered improving relations between public research and the business community as very important, and 50 per cent believed that attracting foreign direct investment in electrolyser and associated technologies was very important. A majority of respondents (71 per cent) suggested that strengthening local and regional synergies in the hydrogen valleys and hubs was very important, while 53 per cent believed that promoting South Africa's international cooperation in R&I on electrolyser technologies was very important (figure 8).

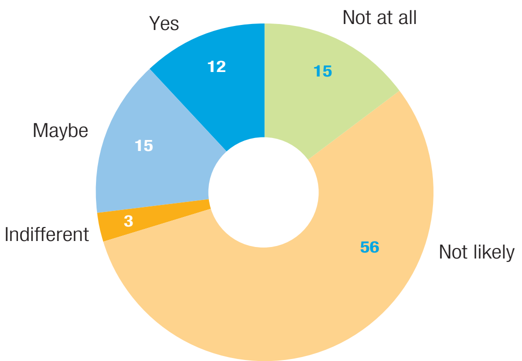
Figure 8:
Views on what should be done to strengthen knowledge creation and applications (percentage of respondents)



Source: UNCTAD and DSTI Survey results.

The last question for respondents was whether they feared that a strong focus on green hydrogen and electrolyser technologies could negatively affect other science and technology (S&T) fields by reducing their funding. As shown in figure 9, most respondents (56 per cent) held the view that such a strong focus was unlikely to negatively affect or reduce funding for other S&T areas.

Figure 9:
Could funding for electrolyser technologies divert funding away from other science and technology fields? (Percentage of respondents)



Source: UNCTAD and DSTI Survey results.

Findings and emerging issues from interviews

Interviews targeted key stakeholders in energy to get their views

In addition to the survey questionnaire, 21 leading representatives from different stakeholder groups were interviewed between December 2023 and February 2024 to gather their perceptions on opportunities and challenges relating to South Africa's entry into the green hydrogen economy, in general, and the benefits and risks of developing and commercializing electrolyser technologies, in particular. The interviewees were from government departments (the DSTI and DMRE), public universities (University of Cape Town and University of Pretoria), funding agencies (Technology Innovation Agency and South African National Energy Development Institute), one State-owned enterprise producing and distributing electricity (Eskom), the Presidential Climate Commission and an independent consultant/doctoral student of energy technologies.

All the interviewees generally agreed that the Government has instituted many policies and instruments to promote the green hydrogen economy. Seven of the interviewees were able to name or outline specific policies and related instruments that pertain to or could affect green hydrogen production and commercialization. However, only those from government departments and Eskom were able to make some general statements about the effectiveness of the policies. All the interviewees noted that there was a high level of policy illiteracy, or lack of awareness and familiarity with, different policies and instruments. One interviewee noted that there "are now many policies, strategies and regulations covering the hydrogen economy, but the detail of each policy remains hidden in the documents because the government is not raising public awareness."

Most interviewees (about 18 per cent) identified the existence of scientific and technological capabilities in hydrogen-related R&I. Expertise for research in green hydrogen and electrolyser technologies, along with a good research infrastructure, gave the country a competitive advantage for entry into the green hydrogen economy. Two interviewees reported that South African institutions participate in international hydrogen R&I networks and programmes, which was an indication of the existence of capabilities for developing electrolyser technologies in the country. However, they emphasized the importance of strengthening existing capabilities, particularly within the HySA CoCs. One interviewee raised concerns about the sustainability of prior accumulated experience and expertise because of declining government and business expenditure on R&D. The interviewee observed that there was no fund dedicated to long-term financing for HySA initiatives, and that the poor performance of the economy would erode gains made in R&D on green hydrogen and related initiatives on electrolysers.

Another cluster of issues raised during the interviews pertain to institutional linkages within the NSI and the hydrogen-related R&I community. Many interviewees (about 70 per cent) observed that South Africa's NSI was weakened due to poor coordination within and between government departments, and poor institutional linkages, both within the public sector and between public and private sectors. Interviewees from the public universities observed that HySA required better coordination between the DSTI and DMRE and a strengthening of linkages among the HySA CoCs. Concern was also raised about proper alignment between the JET-IP initiatives, spearheaded by the Presidential Climate Commission, and HySA led by the DSTI. One interviewee remarked: "there seems to be no clear match between DSTI programmes for green hydrogen and the JET-IP… in terms of a policy position on the sustainability of hydrogen energy in South African context of water scarcity."

