Stanwell Hydrogen Project

Feasibility Study
October 2020

The feasibility study received funding from ARENA as part of ARENA's Advancing Renewables Program.

For further information contact hydrogen@stanwell.com

Table of contents

List of figures

List of tables

List of abbreviations

AACE	Association for Advancement of Cost Engineering
AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
ASA	Ash Storage Area
ATMS	Alkaline
Austrade	Australian Trade and Investment Commission
CEFC	Clean Energy Finance Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EA	Environmental Authority
EOI	Expression of Interest
ERA	Environmentally Relevant Activity
FCEV	Fuel Cell Electric Vehicles
FEED	Front End Engineering and Design
FID	Final Investment Decision
FTEs	Full-time equivalent
HAZID	Hazard Identification
HAZOP	Hazard and Operability Analysis
HPF	Hydrogen Production Facility
ISP	Australian Energy Market Operator's Integrated System Plan
ktpa	kilotonnes per annum
kV	kilovolt
LCOA	Levelised cost of ammonia
LCOH	Levelised Cost of Hydrogen Production
LGCs	Large-Scale Generation Certificates
MHFs	Major Hazard Facilities
MNES	Matter of National Environmental Significance
MOU	Memorandum of Understanding
MW	megawatt
NAIF	Northern Australia Infrastructure Facility
O&M	operations and maintenance
OEMs	Original Equipment Manufacturers
P&G Act	Petroleum and Gas Act (Production and Safety) 2004
P&IDs	Piping and Instrumentation Diagrams
PEM	Proton Exchange Membrane
QTC	Queensland Treasury
REZs	Renewable Energy Zones

RFQ	Request for Quotations
SDA	State Development Area
SIE	social impact evaluation
Stanwell	Stanwell Corporation Limited
the Project	Stanwell Hydrogen Demonstration Project
tpa	tonnes per annum
TUOS	Transmission use of system
WACC	weighted average cost of capital
WFH	Work From Home

Executive Summary

This document summarises the outcomes of the Stanwell Hydrogen Demonstration Project feasibility study ("the Project") which was undertaken from July 2019 to October 2020.

The purpose of the Project is to create momentum towards a large-scale green hydrogen industry in Central Queensland by conducting a hydrogen demonstration project, to be co-located with Stanwell Power Station near Rockhampton.

The Project would see Stanwell Corporation Limited (Stanwell) install a 10-megawatt (MW) electrolyser intended to produce approximately 1,600 tonnes of green hydrogen per annum. The green hydrogen produced by the Project would be supplied to an ammonia and gas producer in the region, which would use Stanwell's green hydrogen as a feedstock in its production process, reducing the carbon footprint of its operations.

The learnings developed through the Project could be used to support a commercialisation pathway to a large-scale green hydrogen and ammonia export project in Central Queensland.

a. Pre-feasibility study

The feasibility study built on a pre-feasibility study (completed by Stanwell in June 2019) which assessed the commercial, technical and strategic viability of three potential pathways to produce and utilise green hydrogen produced through a 10 MW or larger electrolyser.

The pre-feasibility study concluded that power-to-gas (producing hydrogen gas for use in off-site industrial processes, gas grid injection or transportation) and power-to-ammonia (production of ammonia on-site using green hydrogen as a feedstock) represented the most promising pathways. Power to power, which involves utilising hydrogen to produce electricity through a fuel cell or turbine, was assessed as less viable due to the large energy losses involved.

The pre-feasibility study concluded that a 10 MW electrolysis demonstration project could be commercially viable under a 'future market' scenario with reductions in electrolyser capital costs, emergence of a premium for green hydrogen and an innovation capital grant of around 60 per cent of capital costs from the Australian Renewable Energy Agency (ARENA) or other sources.

The pre-feasibility study recommended that Stanwell move to a full feasibility study, and in July 2019 the Stanwell Board approved commencement of the feasibility study.

b. Feasibility study approach

To undertake the feasibility study, Stanwell engaged the assistance of external advisors, namely Advisian, Deloitte and Minter Ellison, to assess the technical, commercial and strategic viability of hydrogen production via electrolysis at Stanwell Power Station. The objectives of the feasibility study included:

- identification, assessment and recommendation of not more than three preferred reference project(s) for the Project;
- determination of a suitable commercial business model and structure which balances the commercial and strategic risk positions of Stanwell; and
- development of a sound knowledge base which will allow Stanwell to progress its role in a long-term hydrogen strategy and export industry.

The commercial streams focused on active engagement with potential offtakers and financiers, along with project modelling and structuring. The technical stream sought advice from the technical advisors around plant layout, logistics challenges and capital cost estimates, while the strategic stream considered policy alignment and stakeholder engagement.

The process and outcomes of each of these workstreams are summarised below.

c. Commercial and market

The market sounding process included identifying and engaging with potential domestic and foreign offtakers and financiers. In furtherance of the market engagement process, Stanwell undertook a market engagement trip to Japan and South Korea in November 2019 facilitated by the Australian Trade and Investment Commission (Austrade). The outcomes of the trip were promising, with several strong connections established, and highlighted and confirmed the depth of interest and potential market for renewable hydrogen and renewable ammonia in those nations.

As a result of the in-depth market sounding approach and subsequent negotiations, several non-binding commercial arrangements were executed.

The market engagement identified the difficulty of attracting a price premium for green hydrogen in a market where hydrogen is a commoditised product produced through a conventional industrial process. It was noted that where green hydrogen was produced for self-consumption, an implied green premium was easier to achieve, because the entity effectively self-funds the premium. For the reference project this was not an achievable outcome, as Stanwell is unable to self-consume the volume of hydrogen produced through a 10 MW electrolyser.

d. Technical solution

The Project's technical advisor, Advisian, was engaged to determine the Project's capital, operating and maintenance costs and a staged approach was adopted for this analysis. The initial analysis was based on Advisian's internal knowledge experience and data bases.

Stanwell and Advisian then undertook an extensive market engagement process with OEMs from Europe and Asia to assess pricing and technical performance of different technical solutions. This approach was initiated through a Request for Quotations (RFQ) process intended to identify potentially suitable providers of technology.

Once initial estimates of capital and other costs had been completed, a process of engagement with OEMs was undertaken in order to improve the range of cost estimates. A vendor identification process identified several potential OEMs. Nine of these displayed an interest and were of sufficient substance to warrant further engagement and this engagement yielded a preferred technical solution for use as the reference technology for the feasibility study. Based on the analysis, Advisian recommended that Stanwell pursue sourcing an Alkaline (ATMS) electrolyser as the baseline for further engineering and analysis and that it be used as the basis for the required cost estimates. If the Project progressed, final selection of the technology provider would be based on a rigorous competitive procurement process.

