ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED HENDRINA GREEN HYDROGEN AND AMMONIA FACILITY AND ASSOCIATED INFRASTRUCTURE IN MPUMALANGA

Socio-Economic Impact Assessment Report

Report for Hendrina Green Hydrogen and Ammonia Facility

Final Report

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Report prepared for:

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He has managed projects for various property and economic studies, such as integrated housing projects and socio-economic impact assessments. He has also facilitated a number of urban and rural renewal and development projects focusing on job creation opportunities and broadening the local economic base through investment attraction in bankable projects. Pierre currently serves as manager of infrastructure projects as well as of Urban-Econ in Mpumalanga and is responsible for the day-to-day operations of the office.

It can be declared that the Urban-Econ Development Economists has contributed independently during the course of this study and the completion thereof.

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1. INTRODUCTION

WSP Environmental was commissioned by **Enertrag South Africa** to undertake a Baseline Assessment for the proposed Hendrina Green Hydrogen Facility which is located in Hendrina situated in the Mpumalanga Province. As part of the specialist studies, it was determined that a **Socio-Economic Impact Assessment (SEIA)** was required. WSP Environmental subsequently appointed **Urban-Econ Development Economists** to conduct the SEIA process. This report seeks to assess the potential socio-economic impacts and has included recommendations to enhance the positive impacts and reduce the potential negative impacts of the project. This is done in order to enhance the foreseeable benefits of the development.

1.1. BRIEF DESCRIPTION OF PROJECT

ENERTRAG South Africa (hereafter "ENERTRAG SA") is a subsidiary of the German-based ENERTRAG AG, a hydrogen and renewable energy developer founded in 1992. ENERTRAG AG has an established track-record of renewable energy projects around the world, comprising over 100 wind turbines with an installed capacity of over 760MW, and over 500 employees. Current Projects are in Germany, United Kingdom, France, Poland, Bulgaria and Belarus.

ENERTRAG SA was established in 2017, with the intention to investigate and develop renewable energy projects in South Africa. The transition from coal-based energy supply to renewables in the Country is inevitable, as coal resources are depleted, coal-based power stations reach the end of their economic life and considering international obligations and commitments to reduced emissions. The Project development area is blanketed with numerous coal prospecting and mining rights. Coal mining and energy derived from coal mining is the likely alternative to the Project. ENERTRAG SA are developing renewable energy projects to contribute to the Just Transition that promises to decarbonise South Africa's energy sector and aims to:

- replace coal-based electricity with renewable electricity
- decarbonise different sectors of the economy through the replacement of fossil-based hydrogen and ammonia with green hydrogen and ammonia.

ENERTRAG SA proposes to develop the Hendrina Renewable Energy Complex, the complex comprises of five separate projects. The projects are:

- Hendrina North Wind Energy Facility (up to 200MW) over 3600ha;
- Hendrina South Wind Energy Facility (up to 200MW) over 2900ha;
- Hendrina North Grid Infrastructure (up to 275kV) – 15km;
- Hendrina South Grid Infrastructure (up to 275kV) – 16km;
- Green Hydrogen and Ammonia Facility (up to 25ha).

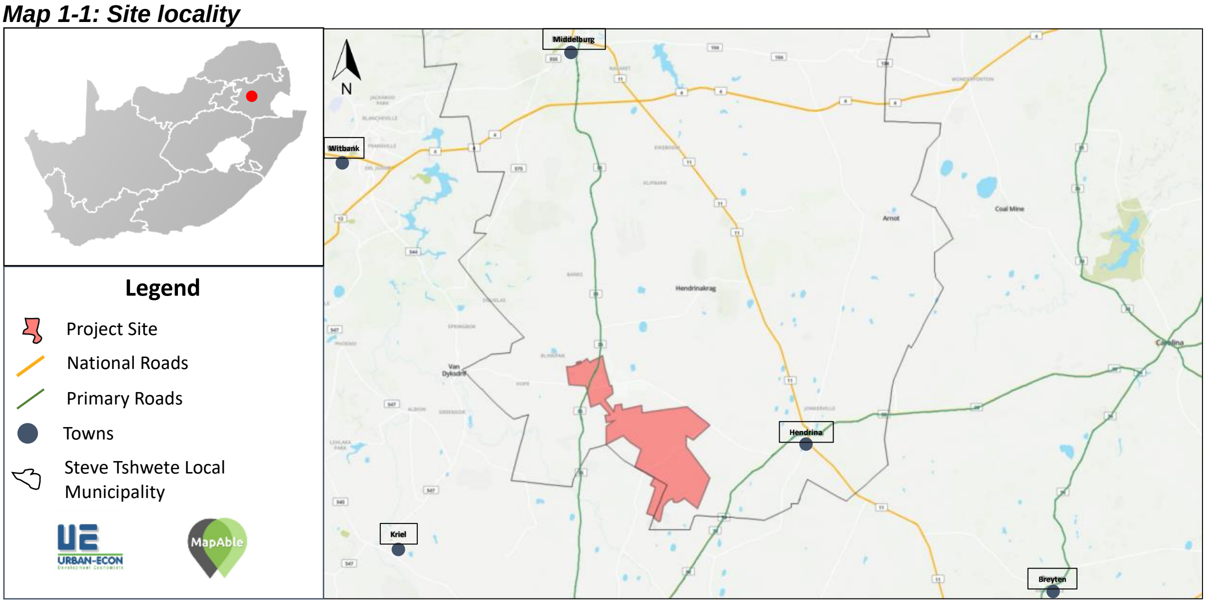
Each of these projects are being assessed, as part of the Complex development, and involve the undertaking of Listed Activities identified in the Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) and as such require an Environmental Authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) before being undertaken.

This report pertains specifically to the **Green Hydrogen and Ammonia Facility ("the Project")**.

1.2. PROJECT LOCATION

The Project is located 17km west of Hendrina, in the Steve Tshwete Local Municipality, of the Nkangala District Municipality, Mpumalanga Province (Map 1-1).

Map 1-1: Site locality



Source: (MapAble, 2021)

Three alternative Project locations are being investigated for the development of the proposed Project:

Site Alternative 1 is located on Portion 3 of the Farm Dunbar 189IS, at the site of an old abandoned farmyard and has three powerline options from the associated Hendrina North and South Wind Energy Facilities ("WEF") as follows:

- Powerline option 1 is up to 2km in length, to the Hendrina North WEF substation Option 1 on Portion 1 of the Farm Dunbar 189IS;
- Powerline option 2 is up to 7km in length, to the Hendrina North WEF substation Option 2 on Portion 3 of the Farm Hartebeestkuil 185IS;
- Powerline option 3 is up to 1.5km in length, to the Hendrina South WEF substation on Portion 3 of the Farm Dunbar 189IS.

Water supply to the Site:

- constructing a new pipeline (up to 16km) from the Komati Power Station

Site Alternative 2 is located on Portion 3 of the Farm Dunbar 189IS and Portion 18 of the Farm Weltevreden 193IS, adjacent to the proposed Hendrina South WEF substation and has three powerline options from the associated wind farms as follows:

- Powerline option 1 is up to 3km in length to the Hendrina North WEF Option 1 substation on Portion 1 of the Farm Dunbar 189IS;
- Powerline option 2 is up to 8km in length to the Hendrina North WEF substation Option 2 on Portion 3 of the Farm Hartebeestkuil 185IS;
- Powerline option 3 is up to 0.5km in length to the Hendrina South WEF substation on Portion 3 of the Farm Dunbar 189IS;

Water supply to the Site:

- constructing a new pipeline (up to 16km) from the Komati Power Station

Site Alternative 3 is located on Portions 14 and 15 of the Farm Weltevreden 193IS and has three powerline options from the associated wind farms as follows:

- Powerline option 1 is up to 5km in length to the Hendrina North WEF Option 1 substation on Portion 1 of the Farm Dunbar 189IS;
- Powerline option 2 is up to 5km in length to the Hendrina North WEF substation Option 2 on Portion 3 of the Farm Hartebeestkuil 185IS;
- Powerline option 3 is up to 7km in length to the Hendrina South WEF substation on Portion 3 of the Farm Dunbar 189IS.

Water supply to the Site:

- constructing a new pipeline (up to 16km) from the Komati Power Station

The Project, and associated water pipeline and powerlines, is proposed over the following farm portions.

Table 1-1: Farm Portions affected by the Project Alternatives

Parent Farm	Farm No	Portion No
Facility Alternative Site 1		
Dunbar	189IS	3
Facility Alternative Site 2		
Dunbar	189IS	3
Weltevreden	193IS	18
Facility Alternative Site 3		
Weltevreden	193IS	14
Weltevreden	193IS	15
Associated pipelines and powerlines may affect portions of the following land parcels:		
Bultfontein	187IS	1
Bultfontein	187IS	2
Bultfontein	187IS	3
Bultfontein	187IS	4
Bultfontein	187IS	6
Bultfontein	187IS	10
Bultfontein	187IS	14
Dunbar	189IS	0
Dunbar	189IS	1
Dunbar	189IS	2
Dunbar	189IS	4
Dunbar	189IS	5
Dunbar	189IS	6
Dunbar	189IS	7
Geluk	26IS	6
Geluk	26IS	7
Hartebeestkuil	185IS	3
Komati Power Station	56IS	0
Wilmansrust	47IS	1
Wilmansrust	47IS	3
Wilmansrust	47IS	9

1.3. SCOPE AND PURPOSE OF THE PROJECT

The socio-economic impact assessment contains information that together with other specialists allows assessment of the project from a sustainable development perspective and assists in identifying "the most practicable environmental option" that provides the "most benefit and causes the least damage to the environment as a whole, at a cost acceptable to society", in the long-term and the short-term. In light of the above and in line with the Environmental Impact Assessment (EIA) Regulations of 2014 as well as the new NEMA GN 320 regulations, the purpose of the socio-economic impact assessment is to assess the need and desirability of the project. It specifically aims to ensure that the project, if approved, provides for justifiable social and economic development outcomes. As such it aims to:

- identify, predict and evaluate geographical, social, economic and cultural aspects of the environment that may be affected by the project activities and associated infrastructure
- advise on the alternatives that best avoid negative impacts or allow to manage and minimise them to acceptable levels, while optimising positive effects

Based on the understanding of the project's objectives, the scope of work for the socio-economic specialist is outlined in the following list.

- Delineate the zone of influence in consultation with other specialists on the team
- Determine the affected communities and economies located in the zone of influence and identify sensitive receptors and beneficiaries within the delineated study area, i.e. people, land uses and economic activities that could be directly or indirectly negatively affected by the proposed project or benefit from it
- Determine the data required to assess potential impacts and respond to the questions outlined in the guidelines related to needs and desirability assessment
- Review secondary data and assess data gaps
- Engage with the environmental practitioner, other specialists on the team and the client to gain necessary background on the project
- Conduct a site visit and collect primary social and economic data (through personal or telephonic interviews) of the parties that may be directly or indirectly be affected (positively or negatively) by the proposed project to address data gaps
- Create a socio-economic profile of the potentially affected and benefiting environment, which would then represent a status of the environment under the "no-go" alternative and would be used to assess the potential changes ensued from the proposed project
- Quantify the potential positive and negative social and economic effects of the proposed development on the local and regional economic activities
- Evaluate the potential positive and negative impacts following the environmental specialist's methodology
- Assess cumulative impacts
- Develop a mitigation plan by proposing mitigation measures for negative effects and enhancement measures for positive impacts

1.4. DELINEATION OF THE STUDY AREA

Study area delineation depends on the type of economic activity that is analysed and the perceived spread of economic impacts that are expected to be generated from the project during both the construction and operation phases. The municipal area where the site is located (Steve Tshwete LM) is likely to experience some direct, indirect and induced impacts resulting from the activities on the site; however, it is unlikely that a local economy can be sufficiently diversified to supply all materials and services and support construction and operational activities from start to finish. Economic impacts therefore tend to extend far beyond municipal boundaries and spread throughout the entire national economy.

1.5. PRIMARY, SECONDARY, AND TERTIARY STUDY AREA

As indicated earlier, the footprint of the Project will stretch across several farm portions. The potential zone of influence of the proposed project, will not be limited to these farm portions but, will extend beyond the boundaries of the project site due to the potential socio-economic impacts. As such, the following zones of influences are delineated for the purpose of the analysis:

- Primary zone of influence: For the purpose of the analysis of the impact on property values and the agricultural industry, as well as the assessment of potential local economic impacts that could ensue from the project, the primary zone of influence is determined to be Steve Tshwete.
- Secondary and tertiary zones of influence: Economic benefits and impacts will not be limited to the site or the nearby towns and settlements only. Most of the goods and services that will be purchased for the construction and will be required for operation of the Project will be secured from outside the primary zone of influence and specifically from areas such a Middelburg and Johannesburg.

  Therefore, the Mpumalanga and the rest of South Africa are defined as the secondary and tertiary zones of influence of the proposed project from an economic perspective.

1.5.1 Visually affected study area

The visual effects that will be experienced during the construction and operation of the Project are intrinsically linked to some of the socio-economic impacts that are considered in this report (such as sense of place, property and tourism impacts etc.). However, due to the large number of coal mines in the study area, the visual impacts of the Project will be minimalistic, as the area is already severely affected by the mining operations and black dust residing from the mines.

1.6. METHODOLOGICAL APPROACH

1.6.1 Economic Impact Assessment Method

Socio-Economic Impact Assessment studies are undertaken to determine, evaluate, and where possible, quantify the effects of an intervention. This intervention could be the expansion to an existing activity within the economy or the development of a new activity (i.e., the development of the Hendrina Renewable Energy Complex).

Socio-economic impacts generated by an intervention can be disaggregated in terms of the initial or direct impacts that occur when the intervention begins. Such impacts in turn trigger secondary and further flow-on rounds of impacts thereby creating a multiplier effect. This multiplier effect can be either positive or negative. In pure economic terms these impacts are expressed as indirect and induced effects, where:

- Indirect effects relate to the changes in economic indicators that are triggered along the upstream industries that supply goods and services to the intervention.
- Induced effects refer to the changes in economic indicators that are stimulated by changes in consumption expenditure of households that were directly or indirectly affected by the intervention.

In addition to the above, two additional types of socio-economic impacts can be distinguished. These include:

- Secondary impacts that are caused by the intervention, but that are further removed in distance or take a greater amount of time to materialise but, are still reasonably foreseeable. Secondary impacts generally relate to changes in land use patterns, economic performance, changes to the character of a community and property values in the vicinity of the interventions location.
- Cumulative effects are the results of incremental consequences of the intervention when added with other past, present, and anticipated future interventions. Cumulative effects consider the manner in which the impacts of a project may affect or be affected by other projects. Such effects are generally difficult to identify as they require a complete knowledge of local conditions and development plans, and accordingly are sometimes even more difficult to quantify.

Projection of the initial impacts and multiplier effects are usually done by employing an input-output model or a General Equilibrium Model. The use of these models in socio-economic impact assessments allows for the quantification of potential impacts in terms of a number of economic indicators such as production, Gross Value Added (GVA), employment and income. The scale of these impacts is dependent on the size and diversification of the economy under analysis which in turn determines the leakage. Secondary and cumulative effects can be identified through an expert opinion technique, consultations, development matrices and interviews. Such impacts can be difficult to quantify. Overall, a socio-economic impact analysis that includes the assessment of primary impacts, multiplier effects, secondary impacts and cumulative effects provides a comprehensive assessment of potential impacts. It furthermore assists in ranking the intervention using a methodology prescribed by the Department of Environment, Forestry and Fisheries (DEFF) (Chapter 4, Part 2: Basic Assessment; Appendix 6, Specialist Reports) (The Republic of South Africa, 1998; 2014).

The socio-economic impact assessment made use of the economic models based on the Mpumalanga Social Accounting Matrix (SAM) developed in 2011 and forecast to represent 2021 figures. The SAM is a comprehensive, economy-wide database that contains information about the flow of resources that takes place between the different economic agents, in this case the Mpumalanga economy. The selection of this model in the assessment is attributed to the expected spatial distribution of procurement during both the construction and operation phases of the project.

1.6.2 Impact assessment model

Appendix 2 of GNR 982, as amended, requires the identification of the significance of potential impacts during scoping. To this end, an impact screening tool has been used in the scoping phase. The screening tool is based on two criteria, namely probability; and, consequence, where the latter is based on general consideration to the intensity, extent, and duration. For further breakdown of the impact assessment methodology, please refer to Annexure B: Impact Assessment Methodology.

1.7. DATA COLLECTION

As part of the data collection process for the socio-economic impact assessment of the Project the following activities were undertaken:

1.7.1 Review of planning documents

In order to document the socio-economic context of the study area within the Steve Tshwete Municipality, a number of important documents or sources of information were reviewed, referenced, and used to inform the SEIA. These documents included, but are not limited to:

- Steve Tshwete Local Municipality SDF 2010
- Steve Tshwete Local Municipality LED 2016-2021

1.7.2 Literature review

In order to substantiate the findings of the socio-economic impact assessment a number of secondary research documents have been considered as they relate to the proposed green hydrogen facility. These documents include academic journals and studies available through online publication or print media. It is intended that these documents substantiate the baseline profile, provide for benchmarking in the industry, while at the same time provide context to the project.

Interviews with selected real estate agents and accommodation owners/representatives in selected areas were conducted electronically and a list of engagements are located in the respective sections.

1.7.3 Interviews with stakeholders

Targeted and structured surveys were undertaken as part of the SEIA to collect information from landowners whose property will be directly impacted by the development of the green hydrogen facility. These surveys were conducted electronically via Survey Monkey between July 2021 and August 2021. These surveys formed the basis of the primary data collection and assisted with the gathering of baseline information as well as establishing the stakeholder’s perceptions, interests, and concerns. A list of individuals contacted can be found in Appendix A.

2. POLICY AND PLANNING ENVIRONMENT & NEEDS AND DESIRABILITY

This chapter examines the key legislation and polices relevant to the proposed development and includes a review of pertinent national, provincial and local polices that have a direct bearing on the development. Following this the chapter outlines the needs and desirability of such a development accordingly.

2.1. POLICY AND PLANNING ENVIRONMENT

The overall aim of this review process is to provide insight into the government's priorities and plans in terms of renewable energies. This assists in determining the relevance of the project with regard to the development objectives of the various spheres of government as well as in identifying potential developmental conflicts that the project might create. A brief review of the most relevant documents is provided in Table 2-1.