On whether benefits outweigh risks of green hydrogen, and the potential of South Africa to become competitive in the global market of electrolyser technologies by 2030, interviewees had varying opinions. One interviewee noted that electrolyser technologies were important for a range of other purposes than the production of green hydrogen, and that there should be increased investment in electrolysis for purposes such as cooling. One third of interviewees observed that green hydrogen could generate some decarbonization benefits, but that South Africa will not be competitive in the global green hydrogen and electrolyser markets because of structural and governance challenges facing the country, including:

- The high cost of capital and doing business;
- "Collapsing logistics", with infrastructure getting eroded and inefficient ports;
- High energy costs and load shedding; and
- Weak capacity of government departments for environment and water affairs to issue licences.

Another interviewee emphasized that developing green hydrogen technologies would require "a huge" upfront investment that the Government is unable to make due to current and anticipated fiscal shortages. According to the interviewee, South Africa launched the HySA strategy at a time when it had a high GDP and fiscal surplus. The economic context or outlook has changed since then, and will affect investments in HySA and green hydrogen in the coming years. Thus, the country lacks the resources necessary to heavily subsidize entry into the green hydrogen economy.

Water scarcity was identified as one of the major bottlenecks to the green hydrogen economy and to the development of electrolyser technologies in South Africa. According to some 40 per cent of interviewees, the scarcity of water and a deterioration of water infrastructure may hamper the country's capabilities to engage in green hydrogen production and become competitive in electrolyser technology markets globally. According to one of the interviewees, investments in green hydrogen will need to be coupled with investments in water purification and conservation technologies, as well as in the maintenance of existing water infrastructure. Also, investments in, and the introduction of, green hydrogen and electrolyser technologies may face resistance, particularly from environmental groups that are concerned with water issues.

There were limited views or opinions on the social and environmental impacts of electrolysers and green hydrogen, in particular their effects on women and youth. Two interviewees noted that the extent to which South Africa could be competitive in the green hydrogen economy depends on whether it will be able to use investments in this area to create new jobs, build skills and facilitate the entry of SMMEs into the green economy or enhance their participation. One interviewee recommended that an analysis or assessment should be done to determine if the electrolyser technologies and green hydrogen will negatively impact existing jobs in the mining sector. The rollout of hydrogen projects in municipalities such as Johannesburg and Ekurhuleni should be informed by a clear assessment of their potential to provide social and economic benefits to local communities.

Lastly, interviewees were asked to make suggestions on how to maximize benefits and reduce any risks of green hydrogen and electrolyser technologies. Some interviewees suggested the following measures:

- Strengthening coordination among various actors in the hydrogen energy ecosystem and the NSI in general.
- Raising public awareness of the benefits and costs of green hydrogen and electrolysers.
- Consolidating the many policies and instruments, including reviewing the HySA strategy,

> One third of interviewees felt that structural and governance challenges would block competitiveness

> Water scarcity was identified as a major issue with green hydrogen

the JET and other hydrogen-related policies and strategies.
- Developing and promoting explicit policy actions for the creation of skills and jobs for the youth through investments in green hydrogen and electrolyser technologies.
- Increasing investments in the HySA CoCs and ensuring their sustainability.

Synthesis of issues from the focus group discussions

A virtual focus group discussion provided additional evidence for the TA

Participants agreed that greater public awareness of green hydrogen is needed

To gather further perceptions and views of the various stakeholders about electrolyser technologies for green hydrogen production, a virtual focus group discussion was held on 23 February 2024. It was attended by 29 stakeholders representing academia, researchers, policymakers and State-owned enterprises. The discussion aimed at building a comprehensive understanding of the current knowledge of electrolysers for green hydrogen production in South Africa, and exploring both the opportunities and challenges of the development of this technology from the perspectives of relevant stakeholders. Because of technical difficulties involved in organizing different small group discussions on a virtual platform, one plenary interactive session was held at which participants discussed the following themes:

(a) Knowledge of and trends in electrolyser technologies in South Africa;

(b) Risks of and challenges to electrolyser technology development, commercialization and use;

(c) Opportunities and benefits of electrolyser technologies for South Africa; and

(d) Future considerations and support for electrolyser technologies.

Several important points were made in the discussion. First of all, there is general agreement that South Africa has accumulated scientific and technical knowledge on electrolyser technologies and green hydrogen. Some public universities have research programmes (e.g. HySA CoCs) and elective courses on hydrogen. There is increasing student interest in hydrogen courses, particularly in departments of chemical engineering. HySA has generated several patents, particularly relating to membranes. The country has a high level of technology readiness in AEL technology and PEM electrolysers, which are reaching commercialization stages.