Advisian also developed Class 4 (+/- 30% accuracy) capital cost estimates for the project.

The technical workstream also identified suitable industrial land, electrical connection and demineralised water at Stanwell Power Station. The regulatory approval requirements are also relatively simple given the project would be on an existing site.

e. Finance and Funding

Stanwell recognises that funding for the Project would be required to be sourced from financiers and stakeholders and that the funding mix would require an equity contribution from Stanwell itself.

Funding sources

Several organisations were approached to assess their appetite for participating in the Project. These included:

- Clean Energy Finance Corporation (CEFC);
- Northern Australia Infrastructure Facility (NAIF);

- Queensland Treasury Corporation (QTC);
- Queensland Government;
- Australian Renewable Energy Agency (ARENA);
- Potential foreign partners; and
- Potential domestic partners

Funding structure

To identify, asses and prepare a funding plan for the Project, a commercial analysis and financial model was developed.

Stanwell developed and optimised a funding plan that would deliver a potentially viable commercial outcome by funding the Project through a combination of equity, concessional debt and grant funding.

Funding arrangements

Stanwell engaged with potential co-financing partners. Based on these assessments and discussions, Stanwell developed a funding plan that would combine equity investment, grant funding and concessional debt. The Project's construction cash flow requirements would initially utilise equity funding to place orders to accommodate the long lead time for equipment and site works. The latter stages of expenditure would include the equipment installation, site integration and plant commissioning. This would be funded through debt.

Financial assessment

Stanwell undertook a financial and commercial assessment of the project on both a geared and ungeared basis. The commercial analysis for the Project shows a modest equity rate of return. This outcome was as expected due to the high capital cost of electrolysers. However, if the project could provide a strategic pathway to a large-scale green hydrogen and ammonia industry in Central Queensland, Stanwell would consider partnering with other equity investors, concessional debt providers and ARENA to deliver the project, with an understanding that Stanwell's equity contribution would have a relatively low expected rate of return.

However, the lack of availability of suitable grant funding for the Project means that it is uncommercial for Stanwell.

f. Additional analysis

Risk management

A comprehensive risk and opportunities management plan was developed for the Project. Risks and opportunities were identified under the Project's development streams, applying Stanwell's risk management and mitigation approach which identifies risks, determines the likelihood of the risk materialising and the severity of the outcome should the risk occur. This approach enables risks to be ranked. In respect of the reference project, it was recognised that the most significant risks were associated with the ability of the Project to attract funding in a way that achieved a commercial outcome.

Regulatory approval requirements

With the assistance of Advisian, Stanwell examined the expected regulatory approval requirements which may need to be addressed prior to commencing the Project and an approvals strategy has been formulated. In addition to its review of planning and regulatory approvals potentially required for the Project, Stanwell has investigated and sought advice on whether it needs to obtain any regulatory licences for delivery of the Project and / or ongoing operation of the electrolyser.

g. Commercialisation pathway

Stanwell recognises the importance of seeking a commercially viable outcome for the hydrogen project and has established that commercial viability is best achieved at significant scale. Further, projects at scale can pursue foreign markets for green hydrogen and green ammonia. Given this, as part of its feasibility investigations, Stanwell has undertaken a high-level concept study focussed on examining the commercial, technical and strategic potential of a large-scale green hydrogen and ammonia export industry in Central Queensland.

This commercialisation pathway could support the development of a domestic hydrogen and/or ammonia industry by providing locally produced green alternatives to existing imports. This is particularly strong in Central Queensland where a sizeable portion of local ammonia is imported. The region's generous endowment of renewable resources and existing infrastructure are critical factors in supporting the development of low-cost green hydrogen required to enable a domestic industry to meet the expected growth in international demand of green hydrogen and related products.

Through market engagement and newly established commercial relationships with Japanese partners, Stanwell has identified that potential demand for green hydrogen and ammonia could require electrolysis capacity in excess of 800 MW by 2026 and in excess of 3000 MW by the early 2030s.

The commercialisation pathway was assessed for a scale up project for each of green hydrogen and green ammonia.

h. Conclusions

Study conclusions – demonstration project

The study conclusions and findings for the demonstration project are:

- the project is technically feasible, with suitable industrial land, electrical connection and demineralised water available at Stanwell Power Station. The regulatory approval requirements are also relatively simple given the project would be on an existing site;
- at the 10 MW scale, a hydrogen demonstration project is only modestly commercially viable if it is able to attract grant funding for a material portion of its capital costs;
- there is a recognition that green hydrogen and ammonia will need to be underpinned by a 'green premium' reflecting the avoided cost of carbon, but the availability of secure offtake with a significant green premium for a demonstration-scale domestic project in Central Queensland is limited;
- the demonstration project is strategically aligned with the policy objectives of the Queensland and Australian Government; and
- in the absence of grant funding or a clear strategic imperative to pursue the demonstration project as a pathway to the commercialisation/scale-up opportunity, it is recommended that no further work be undertaken on the demonstration project and that Stanwell instead prioritises the Central Queensland scale-up opportunity.

Study conclusions – commercialisation pathway

- there is an increasingly strong interest in Australia and globally in green hydrogen and green ammonia to decarbonise a range of sectors including power generation, transport and industrial processes. This is reflected in policy settings and the increasing flows of private and public finance into the development of hydrogen projects;
- the demand for imported green hydrogen and green ammonia is particularly strong in Asian countries, specifically Korea, Japan and Singapore. Stanwell has identified and developed commercial relationships with potential offtakers in each of these economies;
- there is potential for green hydrogen to be produced in Central Queensland at a scale to meet offtaker requirements. Meeting offtaker pricing targets will require sustained capital and renewable energy cost reductions in line with the targets put forward by governments and companies globally.

However, Stanwell and Central Queensland have a range of competitive advantages which will position the project well on a global scale.

i. Next steps

Stanwell will consider establishing a consortium for the development of a large-scale hydrogen industry in Central Queensland, with the view of exporting hydrogen. This consortium with partners would aim to complete a feasibility study and Front End Engineering and Design (FEED) to progress to a Final Investment Decision (FID).

1. Project context and overview

a. Policy and market environment

The development of a commercially viable hydrogen industry in Australia has gained significant traction over the past 18 months, driven by both 'pull' and 'push' factors.