Table 2-1: Brief Overview of relevant policies

Policy	Key Policy Objectives	Source
National Policy: South Africa		
National Development Plan 2030	• Creating jobs and livelihoods • Expanding infrastructure • Transitioning to a low-carbon economy • Transforming urban and rural spaces • Improving education and training • Providing quality health care • Building a capable state • Transforming society and uniting the nation • Fighting corruption and enhancing accountability	(NPC, 2012)
New Growth Path Framework 2011	• Infrastructure investment • Main economic sectors as employment sectors • Seizing the potential of new economies • Investing in social capital and public services • Fostering rural development and regional integration	(South African Government, 2011)
Renewable Energy Vision 2030 South Africa	• Renewable energy as an exceptional source of flexible supply within the context of uncertain energy demand • Comprehensive renewable energy base will support a resilient South African future • A sustainable energy mix that excludes undue risks for the environment of society	(World Wildlife Fund, 2014)
Integrated Resource Plan 2019	• The IRP (2019) has indicated that South Africa should continue to track a diversified energy mix which lessens reliance on a few primary energy sources. • The IRP document expects a total of 9 980 MW of additional wind capacity to be introduced in South Africa by 2030. The wind IPPs constitute the largest single renewables technology procured to date under the Renewable Energy Independent Power Producer Procurement Programme. • Allocations to safeguard the development of wind energy projects aligned with the Integrated Resource Plan (IRP) 2010 should continue to be pursued: o Ensure energy security and supply o Reduce environmental impacts o Endorse job creation and localisation o Lessen cost of energy o Reduce water consumption	(Department of Energy, 2019)

Policy	Key Policy Objectives	Source
	○ Diversify supply sources ○ Promote energy efficiency ○ Promote energy access Additionally, the IRP (2019) indicates that: • Wind energy will be 22.5% of the energy mix compared to solar at 11% by 2030	
The Constitution of South Africa 1996	• "Everyone has the right to an environment that is not harmful to their health or well-being" (S24) • The environment should be protected for the benefit of present and future generations, through reasonable legislative and other measures that: • Prevent pollution and ecological degradation • Promote conservation • Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development	(Republic of South Africa, 1996)
White Paper on Energy Policy of the Republic of South Africa 1998	• Seeks to ensure that an equitable level of national resources is invested in renewable technologies, given their potential and compared to investments in other energy supply options • Aims to create energy security by diversifying the energy supply and energy carriers	(Department of Minerals and Energy, 1998)
White Paper on the Renewable Energy Policy of RSA 2003	• Pledges government support for the development, demonstration and implementation of renewable energy sources for both small and large-scale applications	(Department of Minerals and Energy, 2003)
Provincial Policy: Mpumalanga		
Mpumalanga Economic Growth & Development Path	• Highlights the current economic landscape of Mpumalanga with a view of the future growth and development of the province. The MEGDP identifies the following key sectors: • Infrastructure • Mining • Green Economy • Manufacturing • Agriculture • Tourism • The MEGDP focus on the production of technologies for solar, wind and biofuels and is also supported by the Energy on Integrated Resource Plan	(Mpumalanga Economic Growth & Development Path, 2011)
Mpumalanga Draft Green Economy Sector Plan, 2016	• The Plan aims to provide an integrated approach towards developing the green economy in Mpumalanga by 2030 in line with the Vision 2030. Specific objectives include: ○ Developing a sector plan based on the province's strengths in natural resources endowments ○ Expanding on the economic, green and environmental initiatives that are already underway in the province in order to facilitate quick wins ○ Support the DEDT's drive in sustainable economic development – Develop an action plan for implementation	(DNA Economics, 2016)
Mpumalanga Tourism and Parks Agency Strategic Plan, 2011	• The strategic plan emphasises that Mpumalanga possesses significant potential to capture large numbers of international and domestic tourists. In particular, the Kruger National Park, several other reserves, natural and cultural and historical heritage are attractions that are in demand by all tourist groups. • The plan states that the environmental sector often puts much emphasis on biodiversity conservation without necessarily linking it with eco-tourism. The plan states that much naivety has been observed about what ecotourism can do. The plan calls for improved implementation of policy that will see biodiversity promotion being embraced by the broader tourism industry and the need for improved awareness from players	(Mpumalanga Tourism and Park Agency, 2011)

Policy	Key Policy Objectives	Source
	within the sector to reduce the adverse environmental impacts of tourism.	
Mpumalanga Nature Conservation Act No. 10 of 1998	• This Act ensures that the government of the Province of Mpumalanga shall manage the environment in such a way that the basic right of every citizen can be realised. The Act seeks to ensure that an adverse impact on the environment is limited and that the rights of all that live in the province with regard to the environment are protected. • Applicable clauses within the bill in the context of this study include: o Provides for the transfer of hunting and other rights of a holder of a certificate of adequate enclosure. o Provides for the MEC's general powers in respect of wild animals. o Details restricted activities involving provincially protected and endangered species. o Stipulates obligations of holders of certificates of adequate enclosure. o Details permit requirements of persons and businesses operating game parks etc.	(Mpumalanga Nature Conservation Act 10 of 1998, 1999)
District & Local Municipal Policy: Nkangala DM & Steve Tshwete LM		
Nkangala District Municipality IDP 2019	• The Nkangala District IDP identifies the green economy (including, but not limited to renewable energy and ecosystem services) as a focal point of economic development in the district, noting that such investments are likely to have significant economic spinoffs for the region. To achieve this, the IDP proposes investing in natural capital so as to create a new generation of green and blue economy jobs rooted in renewable energy.	(Nkangala District Municipality, 2019)
Steve Tshwete Local Municipality SDF 2010	• Steve Tshwete Municipality has identified to target renewable energy – not just industrial biofuels and electricity generation, but also domestic.	(Steve Tshwete Loval Municipality, 2010)
Steve Tshwete Local Municipality LED 2016-2021	• The Makana LED notes that "the Strategy informed by newly identified development needs, opportunities, priorities; guide the budgeting and implementing process, unlocking investor potential and creating economic and job opportunities; measuring economic performance and impact of private investment." • The strategy states that provision of environmentally friendly infrastructure is key to the development of the municipality. This infrastructure includes the use of renewable energy to provide electricity to the municipality.	(Steve Tswete Local Municipality, 2016)

The review of the policy environment suggests that utilisation, application and investment in renewable energy sources in South Africa is considered to be an integral means of reducing the carbon footprint of the country, diversifying the national economy, reducing poverty and creating much-needed additional sources of energy. Any project contributing to the above-mentioned objectives can therefore be considered strategically important to South Africa.

From a provincial and municipal policy perspective the facilitation of renewable energy projects and interventions that relate to the broader green economy are seen as a priority in terms of the policies and strategies developed.

2.2. NEED AND DESIRABILITY

2.2.1 Green Hydrogen and Ammonia Background

According to the Hendrina Hydrogen and Ammonia facility's project description, "green" hydrogen and ammonia production differs from traditional production technologies in that the process relies exclusively on renewable resources (renewable energy) and for input air and water (feedstock), to produce commercially usable green hydrogen and ammonia. The only solid waste stream is the production of brine from the water treatment plant.

A gaseous 'waste' (oxygen) is generated from the electrolyses process. Another source of gaseous 'wastes' is from the Air Separation Unit. This is where nitrogen is removed from the air and the other natural gases as expelled back to the environment. Traditional hydrogen and ammonia are produced thought the burning of fossil fuels (coal or natural gas) to provide the required energy needed for their production. This method of production results in 'brown' hydrogen as fossil fuels are used and therefore carbon forms an integral part of such traditional hydrogen production.

Commercially, hydrogen is used as a fuel for transport in hydrogen fuel cells. Alternatively, hydrogen is used for welding and in the production of other chemicals such as methanol and hydrochloric acid and also has other commercial uses like the filling of balloons. It is also a primary input to the production of ammonia. Ammonia in turn is primarily used in the production of ammonium nitrate (fertiliser) and is also used as refrigerant gas and the manufacture of plastics, explosives, textiles, pesticides and other chemicals. Ammonia can also be used as a stable 'carrier' of hydrogen, allowing hydrogen to be readily stored and transported.

A simplified flow process diagram is shown in Figure 2-1 and Figure 2-2.

Figure 2-1: Simplified process flow diagram- traditional ammonia vs green ammonia production

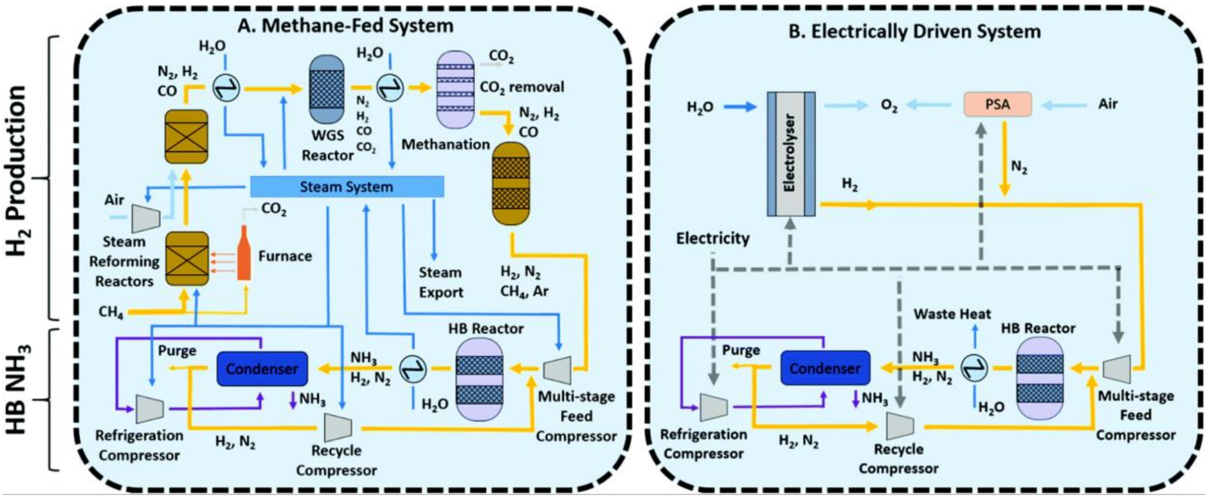
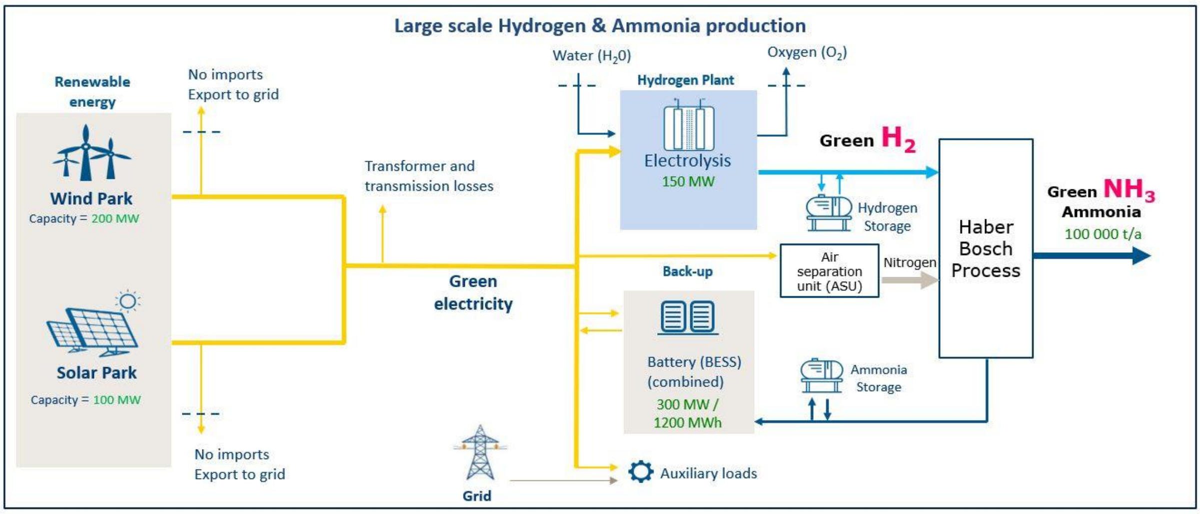


Figure 2-2: Simplified green hydrogen and ammonia production life cycle example

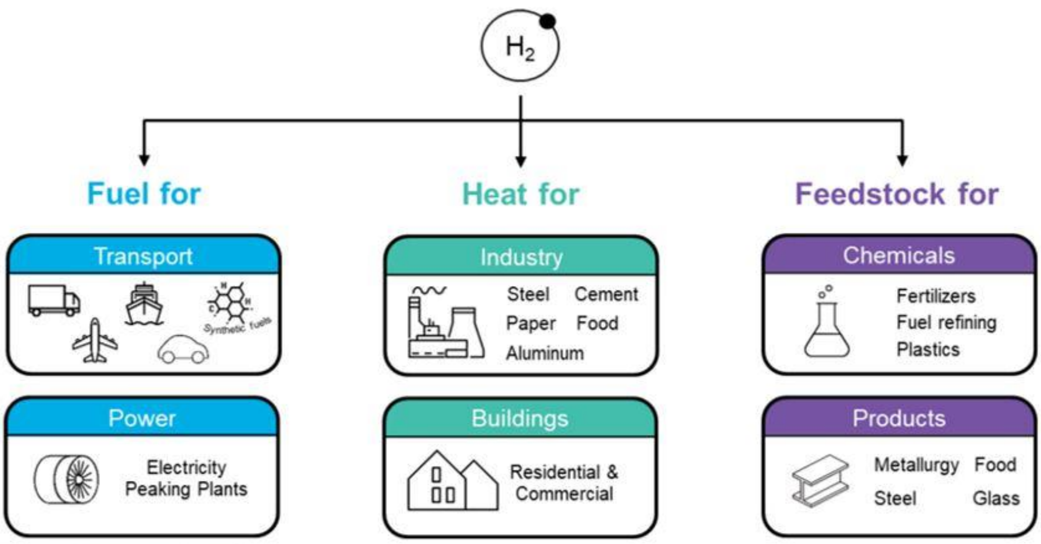


The production, storage and transport of hydrogen and ammonia is an industry undergoing in-depth research and developments. Consequently, technological solutions are constantly being improved and changing.

2.2.2 Global Green Hydrogen and Ammonia Trends

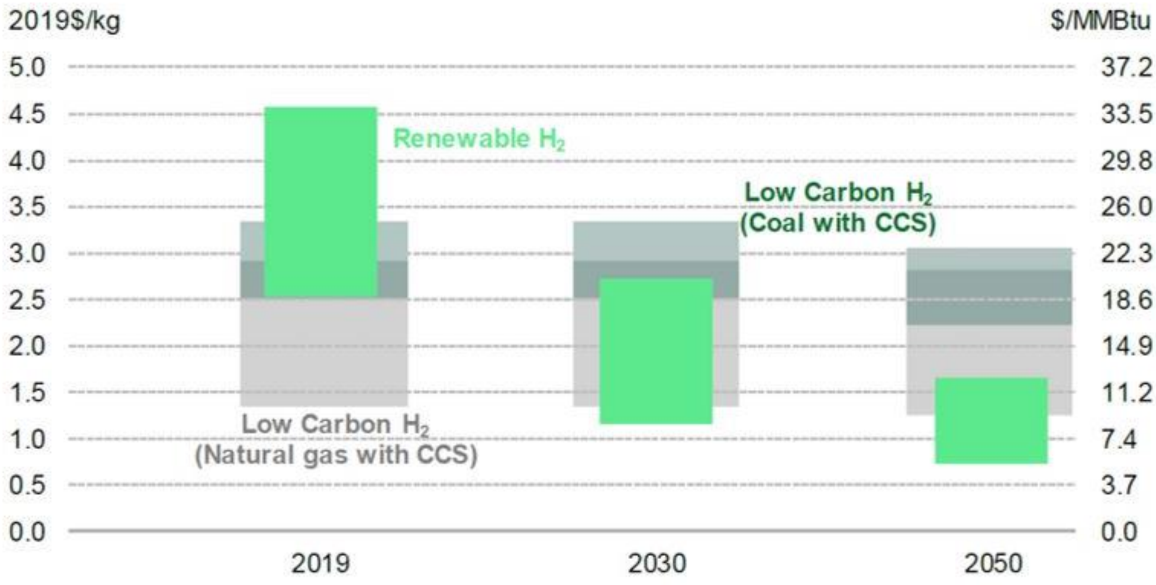
The demand for hydrogen reached an estimated 87 million metric tons (MT) in 2020 and is expected to grow to 500–680 million MT by 2050. From 2020 to 2021, the hydrogen production market was valued at $130 billion and is estimated to grow up to 9.2% per year through 2030. However, over 95% of current hydrogen production is fossil-fuel based, very little of it is “green”. In 2022, 6% of global natural gas and 2% of global coal is converted into hydrogen production (World Bank Blog, 2022). The various uses across multiple sectors are illustrated in Figure 2-3.

Figure 2-3: Green Hydrogen Production Uses



Deteriorating renewable energy prices, linked with the declining cost of electrolysers and increased efficiency due to technology advancements, have increased the commercial viability of green hydrogen production. Figure 2-4 shows the forecast of the global range of levelized cost of hydrogen production for large projects through 2050.

Figure 2-4: Forecast of Global range of Hydrogen Production



**Natural gas prices range from $1.1-10.3/MMBtu, coal from $30-116/t.*

Source: (World Bank Blog, 2022)

According to the Hydrogen Economy Outlook (2020), if these costs continue to fall, green hydrogen could be produced for $0.70 – $1.60 per kg in most parts of the world by 2050, a price competitive with natural gas. NEL, the world's largest producer and manufacturer of electrolysers, believes that green hydrogen production cost parity (or even superiority) with fossil fuels could be achieved as early as 2025.

Australia is the country with the largest number of green hydrogen plants in the world. As of 2022, there were 96 such facilities in the country. Solar photovoltaic is the greatest contributor to Australia's renewable power production, with some 15.7 terawatt hours generated from small-scale solar PV plants, compared with 8.1 terawatt hours generated via large-scale solar PV plants. Australia is expected to see some of the lowest levelized costs for producing green hydrogen by 2050 due to the abundance of solar and wind resources. Germany and Spain had the second most hydrogen production facilities in 2022, with 50 facilities, followed by the Netherlands with 48 facilities (Statista, 2022).