Second, the focus group participants considered whether the public understands and has a positive attitude towards electrolysers for green hydrogen production. According to several participants, there is relatively low public understanding of this technology in the country. Different efforts are being made to build public awareness. For example, HySA has a programme component of green hydrogen in schools as part of the education curriculum, which is implemented by the CSIR. The German Agency for International Cooperation, GIZ, has funded projects for community engagement in hydrogen and knowledge transfer in South Africa. Nevertheless, there was general agreement among participants that more needs to be done to enhance public understanding or awareness of green hydrogen and the hydrogen economy in general.

Third, the focus group discussion considered issues relating to whether there is market confidence in and bankability of electrolyser-related projects in South Africa. In general, there was no consensus on whether there is a ready local market for electrolyser technologies. Some participants argued that PEM electrolyser technologies were more costly than the AEL technology, and the latter did not require high volumes of water, though it was not as decarbonizing as PEM. They seemed to suggest, therefore, that South Africa should focus on AEL technology. On the other hand, South Africa's endowment of PGMs may give it a comparative advantage in producing PEM electrolysers. Several participants noted that, currently, green hydrogen production is very costly. They also observed that commercialization of electrolysers for green hydrogen production will require better infrastructure and efficiencies in certification processes, which, at present, are weak. Overall, issues of water scarcity should be taken into consideration when making choices about investments in electrolysers for green hydrogen production, since the technologies require large volumes of water, and could divert scarce water resources from other critical uses such as household uses. In this regard, commercial production of green hydrogen using electrolysis will require a licence for water use from the Department of Water Affairs under the National Water Act.

Fourth, storage of green hydrogen and its safety during transportation were raised by some of the participants as issues that require careful consideration. If the main use or end product of electrolysers is green hydrogen, it needs to be stored by or through compression. This requires compression equipment and specialized storage equipment that are not easily and cheaply available in South Africa.

Fifth, some participants in the session observed that beneficial production and commercialization of green hydrogen are dependent on the availability of cheap renewable energy. South Africa is endowed with solar and wind capabilities that give it a comparative advantage in the green hydrogen economy. However, the best locations for cheap solar power are in the Northern Cape, where the national grid is constrained and would require a significant upgrade.

Sixth, there are some spin-off companies from the HySA CoCs. For example, the HySA Catalysis at the University of Cape Town created HyPlat, which focuses on turning PGM resources into hydrogen. HyPlat has at least two patents and employs several people, although their exact number could not be established. The HySA Infrastructure CoC at North-West University and the CSIR have also established a private company and generated at least four patents (two granted in the Kingdom of the Netherlands, and one each in the United States and South Africa). The challenges that the HySA universities' spin-off companies face is the limited – or small – local market for hydrogen technologies, and a lack of subsidies or financial support from the Government. Thus, the long-term sustainability of the companies is a matter of concern.

Lastly, the TA of electrolysers for green hydrogen production needs to take a systemic approach, in the sense that there are many interacting non-technical and technical factors that influence the production of hydrogen and the commercialization of green hydrogen technologies such as electrolysers. Non-technical factors, such as an unfriendly business environment, labour strikes and disputes, social inclusion and the impact of the technology on jobs in the mining sector, need to be considered when analysing or assessing the potential of these technologies in South Africa. The focus group discussion did not really address many of these issues. Some participants suggested that there is a need to explore further the social impacts of the electrolyser value chain and green hydrogen on women and low-income communities in the country.

Tradeoffs with water and need to explore social impacts flagged

SWOT Analysis

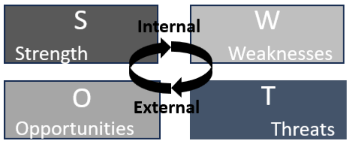
Findings from the survey feedback and interviews, engagement with experts and the virtual focus group discussion revealed the importance of using additional decisional support tools. Accordingly, a SWOT (strengths, weaknesses, opportunities and threats) analysis of electrolyser technologies was developed and applied (see figure 10), which

A SWOT analysis of electrolyser technologies informed the assessment appraised the opportunities and threats in the external environment and the strengths and weaknesses in the internal environment. The analysis found that the potential and opportunities for developing electrolyser technologies in the country at scale for the domestic and international market are outweighed by the inherent water insecurity and socioeconomic instability threats and weakness.