The principal 'pull' factor in developing the Australian hydrogen industry is the credible policy announcements by Japan and South Korea, along with growing interest in Germany and Singapore, to ultimately use imported green hydrogen as a significant part of their future energy supply and decarbonisation strategies. South Korea, Japan and Singapore rely heavily on energy imports and, unlike Australia, do not have access to renewable energy resources and land to enable decarbonisation of the electricity sector (or electrification of other sectors using domestically produced low carbon energy).

The relevant 'push' factors include reports published by the Commonwealth Scientific and Industrial Research Organisation (CSIRO),[1] Australia's Chief Scientist,[2] ACIL Allen,[3] and the International Energy Agency.[4] These all demonstrate the growing technological maturity and cost competitiveness of green hydrogen production, and the accompanying economic opportunities for Australia to capitalise on export markets. In particular, CSIRO has identified the potential for significant capital cost reductions in electrolysis through scaling up plant size.[5]

At the policy level, the Queensland Government Hydrogen Industry Strategy and Australian Government funding support via ARENA and CEFC, have provided a framework for advancing the embryonic industry.

ARENA has identified hydrogen as a key funding priority, with a focus on deploying hydrogen electrolysis at commercial scale (10 to 40 MW). ARENA's current goal is to drive cost reductions in the hydrogen production process which, together with ongoing cost reductions in renewable energy and storage, could make the production of green hydrogen commercially viable and competitive in the medium to long term.[6]

ARENA is currently undertaking a A$70 million hydrogen deployment funding round, and the Australian Federal Government has more recently announced additional funding of A$1.43 billion over the next decade for ARENA, including an amount of A$70 million for the development of a regional hydrogen hub.

As well as aligning with the State Government's Queensland Hydrogen Industry Strategy 2019-2024, the Project matches well with the stated policies of Federal and Local Governments and funding bodies, including:

- National Hydrogen Strategy – the Project aligns with work streams focusing on export markets, transport, industrial use, electricity systems and cross-cutting issues;
- ARENA Investment Mandate – the Project strongly aligns with ARENA's intent to bring the hydrogen industry to scale by deploying electrolysis at a commercial scale, and improve the integration of renewable energy;
- Technology Roadmap – including the Roadmap's goal of "H2 under $2", a goal of achieving a hydrogen price under $2 per kilogram;
- CSIRO Hydrogen Roadmap – the Project supports key CSIRO priorities under the roadmap, including technology demonstration, market development and community acceptance; and

[1] Commonwealth Scientific and Industry Research Organisation (2018). *Hydrogen Research Development and Demonstration: Priorities and Opportunities for Australia*.
2 COAG Energy Council (2019). *Australia's National Hydrogen Strategy*.
[3] ACIL Allen Consulting (2018). *Opportunities for Australia from Hydrogen Exports*.
[4] The International Energy Agency (2019). *The future of Hydrogen: Seizing today's opportunities*.
[5] Commonwealth Scientific and Industry Research Organisation (2018). *National Hydrogen Roadmap*.p.17
[6] ARENA (2019). *Renewable hydrogen: Analysing ARENA's Portfolio & Pathways to capturing the opportunity Presentation to ADGO conference*, March 2019.

- Rockhampton Regional Council / Advance Rockhampton – the local Council is highly supportive of the Project to attract investment and employment to the region and has facilitated contacts with potential international partners.

b. Role of Stanwell – project proponent

Stanwell is a Queensland GOC with a diversified energy portfolio including generation, retail and energy resources. Stanwell has been investigating opportunities to commercialise hydrogen since mid-2018.

Stanwell's involvement in hydrogen has the potential to contribute to all aspects of its corporate strategy:

- **Create future energy solutions** – a hydrogen industry would create new energy load in Central Queensland and revenue diversification opportunities through a new export market;
- **Affordable emissions reduction** – green hydrogen is a vehicle to reduce Stanwell's portfolio emissions intensity and support smooth integration of renewable energy;
- **Benefit community and our shareholders** – the project will create local jobs and economic development and support the Queensland Hydrogen Industry Strategy; and
- **Work smart and build capability** – the hydrogen industry will create jobs and new expertise for Stanwell's workforce in the hydrogen supply chain.

c. Involvement of ARENA

At the completion of the pre-feasibility study, Stanwell engaged with ARENA with the intention of seeking and securing grant funding to support the undertaking of the feasibility study.

An application was lodged with ARENA in September 2019 and further information was subsequently provided in support of the application. In December 2019, ARENA advised Stanwell that the application for grant funding to support a feasibility study had been approved and a funding agreement was executed in February 2020.

2. Pre-feasibility study overview

In June 2019, Stanwell completed a pre-feasibility study into the establishment of a hydrogen production facility.

The pre-feasibility study sought to confirm that there was merit in further investigating and assessing the concept of establishing a green hydrogen demonstration plant to be located at or close to Stanwell Power Station in Rockhampton, Central Queensland.

a. Assessment framework

At the pre-feasibility stage, the project was evaluated under the following framework, consistent with Stanwell's approach for major projects:

Technical viability

This work stream assessed the appropriateness and technical viability of the key technology blocks associated with the project, as well as proposed site integration. Stanwell engaged GHD as technical advisor to develop high level concept designs, capital and operations and maintenance costs for the three pathways, including on-site hydrogen and ammonia production and storage options. GHD also undertook a connection study to assess on-site connection and land requirements.

Commercial viability

This work stream assessed the current and future revenue potential of the pathways, with EY engaged as a commercial advisor. This was done through a combination of market engagement with potential offtake customers and commercial partners, consultation with funding bodies and desktop analysis. A high-level financial analysis was completed to identify the funding gap which would need to be filled through external sources (e.g. ARENA).

Strategic viability

This work stream assessed the alignment of the opportunity with Stanwell's corporate strategy, shareholder objectives, relevant state and national hydrogen strategies and investment priorities. Stanwell developed a stakeholder engagement plan to ensure that shareholders and other key stakeholders are supportive and kept informed of the project.

b. Value chain pathways

Stanwell identified three potential value chain pathways for investigation in the pre-feasibility study:

Power-to-Ammonia:

On-site production of hydrogen and subsequent synthesis of hydrogen to ammonia which would be transported by liquid tanker and used for domestic industrial processes such as production of ammonium nitrate, fertilisers and other chemicals. Longer-term, ammonia is a potential cost-effective storage / carrier medium for exporting hydrogen via ship.

Power-to-Gas:

On-site production of and compression of hydrogen and subsequent transport via tube trailer to be injected into the gas network, used as a domestic industrial feedstock (e.g. ammonia), for mobility applications (e.g. hydrogen refuelling stations), and ultimately export.