2.2.3 Green Hydrogen in South Africa

South Africa has the potential to produce up to 13-million tons of green hydrogen and derivatives a year by 2050. The country would require between 140 GW and 300 GW of renewable energy, which would represent a massive scale up in a context where South Africa had procured only about 7 GW of wind and solar since 2011 (South African Government, 2022).

South Africa aims to deploy 10 gigawatts (GW) of electrolysis capacity by 2030 and produce about 500 kilotons of hydrogen annually by 2030. This growth is forecasted to create 20,000 jobs annually by 2030 and 30,000 by 2040 (CSIS, 2022). South Africa's abundant renewable resources offer another advantage. A recent report by the National Business Initiative (2021) says that South Africa could produce green hydrogen for $1.60 per kg by 2030, one of the lowest costs worldwide. This could help the country reach its goal of doubling its current share of global hydrogen production by 2050 from 2% to 4%.

Green hydrogen can also help South Africa decarbonize. Economy-wide decarbonization in South Africa is crucial to maintaining global temperature increases at 1.5 degrees Celsius, as the country is the world's 14th-largest emitter of greenhouse gases. Hydrogen has the potential to help the country reach a net-zero economy by 2050 (CSIS, 2022).

The key points identified from South Africa's Hydrogen Strategy are listed below:

- South Africa wants to become a major producer and exporter of green hydrogen, capturing a 4% global market share by 2050.
- South Africa's hydrogen strategy reflects several priorities: a desire to decarbonize its economy, an effort to create economic growth, an aim for pursuing a just transition away from coal, and a way to fully exploit its critical mineral resources.
- The country has several assets relevant for hydrogen: expertise in the Fischer-Tropsch process, abundant renewable energy resources, and major production capacity of platinum group metals (PGM), a key input for hydrogen applications.
- PGMs, in particular, offer an opportunity to develop a globally relevant industry, capturing local value added from a resource that is now exported as a raw material. A cornerstone of the government's hydrogen strategy is a "Platinum Valley," an industrial cluster to combine various applications into integrated hydrogen ecosystem.

2.3. SYNTHESIS

The review of the policy and planning legislation outlines that the proposed Project development strongly aligns to the policies at a national, provincial and local level. The needs and desirability section outlines the importance of such a development to the economy and society at large of the country.

3. SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

This chapter documents various aspects of the primary study area including, population and household numbers, income levels and employment. In addition, the chapter also reviews the economic structure and performance of the study area.

The intention of this review is to provide an overview of the socio-economic context of the area so as to better understand the dynamics of the area and to inform the SEIA process.

3.1. POPULATION, INCOME AND EMPLOYMENT PROFILE

The Steve Tshwete Local Municipality falls within the Nkangala District Municipality and collectively account for 17% of the population, and 18% of the households in the district.

Population growth between 2011 and 2021 was 2,5% year-on-year for the LM which compared favourably to the DM (2,2%) and Mpumalanga (1,5%) over the same period.

Table 3-1: Overview of the primary & secondary study areas population structure

Indicator	Mpumalanga	Nkangala District Municipality	Steve Tshwete Local Municipality
Area (km^2)	76 495	16 758	3 976
Population	4 839 562	1 702 174	289 117
Number of Households	1 292 665	467 029	82 678
Population density (km^2)	63	101	72
Average household size	3,8	3,7	3,6
Annual population growth (2011-2021)	1,5%	2,2%	2,5%
Average monthly household income	**R 7 061**	**R 7 601**	**R 11 778**

Source: Quantec Standardised Regional (2021) forecast to 2023

The disposable average monthly income of households in the LM was R 11 778 which was 35% higher than the average for DM (R 7 601) and 40% higher than the average for the Mpumalanga.

Table 3-2: Employment profile of the study areas (2021)

Indicator	Mpumalanga	Nkangala District Municipality	Steve Tshwete Local Municipality
Employed	1 051 844	370 184	89 088
Unemployment Rate	37,3%	40,3%	28,2%
Not Economically Active	1 395 317	498 445	75 071
Labour force participation rate	34,2%	33,1%	44,7%

Source: Quantec Standardised Regional (2023)

The review of the employment profile of the LM indicates that 28,2% of the economically active population within the municipality is formally unemployed (see Table 3-2). The unemployment rate and labour force participation rate in the LM were also notably better than that of the DM (Unemployment rate: 40,3%; Labour force participation rate: 33,1%).

The relatively lower unemployment rate and higher labour force participation relative to the district averages further suggests that the LM is subject to inward migration due to the employment opportunities available within the local municipality.

3.2. ECONOMIC PROFILE

The following subsection outlines the economic profile at a national as well as a provincial and local municipal level.

After contracting by 0,7% in the second quarter of 2022, the South Africa's Gross Domestic Product (GDP) rallied in the third quarter, expanding by 1,6% (StatsSA, 2022). However, after plummeting in the second quarter of 2020 – when lockdown restrictions were at their most stringent – South African GDP clawed itself back to pre-pandemic levels in the first quarter of 2022. (StatsSA, 2022).

3.2.1 Regional economic profile

The GVA (Gross Value Added) of the LM was R 76,7 million in 2021 (2015 constant prices), which collectively accounts for 28,2% of the district economy's GVA, and 11,3% of the Mpumalanga's GVA (Quantec, 2023). This suggests that, although the LM is relatively small in terms of its GVA, it is important in the broader DM in terms of economic output.

Table 3-3: Economic structure between 2011 and 2021 (constant 2015 prices; R' millions)

Sector	Mpumalanga		Nkangala District Municipality		Steve Tshwete Local Municipality	
	2011	2021	2011	2021	2011	2021
Agriculture and hunting	3,80%	6,58%	1,52%	2,84%	1,51%	2,77%
Mining and quarrying	19,35%	21,03%	30,18%	32,42%	29,99%	31,87%
Manufacturing	28,85%	23,77%	22,19%	18,20%	25,56%	20,22%
Electricity, gas and water	6,09%	5,71%	9,91%	9,44%	9,06%	8,74%
Construction	4,19%	3,04%	4,51%	3,42%	4,23%	3,57%
Trade	10,28%	9,86%	8,17%	7,61%	7,57%	7,19%
Transport and communication	5,78%	4,65%	5,44%	4,50%	4,28%	4,04%
Finance and business services	10,49%	12,82%	9,59%	11,97%	10,92%	13,79%
Community services	4,14%	4,87%	3,19%	3,75%	2,71%	3,26%
General government	7,04%	7,67%	5,31%	5,85%	4,16%	4,55%
TOTAL GVA	**R628 607**	**R679 310**	**R251 092**	**R271 693**	**R67 369**	**R76 676**

Source: Quantec Standardised Regional (2023)

The growth of the LM over the last few years was largely due to the strong performance of the mining and quarrying, manufacturing and finance and business services.

Many of these are linked to and service the large mining and manufacturing-based sectors that is present in the town of Middelburg. Electricity is an average size industry in the municipality with only no operational green hydrogen facilities. Any new development would likely greatly increase the contribution of the utilities and construction sectors to the GVA.

Table 3-4: 2021 GVA per sector for the Steve Tshwete Local Municipality (2015 constant prices; in R' millions)

Sector	Steve Tshwete Local Municipality		
	2009	**2019**	**Compound Annual Growth Rate (CAGR)**
Agriculture and hunting	R1 017,1	R2 126,7	7,65%
Mining and quarrying	R20 204,2	R24 434,9	1,92%
Manufacturing	R17 216,4	R15 501,3	-1,04%
Electricity, gas and water	R6 104,9	R6 704,5	0,94%
Construction	R2 850,7	R2 740,0	-0,40%
Trade	R5 097,5	R5 514,0	0,79%
Transport and communication	R2 886,2	R3 096,1	0,70%
Finance and business services	R7 358,0	R10 570,5	3,69%
Community services	R1 828,4	R2 503,1	3,19%
General government	R2 805,7	R3 485,0	2,19%
TOTAL GVA	**R67 369,2**	**R76 676,0**	**1,30%**

Source: Quantec Standardised Regional (2023)

Over the last ten years, the CAGR of Steve Tshwete was +1,3%. The growth of the above-mentioned sectors was somewhat offset by the stagnation of the electricity, gas and water sector and the reduction of the growth in the manufacturing sector which has been in upheaval in the area especially with regards to provision of health, water and other essential services to communities in the area.

As evident by Table 3-5 the mining and quarrying sector employs the most with a 19,44% contribution in 2021. In 2011 the trade sector employed 18,21% of the total employment in the LM.

The local agricultural sector includes limited subsistence (informal) farming, unlike other areas in Mpumalanga, where this practice is more dominant. The presence of this subsistence agricultural means that the number of households that are dependent on agricultural activities for income could be slightly greater than the figures presented in Table 3-5. This is due to the fact that the table only indicates those individuals that are formally employed in the agricultural sector.

Table 3-5: Employment structure and contribution of the Steve Tshwete Local Municipality between 2011 and 2021 per economic sector

Sector	Contribution to Employment per Sector	
	2011	**2021**
Agriculture and hunting	4,11%	4,55%
Mining and quarrying	19,34%	19,44%
Manufacturing	11,36%	10,67%
Electricity, gas, and water	1,93%	1,74%
Construction	7,58%	8,47%
Trade	18,21%	16,25%
Transport and communication	3,18%	3,13%
Finance and business services	11,43%	12,92%
Community services	4,65%	4,84%
General government	18,21%	17,99%
TOTAL EMPLOYMENT	**80 088**	**89 088**

Source: Quantec Standardised Regional (2023)

In general, agricultural activities are relatively labour intensive, thus a small decline in the size of the sector would generally lead to greater job losses than for example in manufacturing or utilities, which tend to be more capital intensive in nature. The agricultural sector is also frequently one of the largest employers in rural areas and it is for these two reasons that the sector is generally prioritised in development strategies. An important aspect to note is that finance and business services now account for a larger proportion of labourers in the municipality than agriculture.

3.3. PROFILE OF THE IMMEDIATELY AFFECTED ENVIRONMENT

A profile of the immediately affected environment was developed utilising available secondary information and surveys conducted with landowners of the affected area. The area and three potential locations are illustrated in Map 3-1.

In order to develop a comprehensive understanding of formal economic activities and businesses that operate within the broader study area in which the proposed Project is to be developed, a database of farm portions and corresponding ownership was created. The intention of this database formulation, and subsequent contact with landowners was to solicit business, and enterprise-specific data, so as to better understand the economic activity and employment dynamics of the area. It should be noted that not all owners chose to respond to the survey, or to some of the specific questions.

The engagements were carried out via Survey Monkey, between July 2021 and August 2021. Table 3-6 below presents a synopsis of the engagements carried out with affected landowners. A full list of landowners contacted is presented in Annexure A.

Table 3-6: Survey & Landowner Engagements

Indicator	Number
Total land portions identified	44
Total number of unique owners identified	8
Total number of owners spoken to telephonically	6
Total number of surveys distributed via emailed or electronic link	8
Total number of interviews and/or completed responses received	5

3.3.1 Land use profile of the directly affected area

The land portions on which the proposed Project will be located are currently used for agriculture (predominant use). This farming is in the form of livestock farming with the predominant form of livestock being beef (50% of respondents). Most of the farms earmarked for development indicated crop farming (drylands). None of the farms are utilised for tourism related activities, such as hunting.

3.3.2 Socio-economic profile of the directly affected area

The following section presents a profile of the farms that will be directly affected by the proposed Project development.

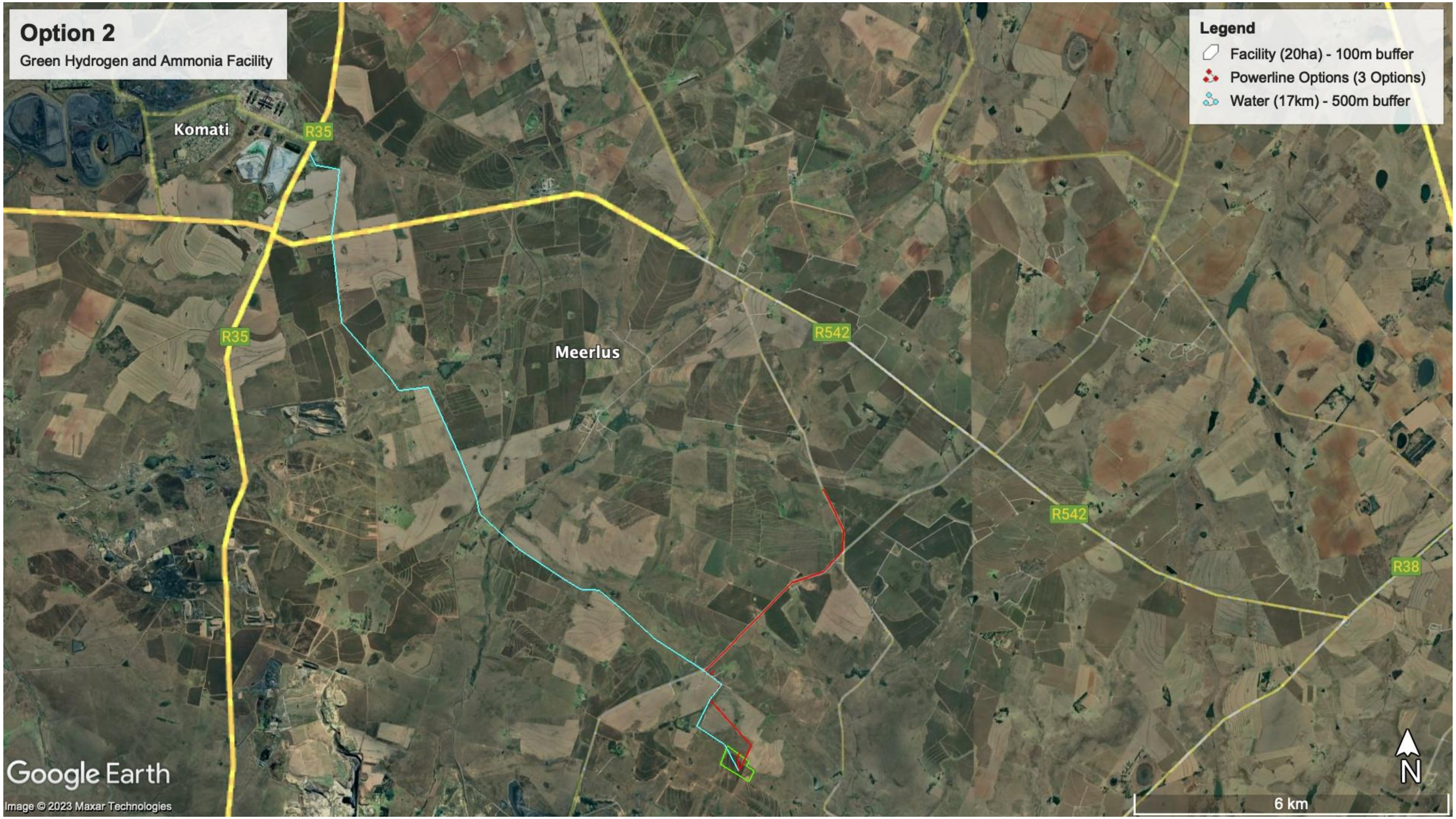
From the data obtained from surveyed landowners, it is estimated that agricultural operations in the directly affected area employ approximately 112 people, the majority of whom are permanent employees (71 people). Most of the employees live on the farm and those who do not, live on the adjacent farms and Kwazamakuhle in Hendrina. It is recognised that the majority farms in the area practice a combination of crop and livestock activity. As such, most farms are involved in both land uses as indicated previously. The following observations were made regarding land use:

- Four of the five respondents operate as commercial farmers
- Beef was the largest portion of livestock, approximately 1 150 cattle, followed by sheep, with approximately 30 sheep. One of the farmers indicated that they farm with pigs (10 pigs)
- The average size of property owned was 1 060 and ranged between 120 and 2 000 ha
- The majority of labourers live on the farms they work on with their family members
- Livestock animals reared for sale and kept for production of food products include goats, sheep and cattle
- All of the farms are the primary residence of the farm owner

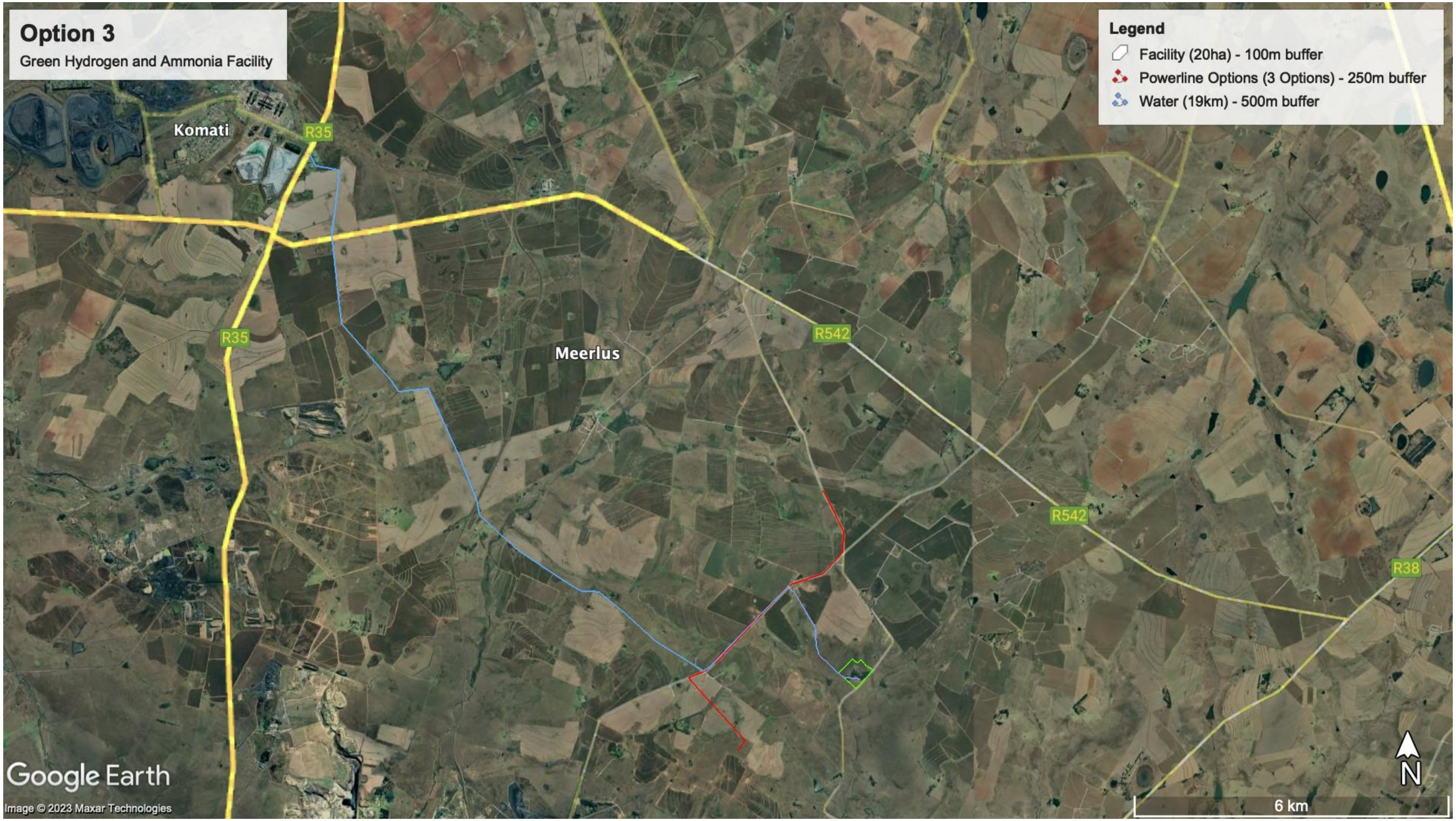
Given the small number of responses received from owners in the area, it has not been possible through primary research to estimate the total contribution of the agricultural industry to the local economy.