Figure 10:
SWOT analysis of electrolyser technologies: Opportunities and threats

- **Renewable energy source**: -the hydrogen is produced from a renewable source feedstock
- **Use and application:** the product -green hydrogen is essential and is needed across many industries and processes such as chemicals, refining, metalworking and glass. Further, hydrogen is a growing zero-emissions fuel source for mining equipment, trains, buses and cars.
- **Transition energy source**: it supports the gradual transition from high-carbon sources to a greener energy economy
- **Customizable supply chain to meet customer requirements**: -the feedstock, production capacity, availability levels can be aligned and customized to the customers needs.
- **Partnerships and customer centric solutions**: the technology is flexible and can be aligned for storage and distribution requirements to ultimately deliver customer centric solutions. Its a energy carrier - a medium to store all forms of energy
- **Agile processes**: the process can deliver a products with low levels of impurities and optimal compression and/or cryogenic liquefaction

- **Capacity and capability:** there is no proven and standing electrolysis skills and expertise in the country
- **Weaker value proposition in the energy mix**: Insufficient local potentials and can be displaced by efficient and cost-effective technologies
- **Infrastructure:** lack of large-scale electricity storages facilities in the country
- **Export routes and hydrogen corridors**: the infrastructure, export routes, and hydrogen corridors are poorly developed –most effort has been on policy and general engagements.



- **Potential and scale:** Electrolysis has the potential to generate hydrogen at scale and at zero carbon footprint and to increase South Africa's capacities due to expected rise in export demand.
- **Electrolyser capital costs** – comparatively the electrolysers are high capital cost, and their trajectories have potential to reduce due to economies of scale and high volumes
- **Efficiencies potential:** all the electrolysers by type (Proton exchange membrane (PEM) electrolysers, Alkaline electrolyser cells (AEC), Solid oxide electrolyser cells (SOEC) presently show great efficiency trajectories into the future (up to 2025), at scale
- **Manufacturing potential and opportunity**: the electolysers (AEC) have electrical capacities that can be scaled up for large scale fertiliser and chlore production
- **Carbon dioxide and steam feedstock**: diversity of feedstock allowing hydrogen and carbon monoxide to be produced from Fischer-Tropsch or methanol production

- **Water supply and insecurity:** South Africa is a water scarce country and large-scale use and export as a stockfeed into hydrogen energy production could threaten food and agriculture security in the country
- **Operating efficiencies:** at present the electrolysers are still operating at low efficiencies.
- **Scenarios and socio-economic instability**: the technology will only flourish under high economic growth scenarios in South Africa. The economy is generally underperforming on the back of energy insecurity, high inflation, high youth unemployment and low skills levels.

Analysis of findings

South Africa's accumulated technological capabilities and natural resource endowments are widely recognized

A review of the literature, the survey, interviews and the focus group discussion session all show that South Africa has been making major efforts to enter the green hydrogen economy by introducing various technologies, including electrolyser technologies. The country has invested in R&I in electrolyser technologies, and has developed a wide range of policies, instruments and strategies for the green hydrogen economy. The country is internationally recognised as a potential player in green hydrogen production because of its accumulated technological capabilities and natural resource endowments.

The following are the main findings of this TA study:

1. South Africa has the necessary scientific and technological capabilities to engage in the production of electrolyser technologies, particularly PEM electrolysers and AEL. HySA is perhaps the most important public sector-funded initiative for R&I in electrolyser technologies, and is generating the relevant knowledge and human skills for the hydrogen economy. There are about 50 South African electrolyser patents, including a number held by South African companies (for example, for the divergent electrode flow through technology developed by Hydrox

Holdings). In addition, HySA CoCs have created spin-off companies and acquired several patents.

2. The green hydrogen sector has a diverse range of actors, but there is relatively weak coordination among them. As detailed above, under section 2, many government departments, State-owned enterprises, private companies, universities, civil society and international partners have growing interest and activities in green hydrogen technologies. Strengthening coordination among these different actors' efforts and activities would enable the country to exploit economies of scale in the hydrogen economy and enhance commercial production of electrolyser technologies. Platforms that mobilize the different actors to contribute to HySA, and strategies on how best to harness electrolyser technologies, need to be established.

3. In general, there is low public understanding and awareness of the green hydrogen economy and electrolyser technologies in the country. Despite a growing number of university-based and private sector initiatives, as well as national hydrogen policies and strategies in place, the public is not adequately informed of potential benefits and risks of electrolyser technologies and hydrogen. Investments in HySA CoCs and their work are known to only a small circle of stakeholders in academia and industry.

4. There is uncertainty about South Africa's potential entry and competitiveness in the international electrolyser market. Less than 30 per cent of survey respondents believed that the country is likely to be competitive in (and be subcontracted to produce) electrolyser technologies globally. According to some interviewees, regulatory hurdles associated with bureaucratic environmental impact assessments, poorly governed public procurement and slow certification processes could negatively impact the production and commercialization of green hydrogen technologies.