Power–to-Power:

On-site production of hydrogen and subsequent use of that hydrogen to generate electricity through a gas turbine, reciprocating engine or fuel cell. Alternatively, the electrolyser could be used as a flexible

load. This pathway would add flexibility to Stanwell's generation portfolio through enabling participation in existing or future energy markets.

The three pathways are illustrated at **Figure 1: Three potential pathways for hydrogen** below.

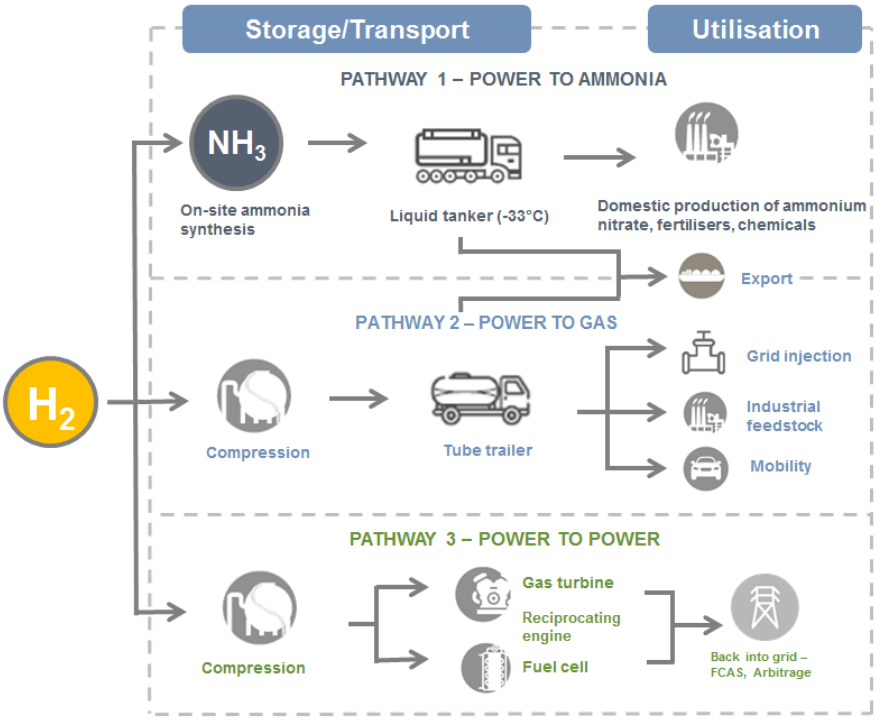


Figure 1: Three potential pathways for hydrogen

c. Pre-feasibility study conclusions

Technical

All the value chain pathways and their associated technology blocks are technically feasible based on a pre-feasibility level of analysis, with commercially available products on the market, or undergoing a certification process. The key resources required to produce hydrogen, ammonia and electricity on-site at Stanwell Power Station are all available, including industrial land, power connection, demineralised water and road access to site.

No technical fatal flaws were identified with any of the pathways, suggesting that the selection of pathways (and technology blocks) would be primarily determined by the underlying economics and commercial viability of the pathways, which are discussed further below.

Commercial

Each of the three value chain pathways has several corresponding current and future markets. The current markets are the visible opportunities to commercialise the hydrogen output of the plant at the time of the study (2019). The future markets are the credible opportunities that have been identified through industry reports and engagement and government policy commitments and are expected to emerge during the life of the project.

The pre-feasibility study concluded that power-to-gas and power-to-ammonia represented the most promising pathways. Power-to-power, which involves utilising hydrogen to produce electricity through a fuel cell or turbine, was assessed as less viable due to the large energy losses involved.

The pre-feasibility study further concluded that a 10 MW electrolysis demonstration project could be commercially viable under a 'future market' scenario with reductions in electrolyser capital costs,

emergence of a premium for green hydrogen and an innovation capital grant of around 60 per cent of capital costs.

Strategic

The project was assessed as being strongly aligned with Stanwell's corporate strategy and with relevant policies at the federal, state and local level.

As well as supporting Stanwell's objectives around load growth, flexible and competitive plant and backing a low carbon future, the project has the potential to deliver broader energy system benefits by maintaining synchronous generation in the market.

The extensive direct stakeholder engagement undertaken through the pre-feasibility stage helped to gather feedback to inform the pre-feasibility study, build and maintain positive collaborative relationships, and create support for the project.

Overall conclusion

The conclusion of Stanwell's pre-feasibility study was that the development of a hydrogen production facility of 10 MW or larger on a site located at or close to Stanwell Power Station was potentially viable and that a feasibility study was warranted to assess the opportunity in more detail.

Based on the findings of the pre-feasibility study, on 2 July 2019 Stanwell's Board approved the progression to a feasibility study for the Project.

3. Feasibility study approach

To undertake the feasibility study, Stanwell engaged the assistance of external advisors, namely Advisian, Deloitte and Minter Ellison, to assess the technical, commercial and strategic viability of hydrogen production via electrolysis at Stanwell Power Station. The objectives of the feasibility study include:

- identification, assessment and recommendations for not more than three preferred reference project(s) for the Project;
- determination of a suitable commercial business model and structure which balances the commercial and strategic risk positions of Stanwell; and
- development of a sound knowledge base which will allow Stanwell to progress its role in a long-term hydrogen strategy and export industry.

The feasibility study would examine the commercial and technical aspects of the Project, including an assessment of the domestic and international hydrogen market, identification and assessment of potential offtakers, potential technology that could be applied, and equipment manufacturers and potential suppliers that were or could be available.

The feasibility study would also consider the potential for the development of a new, fully commercial, large-scale green hydrogen industry in Central Queensland, including the local manufacture and supply of hydrogen industry components.

The outcomes of the feasibility study were finalised in September 2020.

a. Assessment Framework

In undertaking the feasibility study for the Project and noting that the analysis required would be in greater depth than at the pre-feasibility stage, Stanwell identified several interrelated streams which were required to be pursued, analysed and completed. In following this approach Stanwell sought to clearly articulate the requirements and metrics of each of these streams to develop a well-integrated project solution. The streams are noted below:

Technical

The technical stream assessed the Project's technical proposals and solution. It sought to identify and appropriately size an electrolyser, identify potential suppliers and vendors of electrolysers, estimate the capital costs, operating costs, maintenance costs and other costs at an appropriate level of confidence. It further identified and developed the supply chain and logistics requirements and proposed a solution. The technical solution estimated the capital costs at a Class 4 (+/- 30%) level of accuracy.

The technical stream also assessed the power supply requirements and sought to confirm that sufficient power supply, transmission requirements and greening solutions could be achieved.

