HOW CAN HOST COUNTRIES BENEFIT FROM INCREASED DEMAND FOR MINERALS DRIVEN BY THE LOW-EMISSION TRANSITION?

Framework Step:

STEP 1. Adopt a comprehensive long-term vision and implementation strategy to build competitive and diversified economies and create in-country shared value out of natural resources.

1. A What can host governments do?

- Enhance economic competiveness by effectively managing the revenue and spending from and for extractives. In particular, re-invest resource revenues in other sectors to foster diversification efforts and improve capacity to compete in segments of higher value added, with a view to avoiding exacerbating dependence on exports of raw materials.

STEP 2. Build an empirical basis to inform decision making through an inclusive participatory process

2. A What can host governments do?

- Classify systemic value chain links to show the nature of potential interconnections with other products and services in the renewable and non-resource sectors to identify segments with high growth potential. Take appropriate measures so that the extractives sector becomes a catalyst and an anchor for growth, diversified economic activity, and integrated territorial development, creating linkages through which knowledge, inputs, and labour can flow.

STEP 4. Support and contribute to innovation leading to new products and services

4. A What can host governments do?

- Identify changing trends in global consumption and production patterns (progressive ore grades decline and increasing labour, transport, energy, processing, capital/ equipment costs), changes to end uses for minerals (innovation in final products), and carbon emissions trading.
- Support research and development efforts to identify, adapt, and transfer technology, making sure that these efforts are responsive to private sector demands. In doing so, develop ties with local universities, public research institutions, and participate in collaborative initiatives.

4. C Host governments, extractives industries and civil society can work together to:

- Engage in co-operation based on project life cycle analysis, covering the entire value chain and offering the opportunity to build on best practices of several sectors.

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Tags:

☐ local employment
☐ local supplier participation and development, including SMEs
☐ marginalised groups (women, indigenous people)
☒skills development and upgrading
☐ access to credit
☐ shared infrastructure (transport, water, power)
☒ technology transfer
☒ innovation
☒ economic diversification
☒ Other: Low Emission Transition

Problem Statement:

South Africa's mining sector remains important to the country's economy, contributing on average 8% to GDP over the past decade (South Africa Chamber of Mines, 2016). South Africa is also host to 75% of the world's known reserves of Platinum Group Metals (PGM), the key catalytic material used in most fuel cells, including those in electric vehicles, and a growing number of industrial processes and power generation technologies globally. PGMs – palladium, rhodium, iridium, osmium, and ruthenium in addition to platinum – are known for their purity, high melting points, unique catalytic properties and resistance to corrosion.

The concentration of PGMs presented an opportunity for South Africa to capture a significant portion of the nascent international hydrogen fuel cell technology (HFCT) market. By establishing national Research and Development (R&D) capabilities along the technology's value chain, value could be generated in-country through multiple entry points into the hydrogen fuel cell market. By exporting added value PGM materials, components and products, PGMs could potentially contribute to South Africa's economy through knowledge transfer, technology commercialisation, improved manufacturing capacity and job creation.

In addition to harnessing the country's mineral endowments to promote the hydrogen economy and to help reduce South Africa's dependence on raw material exports, the high concentration of PGMs also presented an opportunity to promote the domestic development and consumption of clean energy sources. The vast majority of South Africa's domestic energy consumption – over 75% – is coal-based, and as of 2014 only 1% of domestic supply came from renewables (IEA, 2014). Viable alternative renewable energy sources therefore also needed to be sought and developed for domestic consumption to reduce greenhouse gas (GHG) emissions and to help the country meet its commitment to global emissions reduction targets.

Parties Involved:

- Department of Science and Technology (DST)
- National Research Foundation (NRF)
- South African Agency for Science and Technology Advancement (SAASTA)
- Department of Mineral Resources (DMR)
- Department of Energy (DoE)
- Department of Trade and Industry (DTI)
- University of Cape Town, North-West University, and the University of the Western Cape
- Council for Scientific and Industrial Research (CSIR)
- Mining firms operating in South Africa, including Anglo American Platinum and Impala Platinum (Implats)

Common Ground:

When designing the programme to support R&D efforts around hydrogen and fuel cell technologies and renewable energy use, the South African government sought to ensure efforts were responsive to private sector realities. Fostering collaborative initiatives with industry as well as academic and public research institutions likewise presented an opportunity for the initiative to facilitate knowledge transfer and to improve domestic institutional capabilities. The South African Government's investment in HFCT and related technologies also aimed to exploit potential human capital gains, as the skills and expertise required for the hydrogen sector would lead to job creation along the value chain as global demand for the technology grows (SAASTA, 2015).