5. South Africa has a rich corpus of policies and instruments for the hydrogen economy, and for promoting energy-related R&I in general. The institutional landscape of public agencies is characterized by many implicit and explicit policies and regulations that impinge on R&I in green hydrogen and electrolyser technology development. Moreover, there seems to be low or weak policy coherence and implementation, with limited information or lack of evidence on policy effectiveness. The interviews reveal concerns that the Government lacks capacity to effectively undertake policy monitoring and evaluation. Overall, the NSI is weak and impedes the country's aspirations to enter and be competitive in the green hydrogen economy, in general, and commercialize electrolyser technologies in particular. Overall, this adversely affects the realization of HySA's objectives, the related goals of JET-IP and other policy goals.

6. Through the HySA strategy and other related programmes, South Africa's researchers and policymakers participate in international conferences and programmes on green hydrogen technologies. The country is an active participant in international partnerships for hydrogen-related R&I, including forging bilateral partnerships with several countries such as Germany, Japan and the Kingdom of the Netherlands. Some of these countries support R&I in electrolysers for green hydrogen production in South Africa.

7. Overall, there are scant assessments and studies on the social impacts of electrolyser technologies for green hydrogen production in South Africa. During the interviews and the focus group discussions, questions on social impacts were not answered, or participants did not feel they

There is uncertainty on domestic potential for competitive electrolysers production

Social impacts are poorly understood, but environmental impacts of hydrogen are known

could give their opinions on whether and what social impacts green hydrogen and electrolysers would have on local communities and women. An interviewee suggested that programmes such as HySA need to have a strong focus on gender issues. The same interviewee cautioned against a technology-push approach by a hydrogen policy, and suggested the need to review existing policies and programmes to determine their social impact, with emphasis on gender considerations.

8. Several interviewees and participants in the focus group discussion noted that green hydrogen technologies, including different types of electrolysers, can cause environmental harm and exacerbate problems of water scarcity. As stated earlier, the production of green hydrogen requires significant amounts of water, and therefore risks increasing water shortages in the country. To address such challenges, there is a need to integrate environmental impact assessments in selecting the location(s) of green hydrogen projects in the country.

9. Overall, there is no pronounced opposition to electrolyser technologies and green hydrogen in South Africa. However, a significant number of participants in this TA study were uncertain about the technologies' potential benefits and risks, as well as whether the country could become a global player in the green hydrogen economy and producer of electrolysers for local and global markets.

There were two main limitations of the TA process that should be noted. The first relates to the weak intra- and inter-departmental coordination of the TA process. There was limited engagement of some relevant government departments that were invited by the DSTI to participate in the steering committee. The second limitation was poor public engagement in the TA. Due to budgetary constraints, the DSTI and UNCTAD faced challenges in organizing workshops and holding in-person public engagements as part of the TA. Consequently, the TA process became largely expert-led and technocratic, with limited participation by civil society.

5. Recommendations

Given the challenge of identifying the broad economic, social and environmental implications of developing electrolysers and green hydrogen, the TA study was seen as largely exploratory. Recommendations focus on the need to strengthen hydrogen research and innovation in the country, the need for comprehensive socioeconomic feasibility studies of electrolyser technologies, the need for social and environmental impact assessments, enhancing public awareness and understanding of electrolysers and the desirability of institutionalizing TA taking into account the lessons learned from the pilot project.

This TA study is largely exploratory in nature. It is the first one of its kind to be conducted on electrolysers for green hydrogen production in South Africa. As stated earlier, it is part of a larger UNCTAD project aimed at building national capacities for TA to inform national STI policymaking. Based on the findings and the TA process itself, this section presents a set of recommendations. The first set of recommendations relate to strengthening capacity for the production of electrolyser technologies for green hydrogen production in the country. The second set focuses on how to institutionalize and build capabilities for the design and implementation of future TAs in South Africa.

Building capacity for developing electrolyser technologies for green hydrogen production in South Africa

Strengthen hydrogen research and innovation in the national system of innovation

The initial set of policy recommendations, pertaining to strengthening hydrogen-related R&I in the NSI, focuses on two main aspects: 1) enhancing leadership and governance, and 2) improving policy coherence and effectiveness.