Commercial and market

The commercial and market stream sought to identify potential markets for green hydrogen both domestically and internationally, and to identify and secure committed and prospective hydrogen offtakers. The stream covered domestic and international demand including volume, pricing and the appetite and potential for a green premium.

Financial

The financial stream built upon the capital and operating cost plan determined by the technical stream, the commercial and proposed offtake arrangements established by the commercial stream. The financial stream engaged with potential financiers and sources of funding and using all of the information gathered built and optimised a financial solution which set out the source and application of funds, the Project's balance sheet (assessed as a standalone entity) and its projected revenue and financial rates

of return. The analysis further determined the Project's Levelised Cost of Hydrogen (LCOH). The latter was used to secure commitments from potential offtakers, noting that the process may be iterative.

Risk and opportunity analysis, management and mitigation

Stanwell has a comprehensive risk management approach and the risk stream focussed on identifying project risks and opportunities and on managing these to mitigate the Project's risk profile.

Regulatory approval

The regulatory and approval stream focussed upon identifying the approvals that the Project will be required to secure prior to it proceeding to financial close and execution. The approvals include environmental, regulatory, health and safety, permitting and development.

Stakeholder/Shareholder engagement

As a government owned corporation, the stakeholder engagement stream was responsible for managing the Project's relationship with Stanwell's shareholding ministries, Queensland Government agencies and other local and regional stakeholders.

Social and economic impact assessment

Stanwell is highly mindful of the requirement for securing social acceptance of the Project and a stream specifically focussed upon the Project's social impact and sustainability impact.

Commercialisation pathway

Stanwell is aware that a 10 MW hydrogen project is unlikely to represent a viable commercial opportunity, but it may be an opportunity to develop a body of knowledge which could be applied to a larger project, able to deliver a fully commercial outcome. The commercialisation stream was focussed on scoping the potential path to a large-scale, commercialised hydrogen project in Central Queensland.

4. Identification of Reference Project

a. Initial options filtering

In order to identify one or more reference projects for the feasibility study, Stanwell initially undertook an options filtering process of several potential pathways for the Project. Each pathway was based on an electrolyser at scale (10MW or larger). The three cases assessed were:

- Case 1 – 10 MW electrolyser feeding an 8 kilotonnes per annum (ktpa) ammonia plant
- Case 2 – 20-25 MW electrolyser feeding a 20 ktpa ammonia plant
- Case 3 – 10 MW electrolyser producing ~1,600 tonnes per annum (tpa) of hydrogen

For each case, an estimate of the capital and operating costs was made at a +/- 50% ("Class 5") level of confidence.

Based on the analysis, Stanwell concluded that ammonia production at limited scale (10 MW or 20 MW equivalent) was unlikely to achieve an acceptable commercial outcome and as such Stanwell elected not to proceed with further design and technical analysis of either Case 1 or Case 2.

Case 3 was selected as the reference project and as such forms the basis of the feasibility study.

b. Reference project description

The proposed reference project involves Stanwell making an initial investment

to complete the Project which would be characterised by the following features:

- Installation of a 10 MW electrolyser at Stanwell Power Station which will produce approximately 1,600 tonnes of green hydrogen per annum as feedstock for the domestic ammonia and gas market. This is illustrated below in **Figure 2: Hydrogen production process at Stanwell Power Station**;
- The electrolyser is intended to be located on Stanwell owned land at Stanwell Power Station and connected to a Stanwell generating unit via its connection to the Powerlink 275 kilovolt (kV) grid;
- The primary offtake would involve supplying green hydrogen via truck to a local offtaker which will use the green hydrogen feedstock in the production of downstream products, reducing the carbon footprint of its operations;
- Stanwell would leverage the local availability of network infrastructure, industrial land and on-site demineralised water to minimise other operating costs associated with the Project;
- A renewable energy arrangement to green the Project by purchasing renewable energy and Large-Scale Generation Certificates (LGCs) from a proposed suitable wind farm equivalent to 100 per cent of the energy requirements of the Project;
- Equity contributions from Stanwell and potentially other domestic or international equity partners. Stanwell has received letters of interest from potential partners interested in investing in the Project; and
- Potential concessional debt funding.
- A schematic diagram of the proposed production and offtake process is depicted below in **Figure 2: Hydrogen production process at Stanwell Power Station** and in **Figure 3: The Stanwell Hydrogen Demonstration Project**.

A technical process flow diagram is provided at **Figure 4: Process flow diagram**.