Map 3-1: Hendrina Green Hydrogen and Ammonia Facility Option 1

Map 3-2: Hendrina Green Hydrogen and Ammonia Facility Option 2



Map 3-3: Hendrina Green Hydrogen and Ammonia Facility Option 3



4. GREEN HYDROGEN AND AMMONIA FACILITY DESCRIPTION

ENERTRAG AG developed its first green hydrogen facility, Hybridkraftwerk, in Germany which is powered by wind energy. The Hybridkraftwerk was commissioned in October 2011 and produces 94 tons of hydrogen per year (refer figure below).

Figure 4-1: ENERTRAG AG Germany's Hybridkraftwerk.

Figure 4-2: Closer View of Electrolyser Housing and Storage Tanks

ENERTRAG SA, is proposing the development of up to 150MW green hydrogen and ammonia facility (‘Facility’). The Facility will encompass approximately 25 hectares of land (three alternative locations being assessed), and the affected land parcels are shown in Table 1-1. Thus, the below Facility description is based on available technological solutions, however, the underlying fundamentals will remain.

The facility comprises the following components as summarised in Table 4-1, where the footprint and capacities are presented. These parameters on based on the assumption that an up to 150MW electrolyser is installed (maximum).

These components are detailed further below, but comprise the following general components:

- Water treatment.
- Electrolyser.
- Air separator.
- Ammonia processing unit.
- Liquid air energy system (LAES) for nitrogen storage.
- Feedstock and product storage.
- Utilities.
- Gantry and loading bay.

Associated infrastructure further include:

- Electrical infrastructure required for power supply to the facility.
- Temporary and permanent laydown areas required for temporary storage and assembly of components and materials.
- Access road/s to the site and internal roads between project components, with a width of up to up to 6m wide respectively.
- Fencing and lighting.
- Lightning protection.
- Telecommunication infrastructure.
- Stormwater channels.
- Water pipelines
- Offices.
- Operational control centre.
- Operation and Maintenance Area / Warehouse / workshop.
- Ablution facilities.
- A gate house.
- Control centre, offices, warehouses.
- Security building.

Table 4-1: Facility Components

No.	Component	Footprint (Ha)	Storage Capacity (m^3 / tons)	Maximum Throughput (m^3 / tpa)	Conversion	Note
1	Water Reservoir	2	6 800 / 6 800	800 / 800	Density of water taken as 1 000 kg/m3	Process and utilities water
2	Water Treatment Unit	1.5	N/A	192 000 / 192 000	Density of water taken as 1 000 kg/m3	Process and utilities water
3	Electrolyser Unit	1	N/A	(1 239 157 – 301 932 367) / 20 000	Density of hydrogen can be 16.14kg/m3 at 200 barg and 25 °C or 0.06624 kg/m3 at 0 barg and 90 °C depending on the operating conditions of the unit.	Hydrogen Output Oxygen Output
4	Air Separation Unit	0.5	N/A	92 905 405 / 110 000	The density of air taken as 1.184 kg/m3	Air Input
5	Ammonia Processing Unit	2	N/A	149 253 / 100 000	The density of liquid ammonia taken 670 kg/m3 at -33 °C at 1 atm	Ammonia Output
6	Liquid Air Storage System (LAES)	1	3 983/ 3 505	460 227 / 405 000	The density of liquid nitrogen taken 880 kg/m3 at -33 °C at 1 atm	Nitrogen Storage
7	Liquid Ammonia Storage Tank	2	2 273/ 1 523	261 194 / 175 000	The density of liquid ammonia taken as 670 kg/m3 at -196 °C at 1 atm	
8	Hydrogen and Oxygen Storage Tank Farm	12	59 566/ 800	5 576 208 / 90 000	A density of 16.14kg/m^3 for hydrogen at 200 barg and 25 °C. Oxygen density estimated at liquid boiling point and 1 atmosphere pressure, totaling 1141 kg/m^3.	Hydrogen and Oxygen storage (combined tank farm), i.e. feedstock storage
9	Ancillary infrastructure	3	n/a	n/a	n/a	Includes temporary and permanent laydown areas, parking, offices and other related infrastructure.
	Total Footprint	**25**				

4.1. WATER RESERVOIR

- Water will be stored in a water reservoir with a footprint of up to 1.5ha. The water reservoir will have a capacity of approximately 6800 m^3.
- It is proposed that three water reservoirs will be located on site. Each reservoir will have a diameter of up to 25m and a height of 6m (maximum height up to 15m).
- The water reservoirs will consist of a reinforced concrete or steel cylindrical tanks (refer **Error! Reference source not found.** below).

Identification of possible water sources:

A variety of water sources are being investigated for the broader development, and include the following:

- <u>Komati Power Station</u> (technical preferred option): Bulk water infrastructure from the Usuthu Water Scheme currently feeding the surrounding coal mines and power stations (specifically Eskom Komati Power Station) may be utilised for construction and operational water. Initial water results indicate good quality supply in sufficient quantities is available. This option is the preferred water sourcing for the development due to excess water being available at the Power Station's water reservoirs.
- <u>Groundwater:</u> Various boreholes may be utilised across the project site for extraction of construction and operational water requirements. The volumes will be dependent on the available groundwater and the quality thereof, which has not yet been determined.
- <u>Purified wastewater:</u> Wastewater from nearby commercial or mining facilities could be sourced to provide the facility with water. This would depend on availability of suitable quality wastewater and agreements with the respective entities involved. It is possible that water may be sourced from existing surrounding mining operations that are experiencing or anticipating mine water decant from their operations. Using this water in the green hydrogen and ammonia facility is potentially beneficial.

Figure 4-3: Typical water reservoir (left concrete, right steel tank ~ 6m).

4.2. WATER PIPELINE

An above or below ground water pipeline will be constructed for the continuous or intermittent supply of water to the GH&A facility.

The pipeline will comprise a concrete pressure pipe, ductile iron pipe, galvanised iron or steel pipe, GRP/GRE pipe, Poly Vinyl Chloride Pipes, High Density Poly Ethylene pipes or other suitable material as required by the detailed design phase, situated (where buried) within a trench of up to 3m wide and up to 2m deep. Where required for the avoidance of obstacles, horizontal directional drilling may be utilised for installation. The pipe will carry raw water of 928 880 m^3 per annum at a throughput of up to 40 litres per second (usage requirements varying between the construction and operational phases).

The pipeline inner diameter will be up to 300mm. Major components will include:

- Pipeline segments comprising pipeline length of up to 9.5km.
- Concrete supports (where pipeline is located above ground)
- Pumps (including pump, electrical or oil engine and panel board) housed in pump house for security and safety
- Mains and sumps (if needed)
- Manholes for inspection, with concrete covers. To be spaced no further than 100 metres apart.
- Valves (various, for example sluice, air, scour etc.) as required
- Water and flow meters
- Pipe fitting pieces, joints, clamps, adaptors and couplings as needed
- Bedding material as needed (concrete, sand, tamped down soil) where trenched
- Electrical source for pumps
- Protection systems (pipeline inner liner and outer coating), cathodic protection, pressure meters).

4.3. WATER TREATMENT

Water is required for the production of hydrogen and for heating and cooling purposes. The water treatment facility will be housed in a warehouse with a footprint of 1 ha.

Water treatment technology:

- Water treatment facilities usually contain multi-filtration stages and pumps.
- Water for the facility must first be purified (ASTM Type II quality) through a Reverse Osmosis system (RO). The RO system consumes between 10 - 16 liters of water per kg -of hydrogen. Water consumption ultimately depend on the quality of the feed water.
- The water treatment facility is estimated to consume up to 192 000 tons per annum (tpa) of water per annum, with an additional estimated 2 000 tpa for utilities related to general running of the plant.
- Purified water from the water treatment facility is the main input to the next step in the process, namely the electrolyser.

Figure 4-4: Example of a water treatment plant (EcoPura RO Plant).

4.4. WASTE STREAM

Water required for the electrolysis must first be purified to acceptable standards for the electrolysis process. This purification is achieved through a Closed-Circuit Reverse Osmosis (CCRO) process, including a forced-crystallisation unit. The reverse osmosis operation comprises of high pressure applied in order to drive water through semipermeable membranes that reject salt ions.

CCRO systems further work by recirculating pressurized feedwater until a desired recovery level is reached. Brine is replaced with fresh feed without stopping the flow of pressurized feed or permeate. CCRO systems achieve recovery by recirculation, not with multiple membrane elements and stages in series, and can therefore reach any desired recovery percentage in a single stage. CCRO technology has process has demonstrated recovery rates of up to 98% whilst saving more water and reducing more waste than traditional one-, two- and three-stage reverse osmosis systems. The RO system consumes between 10 - 16 litres of water per kg - of hydrogen.

Two by-products are produced by the RO process – brine and permeate. The permeate (purified water) must be of ASTM Type II quality, defined as having a resistivity of >1 MΩ-cm, a conductivity of <1 µS/cm and <50 ppb of TOCs. In contrast, the brine produced contains all rejected concentrated minerals which was separated through the RO process, which then acts as feedwater for the forced crystallisation unit forming part of the RO plant.

Crystallization is the production of a solid (crystal or precipitate) formed from a homogeneous, liquid which is concentrated to supersaturation levels (concentration > solubility) at that temperature. The crystallization processes utilised has not been selected and will be determined at detailed designed phase based on likely permeate constituents and concentration levels, however, may comprise any of the following:

- Supersaturation by cooling the solution with trivial evaporation
- Supersaturation by evaporation of the solvent with little cooling
- Evaporation by a combination of cooling and evaporation in adiabatic evaporators (vacuum crystallizers)

In addition, various crystalisers technologies may be utilised including steam driven, thermocompression driven, vapour compression cycling and calandria crystalisers, amongst others, depending on the final design.

Crystallisation essentially comprises three broad steps:

i. Pre-concentration: Electrical, concentration-gradient or temperature gradient driven permeable membrane concentration step, which increases the TDS of the feedwater.
ii. Evaporation: Flash evaporation, multiple distillation or increased vapor pressure condensation of the concentrated brine to reduce the water content of the brine.
iii. Crystallization: achieving and promoting crystal development in the brine via heating or spray drying the until supersaturation is achieved.

Crystalisers typically comprise various interconnected modules placed on contained skid systems, which house heaters, vaporators, vapor washers, compressors, motors and zero liquid discharge packages. Ancillary equipment include pumps, platforms and decking, instrumentation, control panels, insulation, valving, electrical systems and wiring, piping, and starter motors (if required). Below is an illustrative 3D rendering and flow diagram of a typical Zero Liquid Discharge system (credit: Veolia[1]):

The product of this zero liquid discharge (ZLD) crystallisation process is a salt ‘cake’ (i.e. solid block of typically mixed minerals and trace metals crystals of various sizes). The resulting cake is typically about 10% moisture[2]. This can be somewhat controlled by adjusting the filtering and drying cycle times, reducing moisture content down to approximately 5%.

The resulting brine cake is then temporarily stored in a hazardous waste skip within a bund on-site which is then removed at regular intervals (no longer than two-weekly) by a third-party waste management company. This third-party waste management company will be suitably licenced for disposal and treatment of both general and hazardous waste. The waste contractor then treats the salt cake by addition of fly-ash to reduce the leachate concentration of the salt to within landfill-disposal regulatory requirements, thereafter disposing of the modified salt cake to a suitably licenced waste disposal facility by road transport.

Given the above brine treatment and Zero Liquid Discharge system, as well as the use of a third-party contractor for treatment and disposal of the produced salt cake, and the relatively small temporary storage facility envisaged and regular removal (<30m3 at any one point in time), it is understood that no treatment of waste triggers as per the National Environmental Management: Waste Act (NEM:WA) are triggered, regardless of Category A, B or C triggers. In addition, it is further understood that no storage activities are triggered for these above activities.

[1] Chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fwww.veoliawatertech.com%2Fsites%2Fg%2Ffiles%2Fdvc3601%2Ffiles%2Fdocument%2F2020%2F08%2FVWT_MBD_4p_6-22HR_Letter.pdf&clen=1664030&chunk=true

[2] chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fwww.suezwatertechnologies.com%2Fsites%2Fdefault%2Ffiles%2Fdocuments%2FTP1028EN.pdf&clen=458187&chunk=true

Therefore, regardless of the classification of the salt cake (hazardous or general), and provided the above activities are implemented as described, no NEM:WA triggers apply and no Waste Management License is therefore necessary. The proponent will however comply with the general duties provided for at section 16 of NEM:WA relating to the management of waste as well as the legal requirements relating to the storage of waste as provided for at sections 21 and 22 respectively.

4.5. ELECTROLYSER (UP TO 150MW)

The up to 150MW electrolyser will be housed in a warehouse building and will have a footprint of up to 1ha. The electrolyser will use direct electric current (obtained from the Renewable Energy Facilities) to drive an otherwise non-spontaneous chemical reaction, in this case the separation of $2H_2O$ (water molecule from the RO process) through a reduction-oxidation (redox) process into H_2 (Hydrogen on the cathode side) and O_2 (Oxygen on the anode side). Electrolysers are modular and currently range in size from 5MW – 20MW. It is proposed that the Green Hydrogen Facility will consist of 15 sets of 10MW electrolysers. Each electrolyser unit will be powered through its own set of transformers and rectifiers.

Two electrolysis technologies may be considered, namely alkaline- and polymer electrolyte membrane electrolysis (‘PEM’). The most likely technology to be used in the PEM, however this will only be confirmed once detailed engineering design has been completed and EPC contractual arrangements concluded.
An up to 150MW electrolyser would produce up to 20,000 tons per annum (tpa) of green hydrogen and up to 40 000 tpa of green oxygen. The oxygen may be released or stored and sold as a by-product. The hydrogen may be directed to the Ammonia production plant (see “ammonia processing” below) or be stored and sold to interested parties directly.

Figure 4-5: Example of an Electrolyser Unit (Nel Proton PEM)

4.6. AIR SEPARATOR UNIT

The air separation until will occupy a footprint of up to 0.5ha and the intake tower will have a maximum height of up to 40m (due to the height of the 'cold box' – the tallest vertical component of the air separation unit). Air is obtained from the immediate surroundings and separated into nitrogen (N_2) and oxygen (O_2) with the impurities removed. The process involves air compression and temperature manipulation in a pressure-controlled environment to separate gasses from one another and produce gaseous N_2. The air separation unit will have a maximum capacity of up to 110,000 tpa. Alternative technologies exist (including Pressure Swing Adsorption (PSA) and Membrane Separation Technologies) and are being evaluated; the most efficient process will be implemented in the final project design.

Figure 4-6: Example of an Air Separation Unit (Linde ECOGAN Containerized System)

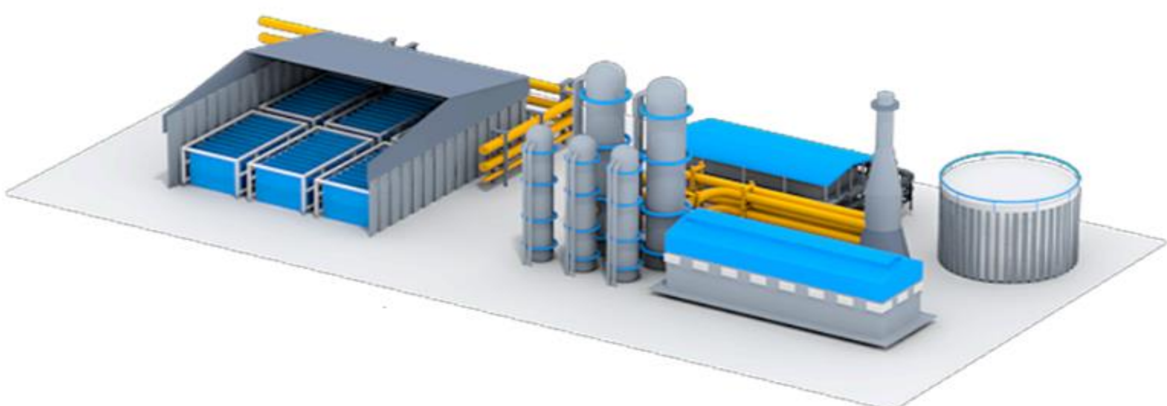
4.7. AMMONIA PROCESSING UNIT

Ammonia is produced through the Haber-Bosch process. This is where stoichiometric amounts of nitrogen and hydrogen are reacted to produce ammonia. The conversion is typically achieved at 100 barg and between 400 - 500 °C to favour the formation of ammonia at equilibrium.