First, the Government of South Africa has demonstrated executive commitment and policy leadership for the hydrogen economy in general. This is manifested in the many policies and programmes instituted by the Government over the 17 years since 2007, with the adoption of the HySA strategy followed by the Hydrogen Society Research Development and Innovation Roadmap approved by the Cabinet in 2021. The country has normative as well as techno-scientific foundations for building a hydrogen economy, including developing and commercializing electrolysers and other hydrogen-related technologies. However, the different policy initiatives scattered across various government departments, universities and science councils need to be consolidated. And it is important for stronger political leadership and engagement in driving the green hydrogen agenda. In this regard, the following are recommended:

- The Government should consider vesting responsibilities for coordinating hydrogen-related policies and

Electrolysers and green hydrogen research and innovation need strengthening programmes in an existing agency with a view to building synergies among different initiatives and actors in the NSI and exploiting economies of scale. For this purpose, a mapping of the different responsible agencies should be conducted.

Further work is needed on economic feasibility and impacts

- The parliamentary portfolio committees for energy, STI, trade and industry, and parliament as a whole, should be actively engaged in hydrogen-related policy and decision-making. In particular, they need to review existing policies and develop appropriate regulations. Capacity-building to enhance lawmakers' awareness or understanding of the benefits and potential risks of green hydrogen is needed.

Greater policy coherence and coordination is desirable

Second, there is consensus that there are policy incoherencies and limited coordination in the implementation of many of the policies and instruments covering energy and STI, including the HySA and other strategies, such as the recently adopted Hydrogen Commercialization Strategy. To address this challenge, the following actions are recommended:

- Develop a compendium of policies and instruments for an STI-energy nexus to ensure policy coherence and effective governance of the hydrogen energy sector. Such a compendium could be developed by the NACI.
- Conduct comprehensive assessments of the effectiveness of the relevant policies and instruments to identify which policies work, which instruments are effective for particular policy goals, and how energy technology policies in the country could be made more effective.
- Build energy technology policy literacy across the government and the public by organizing workshops and media sessions about specific policy goals and actions. This would help to improve understanding and support for implementation of specific hydrogen energy policies in the country.

Evidence on social impacts in particular requires further investigation

Conduct comprehensive socioeconomic feasibility and international competitiveness studies of electrolyser technologies

To inform public opinion and effective government policy on why to invest in electrolysers for green hydrogen production, more localized and technology-specific economic studies are needed. As the review of the literature and interviews illustrated, there are no economic studies on the commercial feasibility of different electrolyser technologies in and for South Africa. It is recommended that the NACI, in collaboration with relevant institutions, commission specific assessments on the economic feasibility of different electrolysers. Such assessments would help make the case for investment in electrolysers for green hydrogen production, and may be used to build public support for the technology. They could also be used by the Government to:

- Develop subsidies and other fiscal policy instruments to incentivize local private sector and SMME participation in electrolysers for green hydrogen production, development and commercialization; and
- Develop clear pathways for commercializing electrolysers for green hydrogen production.

Conduct social and environmental impact assessments

As stated in the analysis of findings, there is scant information on the social and environmental impacts of different electrolysers in different contexts. It was not possible to gather clear opinions about green hydrogen and electrolysers' social impacts in terms of benefits and risks for women, the youth and local communities. It is therefore recommended that the NACI conduct specific studies on social and environmental impacts of different electrolyser technologies taking into account different regional and socioeconomic contexts. Such studies need to be transdisciplinary to enable the gathering of relevant data on different aspects of South Africa's socio-technical systems.

Increase public awareness and understanding of electrolysers

To enhance public understanding and awareness of green hydrogen technologies and build strong constituencies to support continued investments in programmes for implementing HySA and related initiatives, workshops and other outreach activities using various media, including social media, should be launched and implemented. Accessible guides and readers on green hydrogen technologies should also be developed and used by HySA and other programmes to sensitize the public about the green hydrogen economy and different related technologies.

Institutionalizing and building technical assessment capabilities in South Africa

There is need to institutionalize TA in both the energy sector and other sectors, as well as for other new technologies in South Africa. This pilot TA offers several useful lessons on how to organize, design, conduct and use TA. The DSTI should document lessons learnt from the pilot study to inform future TA exercises. Specific issues to consider are: (a) Where should a TA be coordinated from, or which institutional mechanisms are appropriate for coordinating TA in the South African context to ensure that there is multi-stakeholder buy-in and engagement? (b) How can TA exercises be properly resourced or budgeted for, and obtain political authorization? (c) What are the cost-effective ways and means of ensuring adequate public engagement so that TAs are genuinely participatory?