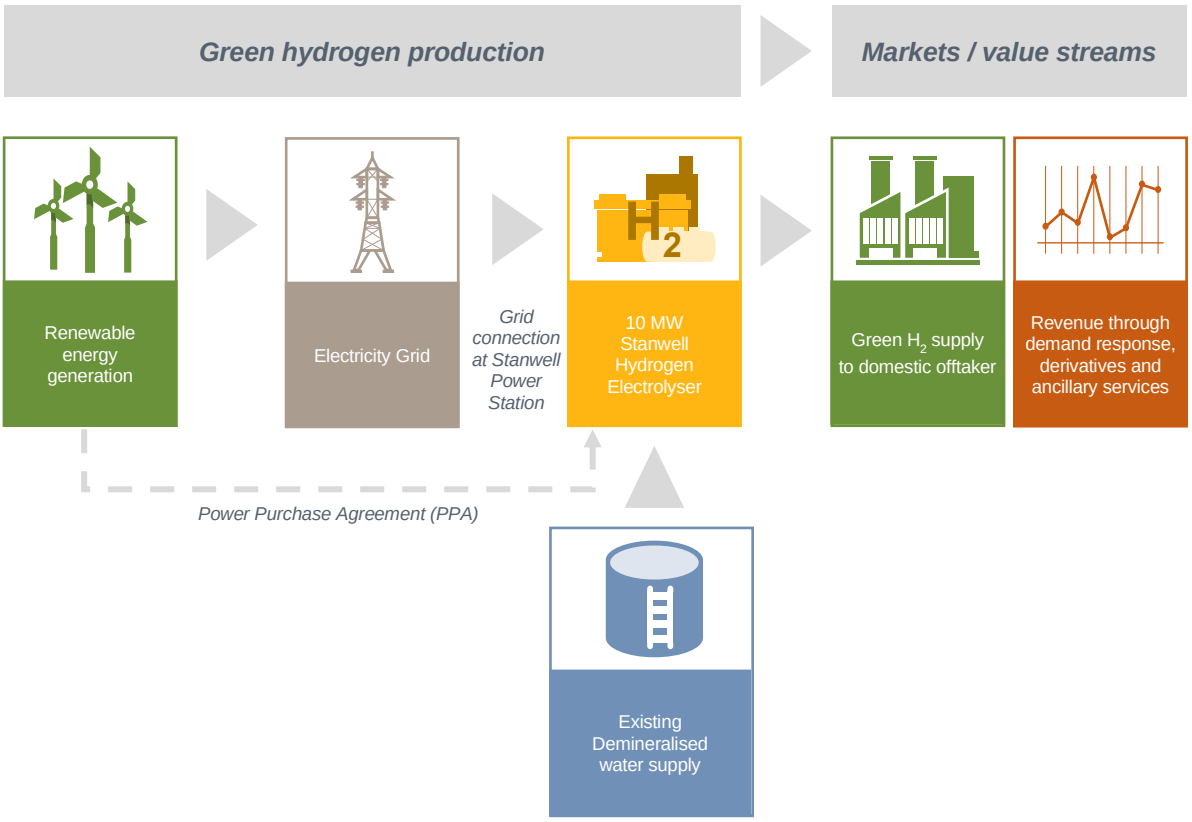


Figure 2: Hydrogen production process at Stanwell Power Station

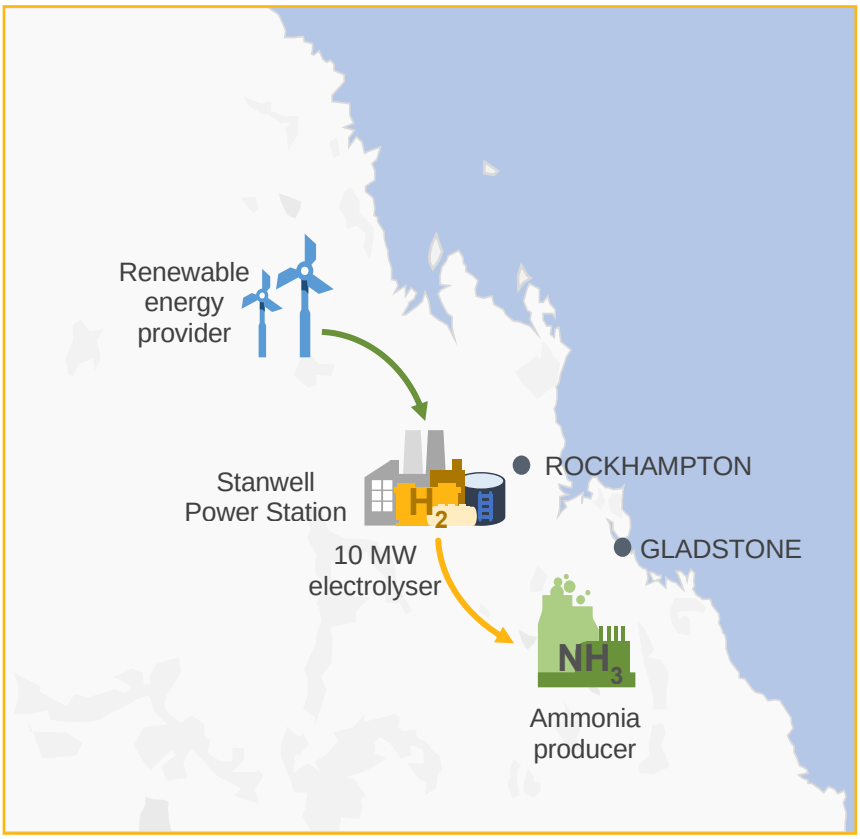


Figure 3: The Stanwell Hydrogen Demonstration Project

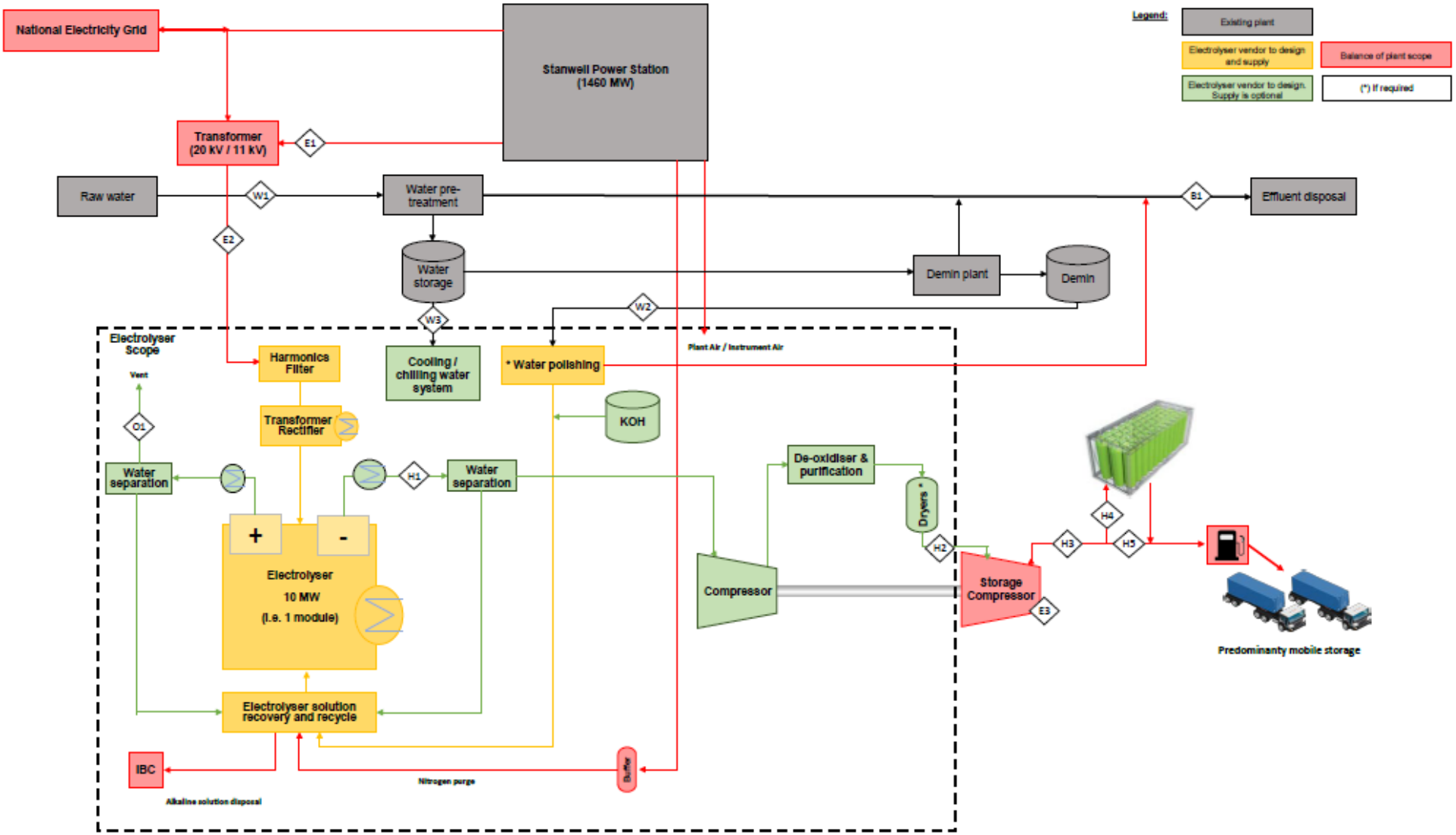


Figure 4: Process flow diagram

5. Project Objectives

The Project's primary objective would be to reduce the LCOH, develop Central Queensland's renewable hydrogen industry, promote a reduction in the cost of electrolysers and minimise potential subsidy requirements for the Project. Stanwell planned to achieve these objectives by:

- deploying electrolysis at scale (at least 10 MW), thereby harnessing economies of scale in production and deployment;
- providing green, reliable, competitively priced electricity to the project through:
    - maintaining high utilisation of the electrolyser through physical supply of high capacity factor electricity via a transmission grid connection;
    - sourcing energy LGCs through a PPA with a wind farm to offset all energy requirements;
    - optimising electricity pricing by using the flexibility of the electrolyser to reduce the level of firming/hedging required for the Project, demonstrating the value of flexibility; and
    - creating additional value streams through demand response, derivatives and ancillary services.
- minimising other costs through local availability of network infrastructure, industrial land and on-site demineralised water at Stanwell Power Station;
- developing domestic green hydrogen markets by partnering with a local ammonia and gas producer to achieve a green premium by using green hydrogen in the production process;
- increasing the skills, capacity and knowledge relevant to renewable energy technologies by positioning Central Queensland as a hydrogen export hub, attracting co-located industries including local manufacturing to generate long-term investment and employment opportunities in regional areas;
- developing strategic commercial partnerships with large Asian hydrogen participants, ammonia companies and OEMs to develop a clear pathway to commercialisation for the Central Queensland scale-up opportunity and to improve the technology and commercial readiness of green hydrogen production;
- reducing barriers to renewable energy uptake by encouraging load growth to underpin the commercial viability of additional renewable investment; and
- deploying flexible hydrogen electrolysis load which will support grid balancing to ensure the reliability and security of energy supply delivering broader economic and commercial benefits to Queensland's energy system.

In achieving these objectives, Stanwell would be able to position itself as a key player and producer of choice in Australia's green hydrogen industry.

6. Commercial and market

Stanwell engaged in an extensive market sounding and engagement process and Stanwell was assisted by commercial and financial advisors Deloitte.

This market engagement process included both domestic and foreign potential offtakers drawn from an initial long list of possible offtakers. Organisations on the long list were assessed for their potential as product offtakers as well as their potential to become financial partners where this was relevant. The assessment process yielded a shorter list of prospective organisations. These were approached on a systematic basis and engaged in a dialogue.