Actions Taken:

Hydrogen fuel cells use hydrogen or hydrogen-rich fuel – such as natural gas, biogas, methanol and oxygen – to generate electricity and heat from the electrochemical reaction between hydrogen, platinum and oxygen, reducing GHG emissions compared to more conventional electricity generation technologies.

South Africa's Hydrogen and Fuel Cell Technologies (HFCT) Research, Development and Innovation Strategy was launched as Hydrogen South Africa (HySA) in 2008. Led by the Department of Science and Technology (DST), the long-term, 15-year programme was structured around three 5-year phases. Following an initial government budget allocation of R400 million (approximately USD 30 million) during the launch phase from 2007 to 2011, HySA subsequently received funding equivalent to approximately USD 7 million per annum.

The goal of HySA is to facilitate the establishment of a South African HFCT industry that can capture a significant share of the global market, with a national target set at supplying 25% of global PGM content to the international fuel cell markets by 2020. For South Africa to become a global leader in fuel cell technology, however, increased domestic R&D capacity was required to address the technological challenges involved in developing commercially viable HFCT. The DST therefore established three Centres of Competence, each with a unique mandate to develop expertise and to address the technological challenges of the programme. These are: HySA Catalysis, HySA Infrastructure and HySA Systems.

To achieve the programme's objectives, the three HySA Centres of Competence formed a national network through collaboration with institutions and partners from the R&D sector, higher education, as well as industry. The three Centres are based in, or co-hosted by, a university research institution and were structured to address different commercial and technological or academic objectives of the R&D strategy. The work of the three Centres is also coordinated by a Programme Office, based in Mintek. HySA Catalysis is mandated to develop catalysts and fuel cell components early in the value chain, and is co-hosted by the University of Cape Town and South Africa's national mineral research organisation, Mintek. HySA Infrastructure, co-hosted by the Council for Scientific and Industrial Research (CSIR) and North-West University, is mandated to develop applications and solutions for small- and medium-scale hydrogen production and storage. HySA Systems hosted by the University of the Western Cape is in turn mandated to develop prototypes and products for the market.

The criteria used for selecting projects by each of the Centres included alignment with the DST strategy as well as industrial interest and potential for commercial application; the opportunity to leverage local technologies; synergy with international initiatives; the opportunity for knowledge production and human resource development; and the opportunity for spin-off technologies and local product, business and technology development. In terms of specific projects, HySA Catalysis became responsible for portable power development, HySA Systems for the combined heat and power (CHP) programme, and for hydrogen fuelled utility vehicles. HySA Infrastructure was responsible for hydrogen fuelling and storage options, hydrogen production from renewable energy, as well as distribution, safety, and codes & standards.

The Programme also sought to address the need for small-scale fuel cell applications such as portable, small-scale power backup, and household fuelling stations, as well as medium-scale hydrogen production.

In managing implementation of the Programme, each of the three 5-year phases includes an integrated monitoring and evaluation stage, the results of which were then used to shape the direction, priorities and actions taken in the subsequent phase. Phase 1 of the HySA programme (from 2008-09 to 2013-14) was dedicated to initiating research and development activities, including the sourcing of necessary expertise and infrastructure. This Phase was reviewed in 2014-15 by an independent panel, comprising international experts in hydrogen, as well as local experts who could advise on the local economic context. Gaps identified in this review, published in a report, helped to shape the priorities and focus of Phase 2. The report indicated, for example, that new, competing hydrogen technologies were becoming active, and that the real market potential of hydrogen technology was shifting to the energy and mobility sectors, more narrow in scope than the originally identified potential sectors covering energy, transportation, manufacturing and jewellery. In order therefore to channel the programme's limited resources productively, the report suggested ways in which the programme might focus on competencies most relevant to the country's economy, above all developing technologies to facilitate access to secure and affordable alternative energy sources.

Phase 2 of the HySA programme commenced in 2014-15 and will run through to 2018-19, with a focus on developing the capabilities necessary to demonstrate the technology for pilot markets. As with Phase 1, this phase will also be closed with a formal review by an independent panel of international and local experts.

The priorities and focus of Phase 3 will therefore be shaped by these results. As of 2017, the issues being prioritised by the Programme were increasing the number of South African-developed hydrogen technologies and systems active in the national and international markets, along with the necessary support infrastructure; the development of the policies and regulations necessary to permit the widespread use of hydrogen fuel cells in the national market, including distribution, safety, and codes & standards, and communication and publicising of hydrogen fuel cells to the public.