A catalyst is also used to favour the production of ammonia. The gas is then rapidly cooled to form anhydrous ammonia with the unreacted nitrogen and hydrogen recycled back to reactor. Nitrogen (N_2) from the air separator process and Hydrogen (H_2) from the electrolyser are reacted over a bed of catalyst to favour the production of ammonia (NH_3). The gas is then rapidly cooled to form anhydrous (free from water) ammonia because it is more stable and less toxic in liquid form. Un-reacted N_2 and H_2 will be recycled back to the reactor.

If the full 20,000 tpa of green hydrogen generated by the electrolyser is directed to this process, this will produce up to 100,000 tpa of liquid, green ammonia for market.
Typical components of an ammonia production plant include compressors, filters, reactor chamber and beds, heat exchangers, water storage vessels, condensers, separators, circulators, absorbers and gas release valves.

Figure 4-7: Example of integrated hydrogen and ammonia complex (ThyssenKrupp)



4.8. LIQUID AIR ENERGY SYSTEM (LAES) FOR NITROGEN PRODUCTION

Liquid air energy will be used to liquefy nitrogen for storage, energy and feedstock requirements. Liquid air energy is the use of liquefied air, nitrogen, oxygen and even hydrogen to store Energy.

LAES consists of three main stages:

i. cooling and separation of the air,
ii. storage (usually in insulated vessels at low pressure) and
iii. (expanded for energy and/or production.

The first stage is the cooling of the air which is done by the air separation unit, the second stage is storage (usually in insulated vessel at low pressure) and the third stage is when extra energy is needed (the liquefied air is pumped and superheated to evaporate at atmospheric temperature). The change in pressure is used to turn gas turbines. These gas turbines produce electricity via the rotation of the generator shaft (mechanical energy is converted to electrical energy).

Components in the LAES include compressors, ambient and cryogenic heat exchangers, expansion valves, storage vessels, pumps, small turbines and generators.

4.9. STORAGE TANKS – GENERAL

Storage Tanks can be stored in pressurised as or gas in liquid form through the utilisation of a variety of specialised tanks. There are different kinds of storage tanks designs to store anhydrous ammonia, these include but are not limited to:

- Fixed roof tanks,
- Floating roof tanks,
- Low-temperature storage tanks, and
- Pressure tanks.

4.9.1 Fixed roof storage tanks

Fixed roof storage tanks are cylindrical storage containers that have flat or conical roofs joined to the shell. These storage tanks are often used to store large quantities of petroleum distillates, petrochemicals, and other liquid chemicals at atmospheric pressure. When the level of fluid in the tank rises and falls, air and vapor are pushed out and drawn into the tank headspace. Consequently, the vapor is lost into the atmosphere during the process of emptying the tank.

A double-walled tank is designed to provide secondary containment by enhancing the protection against tank failure. It can be customized by adding ultrasonic level indicators, leak detectors, and tank ladder assemblies to identify and monitor in case of any leakage. Below are examples of fixed roof storage tanks:

Figure 4-8: Single-walled fixed storage tanks (left and double-walled fixed roof tank (right)

4.9.2 Floating roof tanks

The roof of floating roof tanks floats above the liquid stored at atmospheric pressure. The roof rises and falls as the fluid does. Consequently, floating roof tanks reduce vapor loss, fire, and tank collapse hazards of fixed roof storage tanks. Below are examples of floating roof tanks:

Figure 4-9: Double-deck floating roof storage tank

4.9.3 Low-pressure storage tanks

Low-pressure storage tanks are insulated tanks. These kinds of tanks are more suitable to store volatile liquids for atmospheric storage. They are often used to store ammonia, and liquified gases such as butane at a pressure set by their vapor pressure at the working temperature. Below are examples of low-pressure storage tanks.

Figure 4-10: Low-pressure storage tank

4.9.4 Pressure tanks

Pressure tanks are horizontal-welded pressure vessels with elliptical or hemispherical heads known as bullet tanks. A bullet tank is a storage container that stores natural gas liquids. Bullet tanks are used for high-pressure fluids. Pressure tanks also include spherical pressure tanks known as Horton Spheres and are used to store large quantities of high-pressure fluids. Below are examples of pressure tanks:

Figure 4-11: Bullet storage tank (ammonia storage)

4.10. STORAGE REQUIREMENTS FOR THE DEVELOPMENT

4.10.1 Nitrogen

Nitrogen will be stored (7-14 days) as a liquid with in large cylindrical cryogenic storage tanks with a combine volume of approximately 4 100 tons of nitrogen. A storage tank is usually considered to have 85% usable capacity, this is to allow 15% vapor space to allow for expansion. It is proposed that the facility will house up to two cylindrical cryogenic storage tanks. Each tank will have a diameter of up to 14m and a height of up to 15m with a capacity of up to 2032 tons.

4.10.2 Ammonia

Green ammonia will be stored as anhydrous liquid ammonia, using similar storage equipment as that utilised for storage of Liquid Natural Gas (LNG), i.e. in a storage tank farm (refer Figure 4-12 Energas example and Figure 4-13). Ammonia storage tanks are containers used to store ammonia as liquid or compressed gases. It is important to take note of the design and layout of storage tanks as these properties affect the safety and economical aspect of the plant. Anhydrous ammonia (gas or liquid) is a colorless gas with a sharp smell under atmospheric conditions. The temperature of anhydrous ammonia increases with the increase of surrounding temperature resulting in the vapor pressure in the tank to increase. Thus, it is important to store anhydrous ammonia in containers that can withstand the physical and chemical properties of the liquid form.

Figure 4-12: Liquid Ammonia Storage system (Energas example).

Anhydrous ammonia will be stored within large cylindrical cryogenic storage tanks with a combined volume of 3 750 tons of ammonia. A storage tank is usually considered to have 85% usable capacity, this is to allow 15% vapor space to allow for expansion. It is proposed that the facility will house up to three cylindrical cryogenic storage tanks. Each tank will have a diameter of up to 14m and a height of up to 15m with a capacity of up to 1250 tons each.

Figure 4-13: Cryogenic ammonia storage tanks

4.10.3 Hydrogen

Hydrogen is stored in vertical or horizontal storage bullets. Compressed hydrogen can be storage as a gas or in liquid form. Compressed hydrogen can be stored at ambient temperature. Up to 800 tons of hydrogen will be stored at the facility, in conjunction with that of the oxygen stored on site, in a tank farm of up to 12 ha. The facility will house up to 20 horizontal pressure bullets for the storage of hydrogen. Each bullet will have a diameter of up to 4m and a length of up to 15m.

Figure 4-14: Compressed Hydrogen Storage – horizontal tank

4.10.4 Oxygen

Oxygen will be stored in vertical or horizontal storage bullets and stored under high-pressures. The tanks have a vacuum-insulated double wall consisting of two concentric vessels, a steel inner tank and an outer jacket in carbon steel. Up to 800 tons of oxygen will be stored at the facility, in conjunction with that of the hydrogen stored on site, in a tank farm of up to 12 ha. It is proposed that the facility will house up to 16 vertical cryogenic storage bullets for the storage of oxygen. Each bullet will have a diameter of up to 4m and a length of up to 15m.

Figure 4-15: Cryogenic storage tanks – vertical tanks.

4.11. GANTRY AND LOADING BAY

Ammonia is easily transported by truck and rail as a pressurized liquid. Three loading gantries were assumed where international organisation for standardisation (ISO) containers can be filled with anhydrous ammonia and trucked to an export port location, or similar consumer or off-take point (for example nearby railroad sidings).

The following equipment forms part of these gantries:

- Custody transfer metering.
- Loading arm with coupling.
- Control valve.
- Control unit.

4.12. TRANSPORT

Liquid Ammonia may readily be transported via road, rail or a combination of the two by means of Standard pressurised road tanker or ISOtainer (for road transport options), or via pressured rail container (Isotank).

Figure 4-16: Rail Isotank NH3 storage and transport

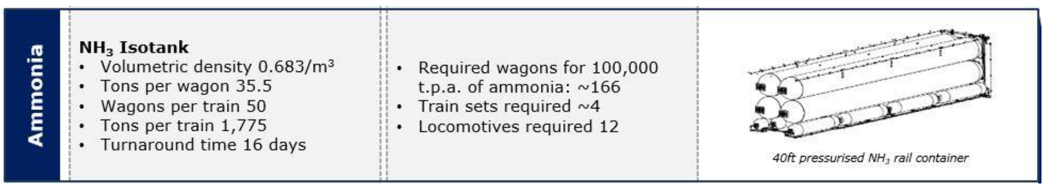
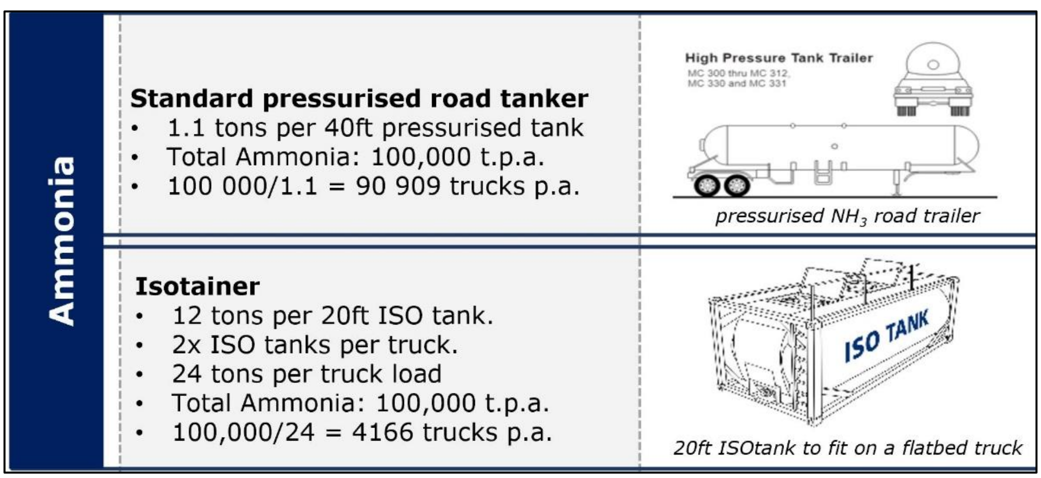
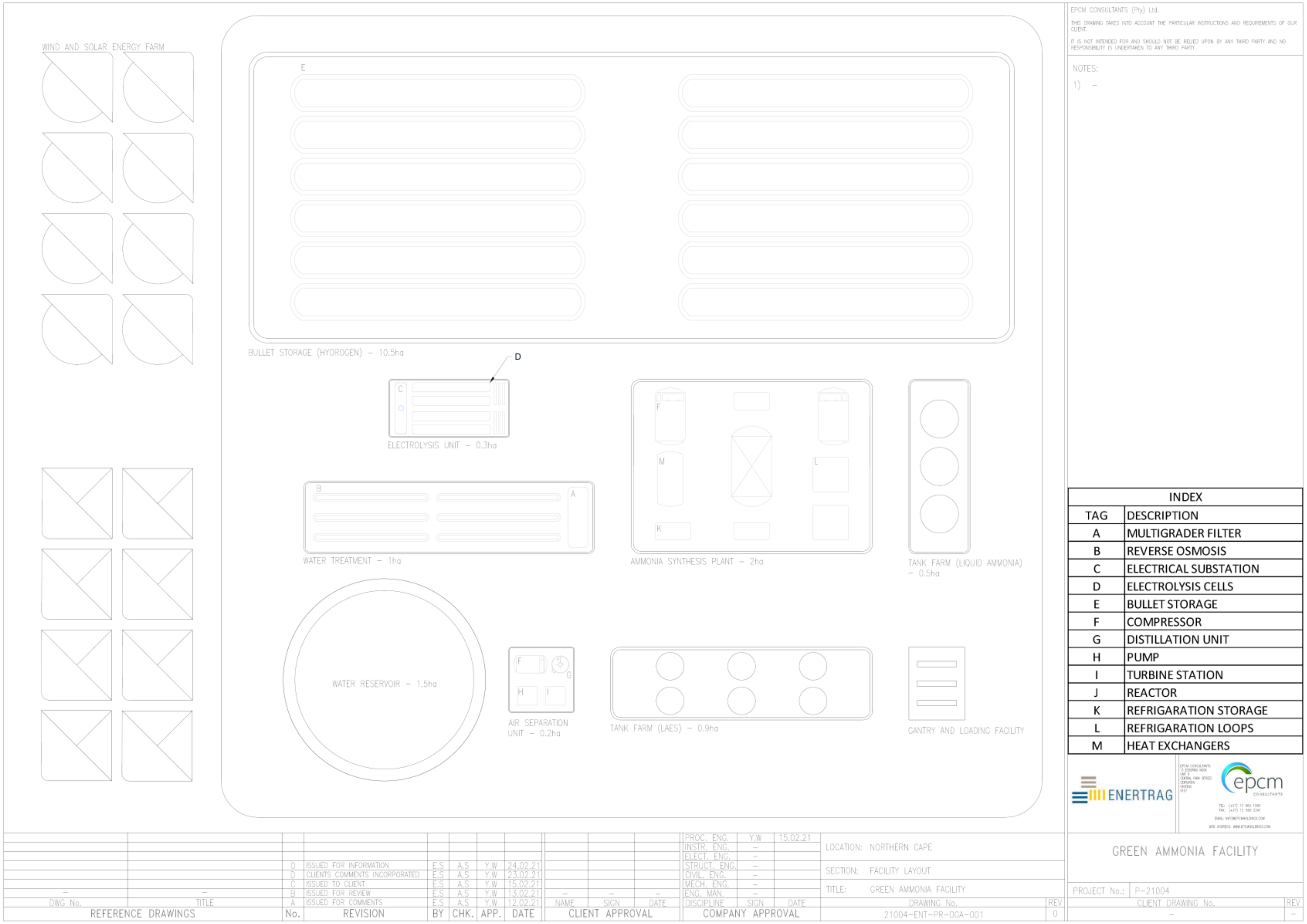


Figure 4-17: Road standard pressured tanker and Isotainer transport



Use of 40ft pressured tanker trucks or trucks with ISOtainer capability (20ft length each). Volumes will be up to 24 tons per truck load depending on pressured tanker or Isotainer, therefore 12 daily 24ton truck ISOtainer trucks envisaged. Depending on the final volumes transported, technical and financial feasibility, between 1 - 24ton road tankers (pressured tanker trucks or ISOtainers) may be utilised.

Figure 4-18: Indicative block layout of the proposed hydrogen and ammonia plant



5. IMPACT ASSESSMENT ASSUMPTIONS

This section of the report describes the assumptions used in the socio-economic impact assessment study and specifically in the economic modelling exercise which aims to quantify the economic impact of the project. The assumptions presented in this section refer to construction, operation, and decommissioning assumptions for the Project as provided.

5.1. GREEN HYDROGEN AND AMMONIA FACILITY

5.1.1 Construction phase assumptions

The following assumptions regarding the construction phase of the proposed Green Hydrogen and Ammonia Facility are made:

- The construction of the facility is planned to commence in 2025 contingent on project approval and will take 24 months to complete.
- The total South African investment into the establishment of the Green Hydrogen and Ammonia Facility is valued at R 4,2 billion.
- Only local expenditure is considered in this analysis.
- The construction of the facility will create an estimated 300 project specific full time equivalent (FTE) employment positions.

5.1.2 Operation phase assumptions

The assumptions regarding the operation phase of Green Hydrogen and Ammonia Facility used in the modelling exercise are as follows:

- The facility is anticipated to begin operating once construction is completed in 2027.
- The facility will operate for 20 years.
- The operations and maintenance cost of the facility will be valued at R 80,0 million per annum over the 20-year operational life of the project.
- The operation of the facility will create an estimated 100 full time equivalent (FTE) employment.

5.1.3 Decommissioning phase assumptions

The costs of decommissioning the plant are not yet known. Given the nature of green hydrogen technology, it is highly likely that instead of decommissioning the plant, the facility will be refurbished in order to extend its lifespan beyond the 20-year period.

6. POTENTIAL ECONOMIC IMPACTS AS A RESULT OF THE GREEN HYDROGEN AND AMMONIA FACILITY

This section of the report seeks to describe the economic impacts that are expected to occur as a result of the development of the Project.

6.1. DEFINING ECONOMIC IMPACTS

Economic impacts can be defined as the effects (positive or negative) on the level of economic activity in a given area(s). The net economic impact is usually measured as the expansion or contraction of an area's economy, resulting from the changes in (i.e., opening, closing, expansion or contraction of a facility, project, or programme.

6.1.1 Temporal nature of impacts

All new projects/interventions have two basic types of investments namely an initial capital injection/expenditure (CAPEX) which can take the form of either a greenfield development (i.e. new construction project on vacant land) or brownfield development (i.e. a modification of an existing structure and there is an annual investment made to maintain/operate the investment).

The economic impacts created by a capital injection (CAPEX) are once-off impacts that will only occur for the duration of construction. Thus, economic impacts associated with the construction phase are not sustainable economic impacts. Operational economic impacts, unlike capital expenditure economic impacts are sustainable and thus are calculated as an annual impact based on operational expenditure (OPEX) for a given year.

It is important to note that due to the temporal nature of CAPEX and OPEX, impacts should not be accumulated to determine the 'total' economic impact.

6.1.2 Types of economic impacts

The net economic impact of an exogenous change in the economy will be translated according to various direct and indirect economic effects, as are defined below:

- **Direct economic impacts:** These are the changes in local business activity occurring as a direct consequence of public or private activities in the economy, or public programmes and policies. Furthermore, increased user benefits lead to monetary benefits for some users and non-users (individuals and businesses) within the geographical area:
    - For affected businesses, there may be economic efficiency benefits in terms of product cost, product quality or product availability, stemming from changes in labour market access, cost of obtaining production inputs and/or cost of supplying finished products to customers. For affected residents, benefits may include reduced costs for obtaining goods and services, increased income from selling goods and services to outsiders,

and/or increased variety of work and recreational opportunities associated with greater location accessibility.

- **Indirect and induced impacts:** The direct benefits to business and the residents of communities and regions may also have broader impacts, including:
  - Indirect business impacts – business growth for suppliers to the directly affected businesses and potential growth of municipal revenue due to raised taxes and service levies.
  - Induced business impacts – business growth as the additional workers (created by direct and indirect economic impacts/effects) spend their income on food, clothing, shelter and other local goods and services.