Stanwell also undertook a market engagement trip to Japan and South Korea in November 2019, facilitated by Austrade. The outcomes of the trip were promising and highlighted and confirmed the depth of interest and potential market for renewable hydrogen and renewable ammonia.

The domestic market engagement process focussed strongly on potential offtakers and potential users of green hydrogen and ammonia. In the light of the supply chain challenges of transporting hydrogen and ammonia, the primary focus of this market engagement process was Central Queensland.

A summary of the discussions with potential domestic offtake partners is provided in the section below.

a. Potential domestic offtake partners

Stanwell sought to engage with several potential offtakers and partners including producers of ammonia as potential future domestic offtake partners, investors and operator of ammonia plants.

These potential offtakers included ammonium nitrate producers and organisations potentially able to include hydrogen in the gas mixture of domestic gas networks or interested in the potential to produce renewable methane.

b. Potential international offtake partners

Stanwell engaged with several potential international partners and off-takers and undertook a market sounding trip to Japan and South Korea to explore the opportunities and appetite for green hydrogen and green ammonia. The trip showed that there is a real interest and appetite for these products and the contacts that were established have in a number of cases developed into material opportunities to establish offtake arrangements for green hydrogen at scale and potential to develop relationships leading to financial partnering.

The Stanwell market sounding trip also met with METI, the Japanese Ministry of Economy, Trade and Industry and Professor Sugiyama, the Queensland Government Hydrogen Envoy.

7. Technical stream

Stanwell's technical steam assessed the Project's technical aspects including site selection, electrolyser analysis and selection, capital cost, operating cost estimates and engagement with potential vendors. Advisian, Stanwell's technical advisor for the Project performed much of the analysis.

a. Project location

Stanwell determined that it would enhance the efficiency of the Project if it were to harness available and existing resources (including electrical connection, industrial land and demineralised water) from the Stanwell Power Station. This approach would deliver substantial cost savings to the Project relative to other hydrogen electrolysis projects.

Stanwell Power Station is located 22 km west of Rockhampton in Central Queensland, approximately 4.5 km by sealed road from the Capricorn Highway. Access to the site has previously been engineered to allow the passage of large construction loads associated with the power station construction so will be suitable for all transport requirements associated with the Project. **Figure 5: Project regional location** below shows the Project's proposed location.

The Capricorn Highway is a major state highway heavily used to support the Central Queensland resource industry. The duplication of the highway section between Gracemere and Rockhampton is currently under construction and will facilitate road transport between the project site and Gladstone.