Obstacles:

- South Africa faces a number of challenges, such as a skills deficit, a lack of electricity supply security, and labour relations challenges. In 2014, for instance, the mining sector experienced lengthy strikes with a significant impact on the PGM sector in particular (Department of the Treasury, 2016), including lost revenues and wages.
- To ensure the highly skilled human capital required across different technologies and segments of the hydrogen fuel cell value chain were available, the country's knowledge base and capabilities needed to be improved, as well as existing capabilities mobilised.
- Key issues of high technology innovation include the risks of appropriation, and potential failure of the technology. While numerous countries, including the United States of America, Germany, Canada, Japan, China and South Korea are undertaking extensive research on hydrogen fuel cell technologies, development of the HFCT has been slower than anticipated (MISTRA, 2013). Given that PGMs, in particular platinum, are comparatively expensive, there is also the risk that new, less expensive technologies may be developed using alternative metals. This would limit the demand for PGMs and locally developed technologies from actors along the value chain, disrupting projected demand.
- To become a global leader in the fuel cell technology required strategic investments to address technological and capacity gaps in the country based upon a long-term vision, which brought with it risks such as stranded technology and infrastructure investments. The

programme's scheduled review structure at the end of each phase helped to ensure that such investments remained aligned with the objectives, context, including shifting demand for substitutes, and any emergent constraints facing the programme.

Enabling Factors:

- The combination of South Africa's extensive reserves of a unique group of minerals and the utility of such minerals in a nascent, cleaner energy value chain, potentially minimising the environmental impact of domestic energy production, provided an opportunity to develop a niche technology market. While mining, refining and export remain important to the country's economy, by developing an industrial cluster linking extraction to the manufacturing of value-added products, as well as the development of technology services that could be exported, signalled significant further potential for South Africa's PGM endowment.
- The programme benefitted a clear mandate and timeline: the 15-year project timeline was broken down into three, 5 year phases. This provided clear postmarks at which to conduct monitoring and evaluation and to adjust objectives, timelines and targets when needed. Each Phase was reviewed by an independent panel, consisting of international hydrogen technology experts – ensuring a global perspective on developments elsewhere – and local experts who could speak to the specific constraints and needs of South Africa. This has ensured that the long-term programme is able to adapt to shifting constraints and realities, such as the slower pace of development and uptake of HFCT.
- After identifying the relevant international expertise required by the programme, the HySa programme has been executed in partnership with local learning and research institutions, to facilitate knowledge and technology transfer relevant to other parts of South Africa's economy, including technical services for domestic use as well as export. Universities and science councils in South Africa were given clear mandates to execute discrete components of the programme and strategy. These institutions were then required to report to the Department of Science and Technology, which implements and coordinates the Strategy on behalf of the whole of government.
- The government also invested in a communications strategy, the HySA Public Awareness, Demonstration and Education Platform, to ensure public engagement with the strategy. Likewise, steps were taken to ensure cross-government coordination. The Department of Energy for instance implemented a policy encouraging renewable energy deployment, linking therefore with HySA's goal to develop local, cost-competitive hydrogen generation solutions based on renewable resources, and the initiative also received support from the Department of Environmental Affairs' National Climate Change Response Policy.

Lessons Learned:

- This is a strong example of how host governments can identify changing trends in global consumption and end uses for minerals, and invest in and support research and development efforts to ensure opportunities resulting from technological advancements and the global low emission transition are mobilised in a way that facilitates technology and knowledge transfer. The Government sought to build South Africa's capacity for platinum value addition by developing manufacturing of platinum-containing technology capabilities. By engaging different government agencies and building capacity within multiple research institutions the Government sought to do so in a manner that systematically builds economic linkages and as a benefit to the wider economy. In particular, through knowledge transfer, technology commercialisation, improved manufacturing capacity and job creation.

- Now entering the final of its three 5-year phases, the HySA programme is also engaging with the needs of the private sector, including PGM producers that are adopting the technology in their own operations. This includes Anglo American and Impala Platinum (Implats). Implats is a PGMs producer that installed in 2017 a 8 MW Doosan fuel cell plant that utilises the locally developed fuel cell technology. This step was taken in line with the company's objective of taking its refinery, near Johannesburg, off-grid, a project that is being carried out in partnership with the Department of Trade and Industry, the Gauteng Industrial Development Zone and supported by the Ekurhuleni metropolitan municipality.
- To date, South Africa has limited fuel cell activity, so most customers are companies from abroad. Further collaborative initiatives with industry may help to reduce the delivered costs of hydrogen in-country.

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