6.1.3 Economic impacts considered

The direct and indirect economic impacts listed are measured according to the following broad economic variable categories:

- **Production/Business Sales**: refers to the value of all inter- and intra-sectoral business sales generated in the economy as a consequence of the introduction of an exogenous change in the economy. Explained more simply, new business sales equate to additional business turnover as a result of the introduction of an exogenous change in the economy.
- **Contribution to GVA:** GVA is a broader measure of the full income effect. This measure essentially reflects the sum of wage income and corporate profit generated in the study area as a result of an exogenous change in the economy.
- **Employment**: Refers to the employment resulting from the construction or operation of the project under investigation.
- **Personal Income:** Refers to the salaries and wages earned as a result of the employment generated from the development of the proposed green hydrogen facility

Using the Input/Output model methodology, various anticipated direct and indirect economic impacts of construction and operation phases of the proposed Complex have been identified. These economic impacts have been derived using an understanding of economic cause-effect relationships. The principle of cause-effect is that for any economic action, there can be a multitude of different economic reactions (effects).

6.2. ECONOMIC IMPACTS DURING THE CONSTRUCTION PHASE

The following table outlines the potential economic impacts during the construction phase of the Green Hydrogen and Ammonia Facility. The total impact on production/business sales is likely to equate to R 18,8 billion (direct, indirect and induced) for the duration of construction and will largely be spent in the Mpumalanga and Gauteng. The total impact on GDP (direct, indirect, and induced) is likely to be R 5,4 billion and create 300 FTE employment positions over the period of 24 months with the total impact on employment being 1 221 FTE employment positions. These will largely be felt through the construction sector and through the value chains associated with the construction of a green hydrogen.

Table 6-1: Estimated impact on the national and local economies (R' million, 2015 Basic prices) as well as employment (FTE positions) for the duration of construction

Indicator	Direct	Indirect	Induced	TOTAL
Impact on Production	R4 200	R8 068	R6 123	**R18 810**
Impact on Gross Domestic Product	R1 320	R2 306	R1 750	**R5 376**
Impact on Personal Income	R630	R1 100	R835	**R2 565**
Impact on Employment	300	524	398	**1 221**

6.3. ECONOMIC IMPACTS DURING THE OPERATION PHASE

The table below provides the potential economic impacts during the operation phase of the Green Hydrogen and Ammonia Facility, this specifically relates to the impact derived from the anticipated direct spend in the maintenance and upkeep of the facility. This does not account for the developer's mandated spend on community development projects, otherwise referred to as socio-economic development spend (SED).

The total impact on production/business sales once the project is fully operational is likely to equate to R 238 million (direct, indirect, and induced) per annum and will largely be spent in the Mpumalanga and Gauteng. The total impact on GDP (direct, indirect, and induced) is likely to be R 144 million per year. It is anticipated that 100 South African based FTE employment positions will be created for the operation of the proposed plant per annum. The total impact on employment will be 270 FTE employment positions which will largely be experienced in the utilities sector and other value chains associated with green hydrogen facility operations.

Table 6-2: Estimated impact on the national and local economies (R' million, 2015 Basic prices) as well as employment (FTE positions) for the duration of operation

Indicator	Direct	Indirect	Induced	TOTAL
Impact on Production	R80,0	R71	R79	R238
Impact on Gross Domestic Product	R53	R43	R48	R144
Impact on Personal Income	R15	R12	R13	R40
Impact on Employment	100	81	89	270

6.4. ECONOMIC IMPACT OF SED SPEND

As required by the National Energy Regulator of South Africa in relation to an Application for an Electricity Generation Licence in terms of the Electricity Generation Act (No. 4 of 2006), the applicant is required to demonstrate certain commitments to empowerment and economic development within the designated local area. The client has not yet indicated the SED plan, so the following provides guidelines of how SED could be incorporated.

The usual spend for SED for a fully operational project will be approximately 2,5% of the Gross Annual Revenue generated. Of the 2,5%, 0,5% could be contributed to the Just Energy Transition Fund, with the remaining 2% being spent on community development initiatives within the immediate vicinity of the proposed project.

The objectives of the above are set out as follows:
Socio-economic spend objectives:

- Increase in the level and diversify the type of skills in communities required to support conscious conservation; and
- Creation of sustainable employment opportunities for the local community which results in a sustainable increase in household income.

The SED spend commitments related to local community enrichment initiatives are detailed below. In future planning, specific budget allocations from the total annual figures could be targeting at the following initiatives:

- Skills Development: Both on-project, and non-wind energy skills development initiatives will be funded. The non-wind energy skills to be developed should be relevant and required in the region and should seek to provide value to the community and the environment.
- Employment Opportunities: In addition to the planned employment creation during construction and 20-year operation of the project, the developer could make a positive contribution to employment opportunities in other non-wind related industries.
- Standard of living for local communities: skills development coupled with sustainable employment creation opportunities listed above, are expected to contribute towards an improved standard of living amongst families that might not have had a sustainable income previously.

7. ASSESSMENT OF IMPACTS AS A RESULT OF THE GREEN HYDROGEN AND AMMONIA FACILITY

This section of the report seeks to describe and assess the economic and socio-economic impacts that are expected to occur as a result of the development of the Project. This section has separated the assessment of the Project into the projects three lifecycle phases namely construction, operation and decommissioning.

7.1. GREEN HYDROGEN AND AMMONIA FACILITY

7.1.1 Construction Phase Impacts

The following sub-sections indicate the impacts that are likely to occur during the construction phase of the proposed Green Hydrogen and Ammonia Facility. Since the facility is expected to have both positive and negative effects in terms of the same indicator, the evaluation of impacts has been grouped accordingly.

Positive impacts during construction:

a) Temporary stimulation of the national and local economy

The proposed facility will cost R 4,2 billion (2023 prices) to establish. This will equate to a total impact of R 18,8 billion (direct, indirect, and induced) on production/new business sales in the country. The localised expenditure on the project will stimulate the local and national economies albeit for a temporary period of 24 months during construction. It is estimated that the project will increase the GDP directly in the country by R 1,3 billion in 2021 prices, which will translate into a total impact of R 5,4 billion (direct, indirect, and induced) of Gross Domestic Product (GDP). These effects will take place for the duration of construction.

The greatest effects on production and GDP stimulated during construction activities will be created through the multiplier effects, specifically through a combination of production and consumption induced effects. The former refers to the impact generated along backwards linkages when the project creates demand for goods and services required for construction and subsequently stimulates the business sales of the suppliers of inputs that are required to produce these goods and services. The latter refers to the effects of household spending which is derived from an increase in salaries and wages directly and indirectly stimulated by the project's expenditure.

Sectors and industries that will experience the greatest stimulus from this expenditure include:

- Basic metals, structural metal products and other fabricated metal products industries
- Trade
- Insurance
- Transport services
- Electrical machinery and apparatus

b) Temporary increase employment in the national and local economies

The construction of the facility will create 300 Full Time Equivalent (FTE) employment positions over the course of the development. The total number of employment that will be created is estimated to 1 221 (including direct, indirect and induced). As evident by Table 3-5 the construction sector of the Local Municipality is relatively small employing only 7 546 people in 2021 (Quantec, 2023). Given the size of the construction sector within the municipality, it is anticipated that there will be sufficient local labour to satisfy the demand for 300 South African based construction workers.

Furthermore, if most of the local staff comes from the Local Municipality it will have a positive effect on local unemployment particularly since the area experiences an unemployment rate above the provincial average.

Beyond the direct employment opportunities that will be created by the project during the construction phase the development will also have a positive spin-off effect on the employment situation in other sectors of the national and local economies. Through the procurement of local goods (i.e., consumption induced effects) the project will support an estimated total of 524 FTE employment positions (indirect). Most of these positions will be in sectors such as construction, business services and trade. The expenditure on the project outside of the local economies will also have a positive effect on employment creation, albeit for a temporary period of 24 months. Through the production and consumption induced impacts the project is envisioned to create an estimated additional 398 FTE employment (induced) positions. Given that a significant portion of the multiplier effects will be generated through backward linkages, more than half of these FTE employment positions will be created along the supply chain and amongst industries providing inputs to the businesses in the supply chain.

Throughout the construction phase it is recommended that the developer encourage the EPC contractor to fill as many local positions as possible using labour from within the Local Municipality rather than from outside of the municipal boundaries.

c) Contribution to skills development in the country and local economy

The construction of the proposed facility is likely to have a positive impact on the skills development in South Africa. During the construction of the facility, which is planned to be conducted in Mpumalanga, it is likely that foreign technical experts will be involved. This will present an opportunity for skills and knowledge transfer between these technical experts and local manufacturers.

It is also expected that the construction staff involved in the project will gain knowledge and experience in respect of the development of such facilities. This will be highly beneficial given that this is relatively a new concept and the plant will be one of the first in South Africa. In addition to the direct effects of the project on skills development in the country and the local economy, the project could contribute to the development of the local research and development (R&D) and manufacturing industries associated with green hydrogen and ammonia technology. This could be achieved through partnerships with the University of Mpumalanga (situated in the Mbombela Local Municipality). Partnerships of this nature could further enhance the development of new skills and expertise.

d) Temporary increase in household earnings

The proposed facility will create an estimated total of 1 221 South African based FTE employment positions during construction generating R 2,6 billion of revenue for the affected households in the country through direct, indirect, and induced effects.

Of this figure R 630 million will be paid out in the form of salaries and wages to those individuals directly employed during the construction phase. The remaining R 1,9 billion in households' earnings will be generated through indirect and induced effects resulting from project expenditure. Given the average household size in the Local Municipality and Mpumalanga is 3,6 and 3,8 respectively, a total of between 1 080 and 1 140 people are likely to benefit from the employment positions created and the income derived through these 300 FTE employment positions.

Although temporary, this increase in household earnings will have a positive effect on the standard of living for these households. This is especially applicable to the households benefitting from the project that reside in the Local Municipality and broader Mpumalanga.

e) Temporary increase in government revenue

The investment in the facility will generate revenue for the government during the construction period through a combination of personal income tax, VAT, companies' tax etc. Additional government revenue will also be earned through corporate income tax, however since the gross operating surplus of the EPC contractor employed to construct the facility is not known, an estimate of the overall corporate income tax value is not possible at this stage. Government earnings will be distributed by national government to cover public spending which includes amongst others the provision and maintenance of transport infrastructure, health, and education services as well as other public goods.

Negative impacts during construction:

a) Negative changes to the sense of place

A community's sense of place is developed over time as it embraces the surrounding environment, becomes familiar with its physical properties, and creates its own history. The sense of place is created through the interaction of a number of different factors such as the areas visual resources, its aesthetics, climate, culture, and heritage as well as the lifestyle of individuals that live in and visit the area. Most importantly, it is a highly subjective matter and dependent on the demographics of the population that resides in the area and their perceptions regarding trade-offs.

For example, a community living in poverty is generally more likely to be accepting of industrial-type development that promises employment opportunities while a more affluent residential area is more likely to oppose such a development on the grounds that the development is not likely to generate gains for the community (Sinding, 2009). The area proposed for the development as well as its surrounds does have large-scale industries such as coal mining. Noise and light intrusion during the night in the area is currently high.

Given the above characteristics the area can be defined as being largely rural with mining activities. Any rapid changes that alter the characteristics that define the area's sense of place could potentially have a negative impact to the local population's sense of place. During the construction of the proposed facility there are likely to be noise and dust impacts caused by the movement of vehicles as well as construction activities on site.

These impacts are anticipated to occur primarily during the day with illumination from the site being experienced during the night. The presence of this noise is likely to alter the way the surrounding environment is experienced by households (farms) in the area. As construction activities progress and the footprint of the facility grows, the visual impact will also become more apparent and the sense of place experienced by households residing within the visually affected area will be altered further. It is anticipated that residents residing on the farm on which the facility is proposed to be established will experience the greatest disruption in their sense of place during the construction period. Individuals who live on the surrounding farms will, over the course of the construction phase of the project, be subjected to either visual or noise disruptions that are currently not present in the area.

The sense of place at the farms located adjacent to or beyond the site of the proposed facility will also be affected to some extent. The facility will be visible from several of these farms. The visual exposure on all these farms during the construction phase will not be continuous given the proximity of some of the farms from the proposed facility. Nevertheless, the knowledge of the facility near the farm and the fact that it could be seen from some parts will still have a negative connotation and will alter the sense of place experienced by the households residing on these farms. As stated, the sense of place of local residents is likely to begin to be altered once the construction of the proposed facility begins.

Visual impacts will, however, remain for the entire operation of the development, this means that although the effect on the sense of place could be relatively small considering the population to be affected, the duration of the impact increases it significantly. It is advisable that all efforts be made to address the factors that will affect individual's sense of place such as visual effects and noise pollution to make them less intrusive. However, due to the current activities in the area, the proposed project will not have a significant impact on the sense of place, as the area is already severely affected by the mining activities.

b) Negative impact on the local agriculture operations

As construction begins at the proposed site, disturbances will likely be minimal. The presence of construction machinery, increased traffic to and from the site (transporting staff, equipment, and material) and staff on or near the site will likely be the largest disturbances. The longer construction continues, the greater the disturbances will likely be. As the plant, and related infrastructure are erected there is likely to be an increased disturbance as this become increasingly visible in the surrounding area.

Once construction is completed the disturbances associated with the vehicular traffic, equipment and staff will be reduced and the remaining disturbance will be that of the facility itself. According to the landowner's survey's they indicated that some agricultural land will be lost, but they support the project. Thus, the impact on the agricultural operations will be minor.

c) Temporary increase in social conflicts associated with the influx of people

Neither the local nor the surrounding municipalities are sufficiently diversified to supply the entire workforce for the construction of the proposed green hydrogen facility, particularly in terms of skilled positions. A significant number of the unskilled and semi-skilled workers required during the construction phase will however be sourced locally. In addition, given the scale and extent of the development, the project is likely to attract job seekers from other parts of the country, particularly from within Mpumalanga and Gauteng. This would be in addition to the migrant workers contracted to work on the project.

The migration of people to the area could result in social conflicts between the local population and the migrant work force as the local population could perceive these migrant workers as "stealing" their employment opportunities. Likewise, the influx of people into the area, could potentially lead to a temporary increase in the level of crime, illicit activity and possibly a deterioration of the health of the local community through the spread of infectious diseases. Semi-skilled and unskilled construction workers could also choose to remain in the area following the completion of the construction phase. Without any form of income these individuals run the risk of exacerbating the level of poverty within the Local Municipality. Aside from the broader community issues the increase in the number of people in the area is likely to have an adverse effect on crime levels, incidents of trespassing, development of informal trading and littering. There is also potentially a likelihood of increased stock theft. The influx of job seekers and the potential social conflicts that can arise with in-migration of temporary workers to an area is difficult to mitigate. Appropriate awareness campaigns and strict adherence to recruiting practices could, however, reduce the extent of the adverse effect.

Addressing the challenges related to potential social impacts is best done in partnership with all stakeholders in the area, specifically the affected and adjacent property owners, local communities, ward communities and municipalities. This would promote transparency; information sharing and help build good relationships between all affected parties. In addition, all opportunities that would include the community in the project should be explored and where possible implemented.

Employment opportunities, including the provision of ancillary services, are particularly relevant in this incidence as the creation of employment opportunities for locals could eliminate the potential alienation between the community and the project as well as migrant workers.

d) Impact on economic and social infrastructure

The proposed facility will create and estimated 300 FTE employment positions (South African based positions) for the duration of the project. Given that these workers will require services there is likely to be an increase in the demand for social services, access to water and electricity. Given the proximity of the development site to Hendrina, it is most likely that the health facilities in the area will experience additional demand for medical services brought about by the influx of works and job seekers.

If a construction camp is established to accommodate workers there will be a need for additional water and electrical connections for both the camp as well as the site office. These connections will, however, be minimal and it is unlikely to alter the demand significantly. The effects of the project on road infrastructure should also be considered as it is highly likely that the development will lead to an increase in traffic volumes on surrounding roads. The deterioration of these roads could place additional financial burdens on the municipality through additional maintenance costs. Additional traffic volumes are also likely to impact the condition of secondary roads used to access surrounding farms. The deterioration of secondary roads could add additional operating costs to farmers in the area due to delays in deliveries and damage to vehicles.

Based on the above discussion it is expected that the basic service provision, health facilities and road infrastructure will be under additional strain during the construction period. Given that the project is anticipated to attract additional people to the area the significance of the impact is considered to be medium. These impacts can however be mitigated if the developer engages with the local municipalities and plans accordingly.

7.1.2 Operation Phase Impacts

The following sub-section describes the impact that the facility will have once it is operational. The facility is envisaged to have a lifespan of approximately 20 years which means that the impacts observed during this phase, regardless of whether the impacts are positive or negative, will be long-lasting.

Positive impacts during operations:

a) Sustainable increase in production and GDP nationally and locally

The proposed facility will require an annual operational expenditure of R 80 million over 20 years. The total impact on production in the country as a result of the project’s operations will equate to R 238 million per annum in 2023 prices for the 20 years. Aside from the utilities sector, industries that will experience the greatest stimulus from the project will include electrical machinery and apparatus, insurance, trade, transport service and chemical production industry. It is estimated that the project will generate R 53 million of value add per year over the 20-year period (comprising gross operating surplus before taxes and labour) and taxes.

In addition to the positive production and GDP impacts arising from expenditure related to the operation of the WEF, the local economy is anticipated to be positively stimulated by expenditure related to the developer's intended socio-economic development contributions in the immediate area.

b) Creation of sustainable employment positions nationally and locally

The proposed facility will create an estimated 100 permanent employment positions across the operation phase of the development which, will be retained for approximately 20 years. Of these, an estimated 100 will be South African based positions. It is envisaged that some of the skilled and low skilled staff will be employed from within the local area with the remaining staff being sourced from other parts of Mpumalanga and the country. Aside from the direct employment opportunities, the facility will support an estimated 89 FTE employment positions created through the production and consumption induced effects. Due to the spatial allocation of procurement spending and direct employment created, most of the indirect and induced positions will also be created within the local area. The trade, manufacturing and community and personal services sectors will benefit the most from these new employment opportunities.

c) Skills development of permanently employed workers

Highly skilled personnel would need to be recruited from outside of the Local Municipality as the economy would not be diversified enough to attract such specialists. These employees would include skilled "mechatronics" engineers (specialised in both electrical and mechanical engineering) likely to be recruited from the Johannesburg Metro.