South Africa should also consider participating in international TA programmes and networks to learn how to conduct and use TAs. As part of its participation in international hydrogen programmes, the Government should consider the following:

- The NACI should coordinate, manage and initiate TAs in the future so as to elevate this function to the Coordination Structure that reports to the Inter-Ministerial Committee on the Hydrogen Economy as approved by the Cabinet in February 2024.
- Establish partnerships with countries such as Germany, Japan and the Kingdom of the Netherlands, as well as with institutions or organizations such as the European Union and others, to conduct TAs.
- Developing a multi-year national TA capacity-building programme that would include benchmarking exercises for policy learning, training workshops or courses, cross-departmental TA exercises, and postgraduate TA fellowships in local universities.

> The pilot TA provided a learning experience, which should be expanded and institutionalized

6. Tentative action plan

Policy recommendations	Implementation	Responsible agencies	Expected outcome	Time frame/ resources
Strengthen hydrogen-related R&I in the NSI	Establish a national committee. Develop a compendium of existing hydrogen-related policies and programmes	DSTI, NACI	Better coordinated governance of hydrogen initiatives; increased economies of scale in the hydrogen economy	tbd
Conduct comprehensive socioeconomic feasibility studies of electrolyser technologies	Commission independent studies. Conduct workshops on socioeconomic impacts of using electrolysers for green hydrogen production	Ministry of Electricity and Energy, Ministry of Minerals and Petroleum Resources, DSTI, NACI	Improved knowledge of economics of electrolysers; and better economic targeting of investments in R&I	tbd
Conduct social and environmental impact assessments	Develop a framework for assessments. Commission independent assessments. Conduct public workshops on impacts	Department of Environmental Affairs, non-governmental organizations, DSTI	Improved knowledge of social and environmental impacts; and increased public support for, and confidence in, electrolyser technologies	tbd
Public awareness and understanding of electrolysers	Develop a manual and briefing materials. Integrate hydrogen in school curricula. Organize public workshops and briefing sessions. Use media to raise public awareness	DSTI	Improved public understanding and support for electrolyser technologies	tbd
Institutionalizing TA in South Africa	Conduct benchmarking and studies on best practices in TA Develop a national TA strategy and guidelines Establish a national committee or inter-agency task force for TA	DSTI, NACI	Strengthened capabilities for undertaking TAs	tbd

Note: The time frame and resources needed for implementation are to be determined.

References

Carmo M, Fritz DL, Mergel J and Stolten D (2013). A comprehensive review on PEM water electrolysis. *International Journal of Hydrogen Energy*, 38(12): 4901–4934.

Chatenet M, Pollet BG, Dekel DR, Dionigi F, Deseure J, Millet P and Schäfer H (2022). Water electrolysis: From textbook knowledge to the latest scientific strategies and industrial developments. *Chemical Society Reviews*, 51(11): 4583–4762.

Hydrogen Council (2021). Hydrogen for net-zero. Hydrogen Council Report, November. Pretoria.

IEA (2019). South Africa energy outlook. In: *Africa Energy Outlook 2019*. International Energy Agency. Paris.

IMF (2024). Regional Economic Outlook: Sub-Saharan Africa, April 2024. IMF, Washington.

Republic of South Africa (2019). *White Paper on Science, Technology, and Innovation: Science, Technology and Innovation Enabling Inclusive and Sustainable South African Development in a Changing World:* xii. Department of Science and Technology, Pretoria.

Republic of South Africa (2021). *The South African Energy Sector Report 2021*, Department of Mineral Resources and Energy, Pretoria.

Republic of South Africa (2022). Green hydrogen commercialisation strategy for South Africa, Final report, 30 November 2022. Department of Trade, Industry and Competitiveness, Pretoria.

Roos T, Chauke M, Oloo F and Mbatha L (2022). *EU-South Africa (EU-SA) Partners for Growth*: Powerfuels, 2: Stimulating domestic hydrogen consumption opportunities in South Africa. GFA Consulting Group GmbH in partnership with DNA, ECDPM – European Centre for Development Policy Management and Eurochambers. Available at: https://www.euchamber.co.za/wp-content/uploads/2022/01/Stimulating-domestic-hydrogen-consumption-opportunities-in-South-Africa-January-2022-1.pdf.

University of Cape Town (2021). Technical analysis to support the update of South Africa's first NDC's mitigation target ranges. University of Cape Town, Cape Town.