As part of the developer's intended SED contributions to the immediate area, both on-project, and non-hydrogen and ammonia skills development initiatives will be funded. The non-energy skills to be developed should be relevant and required in the region and should seek to provide value to the community and the environment.

d) Improved standards of living for benefiting households

The creation of an estimated 270 FTE employment positions throughout the country will generate R 39 million of personal income (2023 prices), which will be sustained for the entire duration of the project's lifespan. Given the average household size in affected local municipalities and nationally, this increase in household earnings will support several people. The sustainable income generated as a result of the project's operation will positively affect the standard of living of all benefitting households. This is specifically applicable to the Local Municipality, as the average income per employee at the facility would far exceed the average household income within these municipalities. Skills development coupled with sustainable employment creation opportunities as a result of the developer's intended SED spend, are expected to contribute towards an improved standard of living amongst families that might not have had a sustainable income previously.

e) Sustainable increase in national and local government revenue

The proposed facility will, through property taxes and salaries and wages payments, contribute towards both local and national government revenue. At a local level, the project will contribute to local government through payments for utilities used in the operation of the facility. It will also increase its revenue through an increase in property taxes compared to the current level. Given that the Local Municipality has a relatively small economy, any additional income would greatly benefit the municipality. On a national level, the revenue derived by the project during its operations, as well as the payment of salaries and wages to permanent employees will contribute to the national fiscus. Although it is impossible to trace exactly how such revenue is allocated, any additional revenue generated means that national governments can increase its spending on public goods and services.

f) Local economic and social development benefits derived from the project's operations

The proposed facility will make a notable contribution to poverty and social and community development in the area. It is advised that 2% of the gross annual revenue will be dedicated to socio-economic and economic development initiatives for the duration of operation of the green hydrogen facility, while 0.5% will be channelled to the Just Energy Transition Fund. Thus, this revenue share of the project can subsequently be utilised for local social and economic development projects.

Since the community has not yet been selected, it is not possible to quantify the number of households that will be direct beneficiaries of the project at this stage. Furthermore, the social and economic development plan will prioritise numerous local welfare projects and community development initiatives that will be directed at uplifting local people and improving their standards of living.
At this stage it is unknown how much the proposed development will contribute towards local economic development but, it is envisioned that the revenue generated for local economic development will be significant and assist in uplifting the local communities.

g) Sustainable rental revenue for farms where the facility is located

It is anticipated that farms where the facility are located on will enter into a rental agreement with the developer. The owners will likely thus receive rental revenue as a result of hosting the facility on their property. The revenue that the owners of the properties receive will have a positive impact on the local economies especially if spent in the local area. This revenue is also likely to assist local property owners in dealing with economic shocks to their current business activities such as drought or unfavourable economic conditions that currently prevail. The revenue generated from the rental of land for the facility will additionally assist farmers in investing in new technologies to improve the efficiencies of their current agricultural practices and allow farmers to better compete in the open market.

h) Sustainable increase in hydrogen and ammonia production in South Africa

The development of the facility will lead to a sustainable increase in the supply of hydrogen and ammonia for the country. Commercially, hydrogen is used as a fuel for transport in hydrogen fuel cells. Alternatively, hydrogen is used for welding and in the production of other chemicals such as methanol and hydrochloric acid and also has other commercial uses like the filling of balloons. It is also a primary input to the production of ammonia. Ammonia in turn is primarily used in the production of ammonium nitrate (fertiliser) and is also used as refrigerant gas and the manufacture of plastics, explosives, textiles, pesticides and other chemicals. Ammonia can also be used as a stable ‘carrier’ of hydrogen, allowing hydrogen to be readily stored and transported.

Negative impacts during operations:

a) Negative changes to the sense of place

The effects on the community’s sense of place will initially be felt during the construction period and will continue into the operation phase. The assessment of the negative change in the sense of place that was examined in the construction phase will likely be in place during the operation phase due to the long-term duration of the development. However, due to the current conditions (coal mining) in the area, the facility will not have a significant negative impact on the sense of place.

b) Negative impact on agricultural operations

The impact of agricultural land was assessed through a survey that was distributed among the landowners. Some of the landowners indicated that they will be impacted by reduced dryland farming portions due to the facility (approximately 20 hectares). However, the landowners indicate that they are comfortable with the project and support the renewable energy that will be created. Thus, the impact on the farming operations will be low due to the local farming community’s support.

7.1.3 Decommissioning Phase Impacts

Upon the expiry of the facility’s lifespan, the facility would need to be disbanded, although the facility would likely be upgraded in order to maintain and prolong the lifespan of the facility. If the facility is decommissioned, the land will be rehabilitated in order to return it to pre-project conditions. This also means that all impacts whether positive or negative, which take place during the operation phase will cease to exist. At the same time spending on the disassembly of the components and rehabilitation of land will increase the demand for construction services and other industries, thus stimulating economic activity in the local area, albeit over a temporary period. Socio-economic impacts stimulated during the decommissioning phase are expected to be similar to those that took place during the construction phase.

Table 7-1: Hydrogen and Ammonia Facility Construction Phase Impact Table

Impact number	Aspect	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation						
						(M+	E+	R+	D)x	P=	S	Rating
Impact 1:	Production/new business sales	Temporary increase in the GDP and production of the national and local economies during construction	Construction	Positive		4	5	3	1	5	**65**	**P4**
					Significance	**P4 - High**						
Impact 2:	Increase in Employment	Temporary increase employment in the national and local economies	Construction	Positive		4	4	2	1	4	**44**	**P3**
					Significance	**P3 - Moderate**						
Impact 3:	Improved skills	Contribution to skills development in the country and local economy	Construction	Positive		4	4	2	1	4	**44**	**P3**
					Significance	**P3 - Moderate**						
Impact 4:	Increase in household income	Temporary increase in household earnings	Construction	Positive		4	4	2	1	5	**55**	**P3**
					Significance	**P3 - Moderate**						
Impact 5:	Increase in personal TAX and VAT	Temporary increase in government revenue	Construction	Positive		2	4	1	1	4	**32**	**P3**
					Significance	**P3 - Moderate**						
Impact 6:	Construction activities of the Facility	Negative changes to the sense of place	Construction	Negative		4	3	2	1	4	**40**	**N3**
					Significance	**N3 - Moderate**						
Impact 7:	Noise and space	Impact on the agriculture operations	Construction	Negative		3	2	1	1	4	**28**	**N2**
					Significance	**N2 - Low**						
Impact 8:	Influx of people	Temporary increase in social conflicts	Construction	Negative		3	4	2	1	4	**40**	**N3**
					Significance	**N3 - Moderate**						
Impact 9:	Impact on basic services	Impact on economic and social infrastructure	Construction	Negative		3	4	2	1	4	**40**	**N3**
					Significance	**N3 - Moderate**						

Table 7-2: Hydrogen and Ammonia Facility Construction Phase Mitigations

No	Activity	Management Actions
1	Construction activities of the Facility	The developer should encourage the contractor to increase the local procurement practices and promote the employment of people from local communities, as far as feasible, to maximise the benefits to the local economies. The developer should engage with local authorities and business organisations to investigate the possibility of procuring construction materials, goods and products from local suppliers were feasible.
2	Employees need to conduct construction activities	Co-ordinate with the local municipality and relevant labour unions to inform the local labour force about the project that is planned to be established and the jobs that can potentially be applied for. Recruit local labour as far as feasible. Employ labour-intensive methods in construction where feasible. Sub-contract to local construction companies particularly SMMEs and BBBEE compliant enterprises where possible. Use local suppliers where feasible and arrange with the local SMMEs to provide transport, catering and other services to the construction crews.
3	Skills learned by employees during construction	Facilitate knowledge and skills transfer between foreign technical experts and South African professionals during the pre-establishment and construction phases. Facilitate a broader skills development programme as part of socio-economic development commitments.
4	Employee salaries	Recruit local labour as far as feasible to increase the benefits to the local households. Employ labour intensive methods in construction where feasible. Sub-contract to local construction companies where possible.
5	Public spending	None suggested
6	Construction activities of the Facility	Natural areas that are not affected by the footprint should remain as such. Efforts should also be made to avoid disturbing such sites during construction. Public relations (PR) campaign prior to commencement of construction to communicate to community members the construction programme, inclusive of regular updates to generate excitement in the community
7	Construction activities on farms	Ensure that the farm owners are aware of construction activities that will take place on their premisses.
8	Influx of people	Employ locals as far as feasible through the creation of a local skills database. Ensure that any damages or losses to nearby affected farms that can be linked to the conduct of construction workers are adequately reimbursed. Assign a dedicated person to deal with complaints and concerns of affected parties.
9	Increase in local traffic and migration of construction workers	Provide adequate signage along the access roads to warn motorists of the construction activities taking place on the site. Where feasible, assist the municipality in ensuring that the quality of the local social and economic infrastructure does not deteriorate through the use of social responsibility allocations.

Table 7-3: Hydrogen and Ammonia Facility Construction Phase Impacts with Mitigation

Impact number	Aspect	Description	Stage	Character	Ease of Mitigation	Post-Mitigation						
						(M+	E+	R+	D)x	P=	S	Rating
Impact 1:	Production/new business sales	Temporary increase in the GDP and production of the national and local economies during construction	Construction	Positive		4	5	4	1	5	**70**	**P4**
					Significance	**P4 - High**						
Impact 2:	Increase in Employment	Temporary increase employment in the national and local economies	Construction	Positive		4	4	3	1	4	**48**	**P3**
					Significance	**P3 - Moderate**						
Impact 3:	Improved skills	Contribution to skills development in the country and local economy	Construction	Positive		4	4	3	1	4	**48**	**P3**
					Significance	**P3 - Moderate**						
Impact 4:	Increase in household income	Temporary increase in household earnings	Construction	Positive		5	4	2	1	5	**60**	**P3**
					Significance	**P3 - Moderate**						
Impact 5:	Increase in personal TAX and VAT	Temporary increase in government revenue	Construction	Positive		2	4	2	1	4	**36**	**P3**
					Significance	**P3 - Moderate**						
Impact 6:	Construction activities of the Facility	Negative changes to the sense of place	Construction	Negative		4	3	1	1	4	**36**	**N3**
					Significance	**N3 - Moderate**						
Impact 7:	Noise and space	Impact on the agriculture operations	Construction	Negative		2	2	1	1	4	**24**	**N2**
					Significance	**N2 - Low**						
Impact 8:	Influx of people	Temporary increase in social conflicts	Construction	Negative		2	2	1	1	4	**24**	**N2**
					Significance	**N2 - Low**						
Impact 9:	Impact on basic services	Impact on economic and social infrastructure	Construction	Negative		3	4	1	1	4	**36**	**N3**
					Significance	**N3 - Moderate**						

Table 7-4: Hydrogen and Ammonia Facility Operational Phase Impact Table

Impact number	Receptor	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation						
						(M+	E+	R+	D)x	P=	S	
Impact 1:	Production/new business sales	Sustainable increase in the GDP and production of the national and local economies	Operational	Positive		3	5	2	4	4	**56**	**P3**
					Significance	**P3 - Moderate**						
Impact 2:	Increase in Employment	Creation of sustainable employment positions nationally and locally	Operational	Positive		3	5	1	4	4	**52**	**P3**
					Significance	**P3 - Moderate**						
Impact 3:	Improved skills	Skills development of permanently employed workers	Operational	Positive		2	4	2	4	4	**48**	**P3**
					Significance	**P3 - Moderate**						
Impact 4:	Increase in household income	Improved standards of living for benefiting households	Operational	Positive		3	4	2	4	4	**52**	**P3**
					Significance	**P3 - Moderate**						
Impact 5:	Property taxes, salaries and wages	Sustainable increase in national and local government revenue	Operational	Positive		3	5	3	4	4	**60**	**P3**
					Significance	**P3 - Moderate**						
Impact 6:	Operational expenditure	Local economic and social development benefits derived from the project's operations	Operational	Positive		3	4	3	4	4	**56**	**P3**
					Significance	**P3 - Moderate**						
Impact 7:	Additional revenue	Sustainable rental revenue for farms where the facility is located	Operational	Positive		2	1	3	4	5	**50**	**P3**
					Significance	**P3 - Moderate**						
Impact 8:	Additional hydrogen and ammonia produced	Sustainable increase in hydrogen and ammonia available for the local region and South Africa	Operational	Positive		2	5	4	4	5	**75**	**P4**
					Significance	**P4 - High**						
Impact 9:	Visual impacts	Negative changes to the sense of place	Operational	Negative		2	2	5	4	5	**65**	**N4**
					Significance	**N4 - High**						
Impact 10:	Loss of space	Impact on the agriculture operations	Operational	Negative		2	1	5	4	4	**48**	**N3**
					Significance	**N3 - Moderate**						

Table 7-5: Hydrogen and Ammonia Facility Operational Phase Mitigations

No	Activity	Management Actions
1	Operational expenditure	The operator of the green hydrogen facility should be encouraged to, as far as possible, procure materials, goods and products required for the operation and maintenance of the facility from local suppliers to increase the positive impact in the local economy
2	Operational team for facility	Where possible, local labour should be considered for employment so as to increase the positive impact on the local economy.
3	Skills learned by employees during operations	The developer should consider establishing vocational training programmes for the local labour force to promote the development of skills required by the green hydrogen facility and thus provide for the opportunities for these people to be employed in other similar facilities elsewhere in the future.
4	Employee salaries	Where possible, the local labour supply should be considered for employment opportunities to increase the positive impact on the area's economy.
5	Public spending	None suggested
6	Operational expenditure	When identifying enterprise development initiatives, the focus should be on creating sustainable and self-sufficient enterprises. In devising the programmes to be implemented, the developer should take into account the local Integrated Development Plans.
7	Operational expenditure	None suggested
8	Facility operation	None suggested
9	Visual impacts	Natural areas that are not affected by the footprint should remain as such. Efforts should also be made to avoid disturbing such sites during operations.
10	Facility operation	Ensure that the farm owners get the revenue from rent paid

Table 7-6: Hydrogen and Ammonia Facility Operational Phase Impacts with Mitigation

Impact number	Receptor	Description	Stage	Character	Ease of Mitigation	Post-Mitigation						
						(M+	E+	R+	D)x	P=	S	
Impact 1:	Production/new business sales	Sustainable increase in the GDP and production of the national and local economies	Operational	Positive		3	5	3	4	4	**60**	**P3**
					Significance	**P3 - Moderate**						
Impact 2:	Increase in Employment	Creation of sustainable employment positions nationally and locally	Operational	Positive		3	5	2	4	4	**56**	**P3**
					Significance	**P3 - Moderate**						
Impact 3:	Improved skills	Skills development of permanently employed workers	Operational	Positive		3	4	2	4	4	**52**	**P3**
					Significance	**P3 - Moderate**						
Impact 4:	Increase in household income	Improved standards of living for benefiting households	Operational	Positive		3	4	3	4	4	**56**	**P3**
					Significance	**P3 - Moderate**						
Impact 5:	Property taxes, salaries and wages	Sustainable increase in national and local government revenue	Operational	Positive		3	5	3	4	4	**60**	**P3**
					Significance	**P3 - Moderate**						
Impact 6:	Operational expenditure	Local economic and social development benefits derived from the project's operations	Operational	Positive		4	4	3	4	4	**60**	**P3**
					Significance	**P3 - Moderate**						
Impact 7:	Additional revenue	Sustainable rental revenue for farms where the facility is located	Operational	Positive		2	1	3	4	5	**50**	**P3**
					Significance	**P3 - Moderate**						
Impact 8:	Additional hydrogen and ammonia produced	Sustainable increase in hydrogen and ammonia available for the local region and South Africa	Operational	Positive		2	5	4	4	5	**75**	**P4**
					Significance	**P4 - High**						
Impact 9:	Visual impacts	Negative changes to the sense of place	Operational	Negative		2	2	4	4	4	**48**	**N3**
					Significance	**N3 - Moderate**						
Impact 10:	Loss of space	Impact on the agriculture operations	Operational	Negative		2	1	5	4	3	**36**	**N3**
					Significance	**N3 - Moderate**						

The following can be concluded from the data presented in tables above as a summary of the Project:

- ***During construction:*** The comparison of gains and losses associated with the project during the construction phase indicates that gains related to production, employment, skills development, government revenue and household income outweigh the expected losses with regard to the same indicators. This shows that from a pure economic perspective the project's construction would be highly beneficial to the national economy and specifically the local economy which is affected by a relatively high unemployment level. The project will, however, bring some form of disruption in the lives of the local communities and will put additional pressure on the local economic and social infrastructure. Furthermore, there is a very low probability that the property values of nearby farms could be affected although evidence at a national and international level indicate this is unlikely. The main trade-off during the construction phase would therefore be between the economic net benefits that would accrue in the national and local economies and the socio-economic negative impacts experienced by the local communities. The positive net effect on the economy though is deemed to be notably greater than the negative net effects that can ensue from the project.

- ***During operations:*** The project is associated with a notably greater set of positive net impacts than negative net impacts. It is also evident that when considering the nation-wide effects of the project on production, employment, income, and government revenue it is associated with greater potential gains than losses. Locally, the project is also associated with greater positive economic gains than losses, especially in respect of community benefits, employment and household income. Net negative impacts that can ensue from the project are expected to relate to the loss of sense of place. This impact will be caused by changes in aesthetics and visual resources of the environment and can be mitigated to some degree although not entirely eliminated. Nevertheless, the positive net effects are expected to outweigh the net negative impacts.

- ***During decommissioning:*** The impacts that can occur during decommissioning would be similar to those observed during the construction phase. These impacts would however be experienced over a much shorter period and would be associated with significantly lower gains. Some impacts on the local infrastructure and the lives of the communities in the area could take place, however, they will also be short lived. Overall, the trade-offs between positive and negative impacts would be small.

The review of the net effects of the project and the trade-offs between positive and negative impacts suggest that positive effects and impacts would outweigh the negative effects. This is largely due to the fact that the project is expected to have a positive net impact on economic development, employment, household earnings, government revenue and skills development in the country and most importantly in the local community that experiences a high unemployment rate as well as a small economic base. The negative impacts that are expected to occur as a result of the project will be far more localised and would affect a significantly smaller number of people and households than in the case of the net benefits that would be derived by the project.

8. KEY FINDINGS AND RECOMMENDATIONS

This report contains the analysis of the socio-economic impact assessment for the proposed Hendrina Green Hydrogen and Ammonia Facility. The facility is proposed to be established on several farms within the vicinity of near Hendrina in the Mpumalanga Province. Once construction is completed the facility is anticipated to have an operational lifespan of 20 years.

The purpose of the socio-economic impact assessment is to determine, and where possible, quantify the potential socio-economic impacts that can result from the proposed project. It compares various alternatives and, based on these, provides recommendation in respect of the most beneficial option. The study made use of the economic modelling technique based on the Social Accounting Matrix to quantify the potential positive and negative impacts of the project where feasible and applicable.

The following section outlines the key findings of the study and provides recommendations on the way forward.

8.1. POLICY REVIEW AND BASELINE ASSESSMENT

The study includes an analysis of various strategic polices and documents, as well as the socio-economic characteristic of the study area to understand the context within which the proposed facility is to be established.

The review of the policy environment covered national, provincial, and municipal strategic documents. The review of national strategic documents suggested that the utilisation of renewable energy sources in the country is considered to be an integral means of reducing the carbon footprint of South Africa, diversifying the national economy, and reducing poverty. This means that any project that would contribute towards achieving the above-mentioned objectives could be considered to be strategically important.

It can thus be concluded that the policy reviewed supports the proposed development from a planning perspective as it will contribute to the development of the economic and social environment of the region.

The review of the local municipality's socio-economic characteristics revealed that the Local Municipality economy is relatively small and dependant on the mining and quarrying, manufacturing and finance and business services sectors. This indicates that the proposed project will further contribute to these strong economic sectors in the Local Municipality. In 2023, Steve Tshwete Local Municipality has a population of approximately 289 117 as well as population growth trends that suggest in-migration. This figure is also indicative of an area with low employment absorption capacity and a small economic base. The average household income for the area was R 11 778 per month – which was 35% higher than the district figure. There is also a high unemployment rate (28%) and a relatively poor labour participation rate (45%).

8.2. IMPACTS ASSOCIATED WITH THE PROJECT

The proposed Project will generate both positive and negative impacts starting from the construction period and ending with the decommissioning phase. The following paragraphs and tables summarise the key socio-economic impacts that were identified to have the potential to occur during the different phases and sub-projects.

8.2.1 Impacts during construction

During the construction phase, the proposed facility will have both positive and negative effects on the socio-economic environment.

The facility is anticipated to make a prominent contribution towards the national and local economy. It is estimated that a total of R 18,8 billion of new business sales, R 5,3 billion of GDP and 1 221 FTE employment positions will be generated by the project in the national economy through multiplier effects. Aside from the above positive effects, the project will contribute to skills development in the country, specifically as far as construction of the hydrogen and ammonia facility is concerned as well as increasing household earnings. The increase in household earnings is also likely to improve the standards of living of the affected households albeit temporarily.

Aside from the positive impacts though, the project will be creating negative direct, secondary and cumulative impacts on the local communities, specifically areas surrounding the site where the proposed facility is to be built. The main factors that will cause this negative impact are (1) the influx of workers and job seekers from outside of the local community and (2) visual and noise disturbances that would be created by the construction activities as the footprint of the facility grows. Potential negative impacts can be mitigated, although some more successfully than others. Visual impacts though cannot be eliminated although it is possible to reduce their significance. The summary of the significant socio-economic impacts during construction is provided in Table 8-1.

Table 8-1: Summary of construction phase impacts resulting from the facility

Impact	Nature of Impact	Before Mitigation	After Mitigation
CONSTRUCTION PHASE			
Temporary increase in the GDP and production of the national and local economies during construction	Positive	High (65)	High (70)
Temporary increase employment in the national and local economies	Positive	Moderate (44)	Moderate (48)
Contribution to skills development in the country and local economy	Positive	Moderate (44)	Moderate (48)
Temporary increase in household earnings	Positive	Moderate (55)	Moderate (60)
Temporary increase in government revenue	Positive	Moderate (32)	Moderate (36)
Negative changes to the sense of place	Negative	Moderate (40)	Moderate (36)
Impact on the agriculture operations	Negative	Low (28)	Low (24)

Impact	Nature of Impact	Before Mitigation	After Mitigation
Temporary increase in social conflicts	Negative	Moderate (40)	Low (24)
Impact on economic and social infrastructure	Negative	Moderate (40)	Moderate (36)

8.2.2 Impacts during operations

During the operation of the facility the socio-economic impacts are likely to last longer when compared to those observed during the construction phase. This is the case for both positive and negative effects. The operation of the proposed Project will generate R 237 million of new business sales, contribute R 144 million to GDP and create 100 sustainable FTE employment positions. The developer's intended SED spend will also notably contribute towards local employment, skills development and various conservation enterprises within the immediate area.

Negative impacts include the potential loss of sense of place and potential loss of income from agriculture-based businesses. These potential losses may, however, be mitigated by the rental that will be paid to land owners where the facility will be erected. As in the case with the impacts observed during construction, negative effects can be mitigated, and positive impacts enhanced. Mitigation of the negative impacts though will not result in their complete elimination as visual disturbance of the nature inherent to the project are difficult to eradicate entirely. Nevertheless, the significance ratings of the negative impacts are expected to be somewhat reduced.

Table 8-2: Summary of operational phase impacts resulting from the facility

Impact	Nature of Impact	Before Mitigation	After Mitigation
OPERATIONAL PHASE			
Sustainable increase in the GDP and production of the national and local economies	Positive	Moderate (56)	Moderate (60)
Creation of sustainable employment positions nationally and locally	Positive	Moderate (52)	Moderate (56)
Skills development of permanently employed workers	Positive	Moderate (48)	Moderate (52)
Improved standards of living for benefiting households	Positive	Moderate (52)	Moderate (56)
Sustainable increase in national and local government revenue	Positive	Moderate (60)	Moderate (60)
Local economic and social development benefits derived from the project's operations	Positive	Moderate (56)	Moderate (60)
Sustainable rental revenue for farms where the facility is located	Positive	Moderate (50)	Moderate (50)
Sustainable increase in hydrogen and ammonia available for the local region and South Africa	Positive	High (75)	High (75)
Negative changes to the sense of place	Negative	High (65)	Moderate (48)
Impact on the agriculture operations	Negative	Moderate (48)	Moderate (36)

8.2.3 Impacts during decommissioning

Socio-economic impacts stimulated during the decommission phase are expected to be similar to those that take place during the construction phase. The impacts though are expected to be of low significance due to the very short duration therefore and lower magnitude. Enhancement and mitigation measures proposed for the construction phase impacts would also apply to the decommissioning phase.

8.2.4 Cumulative Impacts

Currently the Hendrina Green Hydrogen and Ammonia Facility is the only project of its kind in the area. Resulting in limited cumulative impacts, however should the facility be constructed simultaneously with the Hendrina North and South Wind Energy facilities, some cumulative impacts will be experienced.

8.3. NET EFFECT AND TRADE OFF ANALYSIS

The assessment of the proposed facility, and its net effective impact from a socio-economic perspective, indicates that the project would generate greater socio-economic benefits during both the construction and operation phases than the potential losses that could occur as a result of its establishment. Stimulation of production, employment, government revenue, skills development and household income as a result of the investment in the project and its subsequent operations will outweigh possible production, employment and household income losses that could be experienced by local businesses affected by changes in the areas aesthetic and visual resources. It should be noted though that the positive and negative impacts will be distributed mostly amongst different receptors but will not result in inequality. Adherence to the proposed mitigation measures, however, would ensure that the offset of impacts is more balanced and that it also takes into account communities and businesses that will be negatively affected.

The positive effects generated by the project will not directly offset many of the negative impacts. These include impacts on the sense of place and property and business values that could occur during both construction and operation, the effect on social and economic infrastructure, and crime and social conflicts in the area that could be created during only the construction phase. These impacts though will only affect local communities either temporarily or over the long term.

These impacts are not highly significant and can be traded off for the net positive impact created by the project in terms of production, employment, government revenue, community benefits and households' earnings. This means that when compared with the no-go option, the proposed project is associated with greater socio-economic benefits.

8.4. RECOMMENDATIONS

Based on the information presented in this report, the following can be recommended from the socio-economic perspective:

- The net positive impacts associated with the development and operation of the proposed Project are expected to outweigh the net negative effects. The project is also envisaged to have a positive stimulus on the local economy and employment creation, leading to the economy's diversification and a small reduction in the unemployment rate. The project should therefore be considered for development. It should, however, be acknowledged that the negative impacts would be largely borne by the nearby farms and households residing on them, whilst the positive impacts will be distributed throughout both the local and national economies. Due to this imbalance, it is recommended that the mitigation measures suggested be strictly adhered to. Application of these mitigation measures will ensure that the negative impacts on the nearby farms and businesses are minimised and that the distribution of the potential benefits of the project are more balanced.

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ANNEXURE A: LANDOWNER ENGAGEMENTS

Landowners/ Representative Name	Applicable Properties/ Business	Cell Number	Email	Comments
Daleen von Wielligh	Bultfontein	082 786 7908	daleenvonwielligh@gmail.com	None
Hannes de Beer	Broodsnyersplaas	082 388 3636	hannes@jmdeb.co.za	None
WA De Klerk	Dunbar 189 IS	082 413 3820	wadeklerkbdy@mweb.co.za wagondeklerk@hotmail.com	Wil probably lose a bit of agricultural land, but in the long run I am all for wind energy
Dirk van Woudenberg	Hartebeestkuil 185IS (portion 2 and 4), Dunbar 189IS (portion 4)	082 331 1808	dirkvanwoudenberg@gmail.com	None
Anton Pelser	1, 3, 5, 6, 7/189 Dunbar ; 6, 11, 15/190 Halfgewonnen; 0, 2, 10, 14, 15, 17, 18/193 Weltevreden	082 804 1796	astro2@megaweb.co.za	Uncontrolled access, veld fires, damage to agricultural land, interference with agricultural activities (especially big implements), aerial spraying,

ANNEXURE B: IMPACT ASSESSMENT METHODOLOGY

SCOPING PHASE

Reporting Requirements

- Project Description
- Legislative Context (as applicable)
- Assumptions and limitations
- Description of Baseline Environment – including sensitivity mapping
- Identification and high-level screening of impacts
- Plan of Study for EIA

High-Level Screening of Impacts and Mitigation

Appendix 2 of GNR 982, as amended, requires the identification of the significance of potential impacts during scoping. To this end, an impact screening tool has been used in the scoping phase. The screening tool is based on two criteria, namely probability; and, consequence, where the latter is based on general consideration to the intensity, extent, and duration.

The scales and descriptors used for scoring probability and consequence are detailed below:

Table: Probability Scores and Descriptors

SCORE	DESCRIPTOR
4	**Definite**: The impact will occur regardless of any prevention measures
3	**Highly Probable**: It is most likely that the impact will occur
2	**Probable**: There is a good possibility that the impact will occur
1	**Improbable:** The possibility of the impact occurring is very low

Table: Consequence Score Descriptions

SCORE	NEGATIVE	POSITIVE
4	Very severe: An irreversible and permanent change to the affected system(s) or party(ies) which cannot be mitigated.	Very beneficial: A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit.
3	Severe: A long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these.	Beneficial: A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these.
2	Moderately severe: A medium to long term impacts on the affected system(s) or party (ies) that could be mitigated.	Moderately beneficial: A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way.
1	Negligible: A short to medium term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary.	Negligible: A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.

Table: Significance Screening Tool

		CONSEQUENCE SCALE			
PROBABILITY SCALE		**1**	**2**	**3**	**4**
	1	**Very Low**	**Very Low**	**Low**	**Medium**

	2	**Very Low**	**Low**	**Medium**	**Medium**
	3	**Low**	**Medium**	**Medium**	**High**
	4	**Medium**	**Medium**	**High**	**High**

The nature of the impact must be characterised as to whether the impact is deemed to be positive (+ve) (i.e. beneficial) or negative (-ve) (i.e. harmful) to the receiving environment/receptor. For ease of reference, a colour reference system has been applied according to the nature and significance of the identified impacts.

Table: Impact Significance Colour Reference System to Indicate the Nature of the Impact

Negative Impacts (-ve)	Positive Impacts (+ve)
Negligible	**Negligible**
Very Low	**Very Low**
Low	**Low**
Medium	**Medium**
High	**High**

EIA PHASE

Reporting Requirements

- Project Description
- Legislative Context (as applicable)
- Assumptions and limitations
- Description of methodology (as required)
- Update and/or confirmation of Baseline Environment – including update and / or confirmation of sensitivity mapping
- Identification and description of Impacts
- Full impact assessment (including Cumulative)
- Mitigation measures
- Impact Statement

Ensure that all reports fulfil the requirements of the relevant Protocols.

Assessment of Impacts and Mitigation

The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

The key objectives of the risk assessment methodology are to identify any additional potential environmental issues and associated impacts likely to arise from the proposed project, and to propose a significance ranking. Issues / aspects will be reviewed and ranked against a series of significance criteria to identify and record interactions between activities and aspects, and resources and receptors to provide a detailed discussion of impacts. The assessment considers direct[3], indirect[4], secondary[5] as well as cumulative[6] impacts.

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[3] Impacts that arise directly from activities that form an integral part of the Project.

[4] Impacts that arise indirectly from activities not explicitly forming part of the Project.

[5] Secondary or induced impacts caused by a change in the Project environment.

[6] Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.

A standard risk assessment methodology is used for the ranking of the identified environmental impacts pre-and post-mitigation (i.e. residual impact). The significance of environmental aspects is determined and ranked by considering the criteria[7] presented.

Table: Impact Assessment Criteria and Scoring System

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries
Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite
Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
IMPACT SIGNIFICANCE RATING					
Total Score	**4 to 15**	**16 to 30**	**31 to 60**	**61 to 80**	**81 to 100**
Environmental Significance Rating (Negative (-))	**Very low**	**Low**	**Moderate**	**High**	**Very High**
Environmental Significance Rating (Positive (+))	**Very low**	**Low**	**Moderate**	**High**	**Very High**

Impact Mitigation

The impact significance without mitigation measures will be assessed with the design controls in place. Impacts without mitigation measures in place are not representative of the proposed development's actual extent of impact and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the application of mitigation and management measures and is thus the final level of impact associated with the development.

[7] The definitions given are for guidance only, and not all the definitions will apply to all the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

Residual impacts also serve as the focus of management and monitoring activities during Project implementation to verify that actual impacts are the same as those predicted in this report.

The mitigation measures chosen are based on the mitigation sequence/hierarchy which allows for consideration of five (5) different levels, which include avoid/prevent, minimise, rehabilitate/restore, offset and no-go in that order. The idea is that when project impacts are considered, the first option should be to avoid or prevent the impacts from occurring in the first place if possible, however, this is not always feasible. If this is not attainable, the impacts can be allowed, however they must be minimised as far as possible by considering reducing the footprint of the development for example so that little damage is encountered. If impacts are unavoidable, the next goal is to rehabilitate or restore the areas impacted back to their original form after project completion. Offsets are then considered if all the other measures described above fail to remedy high/significant residual negative impacts. If no offsets can be achieved on a potential impact, which results in full destruction of any ecosystem for example, the no-go option is considered so that another activity or location is considered in place of the original plan.

The mitigation sequence/hierarchy is shown below.

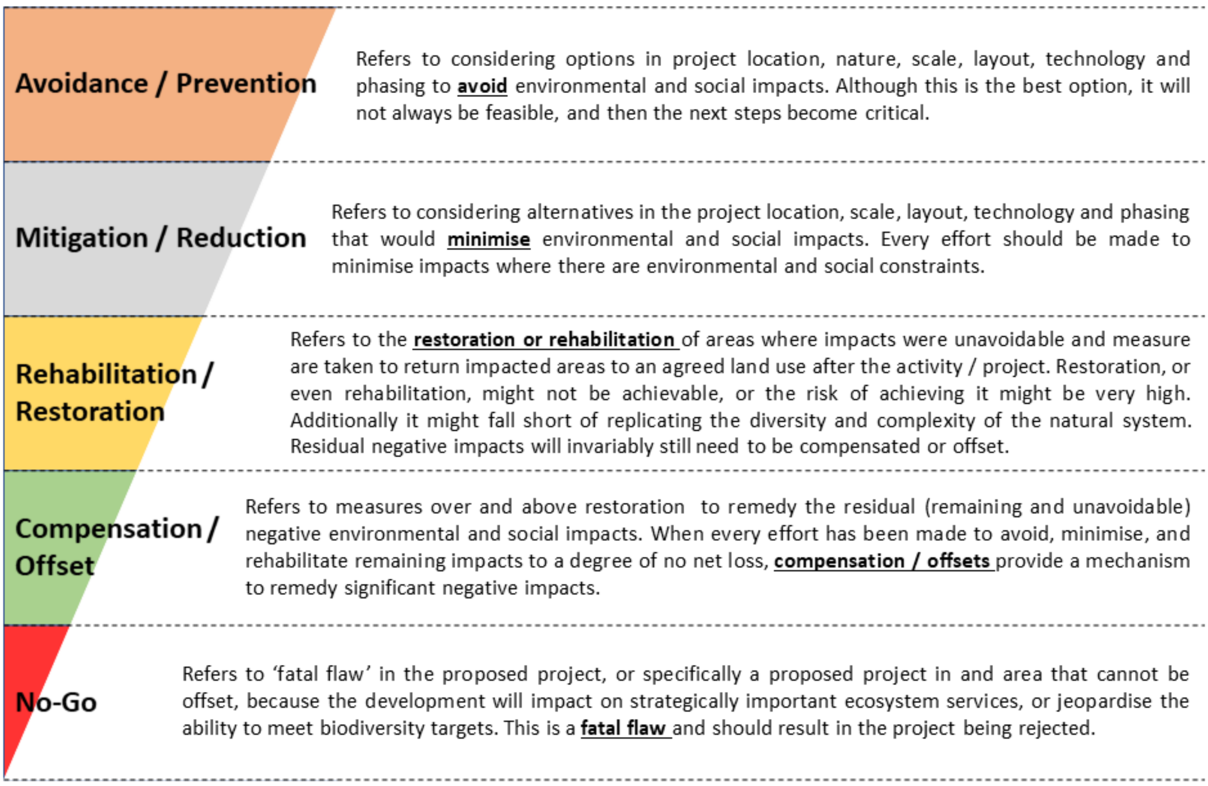

Figure: Mitigation Sequence/Hierarchy