Annexes

Annex 1: List of steering committee and expert group members

- Ms Mmampei Chaba, Chief Director, Multilateral Cooperation and Africa – Chair of the Steering Committee
- Dr Mwana wa Kalaga Mbukani, University of Pretoria (Expert)
- Dr Neville Smith, South African National Energy Development Institution (Expert)
- Dr Tozamile Rubuluza, Technology Innovation Agency (member, Steering Committee)
- Mr Mbangiseni Mabudafhasi, DSTI (Member, Steering Committee)
- Dr Cosmas Chiteme, DSTI (Member, Steering Committee)
- Professor Josephine Masango, University of Cape Town (Expert)
- Professor John Ouma Mugabe, University of Pretoria (Expert)
- Professor Anastassios Pouris, University of Pretoria and Icon (Expert)

Annex 2: Survey questionnaire distributed to conference participants

A: BACKGROUND INFORMATION

The projected ramp-up of the green hydrogen economy will go hand in hand with a significant expansion of electrolyser capacities in South Africa. Europe envisages having 40 gigawatts (GW) of electrolysers by 2030, and Germany alone plans 10 GW. South Africa combines deep technical and capital markets with world-class conditions for generating renewable electricity through solar and wind power, which are critical drivers in the production of green hydrogen. South Africa aims to deploy 10 GW of electrolysis capacity in Northern Cape by 2030, and produce about 500 kilotons of hydrogen annually by 2030. This growth is forecast to create 20,000 jobs annually by 2030 and 30,000 by 2040. This implies enormous opportunities for South Africa to build a domestic electrolyser manufacturing industry. Polymer electrolyte membrane (PEM) electrolysers are one of the dominant technologies in this application field. One core input in PEM electrolysers is platinum group metals, in which South Africa has dominated the global market since the end of the 2000s. South Africa has followed a strategy to develop technological competencies around PGMs, mainly for fuel cell and hydrogen production. The overarching question for this first survey is to conduct a technology assessment (TA) for electrolysers in South Africa. The survey is directed at experts from the government, public research insitutions (universities), the private sector, industry, civil society and from large and small companies. None of the questions implies that the respondents might have to reveal core information. Should you require advice completing the questionnaire, don’t hesitate to contact Mr Selby MODIBA at the UNCTAD/DSI Project Secretariat of the Department of Science and Innovation (DST),. His cell number is: ….., and fixed line phone number is: ….; or e-mail him at: …..

B: INSTITUTION PROFILE INFORMATION

1. Date:				
2. Type of institution:	Government Ministry	Parastatal/ semi- government	Private sector/ industry	Research institution

In February 2022, the South African Hydrogen Society Roadmap (HSRM) was published by the South African Department of Science and Innovation, marking an important milestone in the launch of South Africa's hydrogen economy. The HSRM was developed by the Department of Science and Innovation, Hydrogen South Africa (HySA), jointly with government and industry stakeholders. It focuses on national ambitions, sector prioritization, the overarching policy framework, and the macroeconomic impact of the hydrogen economy throughout South Africa. The roadmap is aligned with the country's Integrated Resource Plan, the Integrated Energy Plan and the Renewable Energy Policy, all of which acknowledge the critical role of hydrogen in South Africa's just energy transition, which aims for net zero emissions by 2050.

Q1: If you look to 2030, do you assume South Africa will be a relevant supplier of electrolysers and elements (e.g., membranes) to domestic, regional and global markets?

	Not at all	Not Likely	indifferent	Maybe	Yes
Domestic market					
Regional (African) market					
International market					

Q2: Should South Africa be subcontracted in the coming years by international manufacturers of electrolysers to supply specific components?

	Not at all	Not Likely	indifferent	Maybe	Yes

Q3: What do you see as the main advantages of South Africa in the international electrolyser market?

	Very important	Important	indifferent	Not so important	Of no importance
Qualified personnel					
Availability of PGMs					
Technological knowledge					
Other					

Q4: What do you see as the main disadvantages of South Africa in the international electrolyser market?

	Very important	Important	indifferent	Not so important	Of no importance
Energy costs and security					
Lack of specific qualifications					
Other:					

Q5: What should be done to strengthen knowledge creation and application related to electrolyser technologies in South Africa?

	Very important	Important	indifferent	Not so important	Of no importance
Increase research capacities at universities and research councils					
Improve relations between public research and the business community					
Initiate programmes to promote the formation of new businesses in electrolysers and related technologies					
Attract foreign direct investment in electrolysers and related technologies.					
Promote internationally South Africa's science and technology related to electrolyser technologies					
Strengthen local and regional synergies in the hydrogen valleys and hubs					

Q6: Do you fear that a strong focus on hydrogen/electrolyser technologies could imply that other important science and technology fields get inadequate funding/attention?

	Not at all	Not Likely	indifferent	Maybe	Yes

Any comments on the Government's desire to support electrolyser technologies?

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