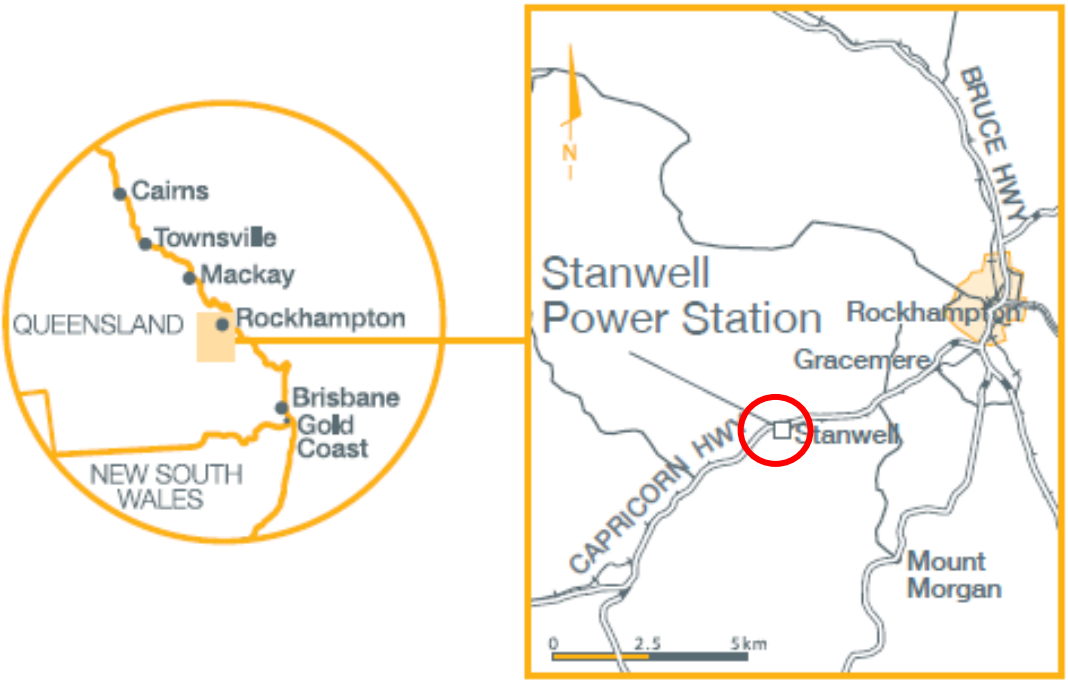


Figure 5: Project regional location

The 10 MW hydrogen plant is proposed to be located immediately adjacent to Stanwell Power Station - approximately 150 metres north of the Stanwell Unit 1 boiler house illustrated at **Figure 6 below.**

The site is wholly contained within the main security cordon of Stanwell Power Station which, as a key piece of national infrastructure, has existing security requirements. The site selected for the Project is not close to any site boundary where public access is likely to occur.

The proposed site has been levelled and profiled with internal roads paved and curbed. There are also some underground facilities (such as service trenches). It has previously been used as a temporary

contractor lay down area during construction of Stanwell Power Station but is now completely vacant. It is at the same grade as the site housing power station units and not subject to flooding. The block is significantly larger than the expected plant footprint (allowing for expansion opportunities) and meets the minimum code assessable lot size in the Special Industry Code of the *Rockhampton Region Planning Scheme 2015.*

The separation of the land parcel from Stanwell Power Station operational land is an advantage for approvals since it will be subject to a separate EA and as such, will have no expected impact on the existing Stanwell Power Station EA. A parcel of 1.84 hectares will be excised for the Project along with additional easements covering connecting infrastructure and servicing roads.

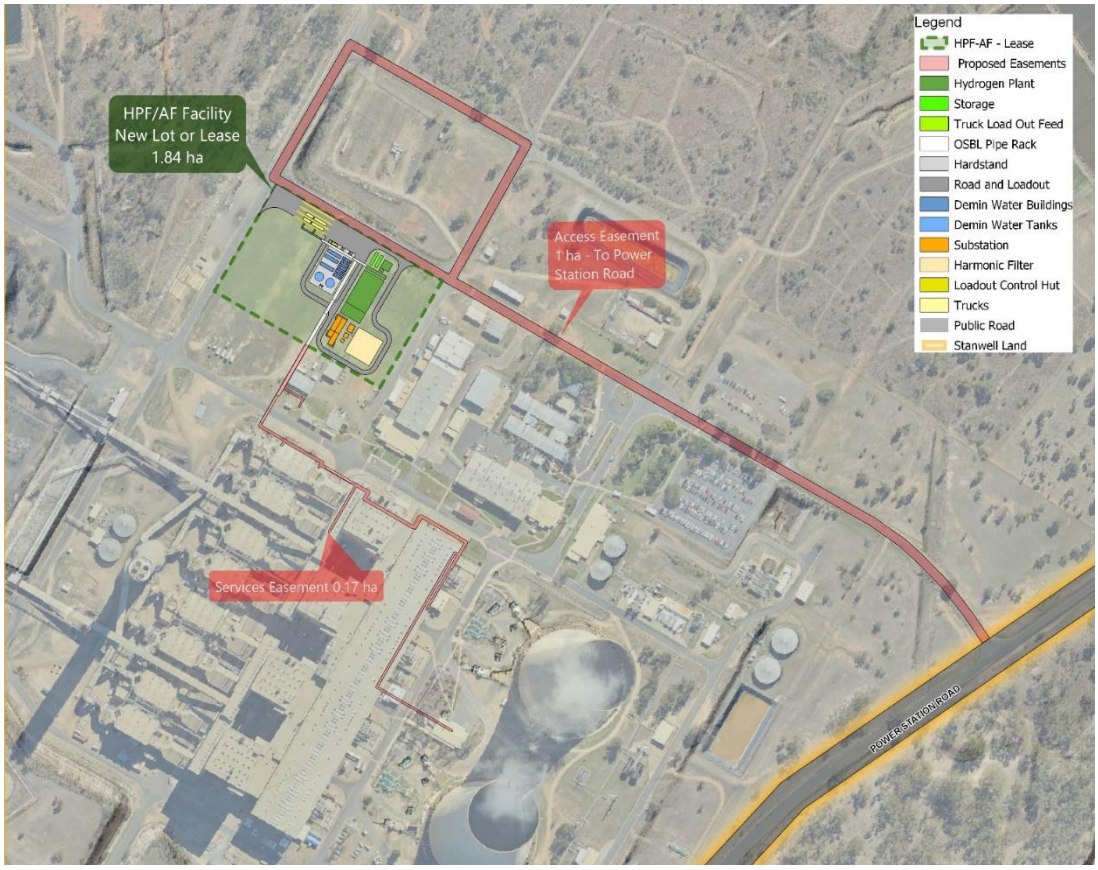


Figure 6: Proposed plant location

b. Technology supplier/s

Stanwell's technical advisor, Advisian, has undertaken an extensive market engagement process with OEMs from across Europe and Asia to assess pricing and technical performance of different technical solutions. This approach was based on an RFQ process intended to identify potentially suitable providers of technology. Further, a number of fledging technology suppliers have approached Stanwell once Stanwell's interest in the hydrogen sector began to become well known. None of these had technology that was sufficiently well developed to warrant further focus at this stage of the Project.

The Project's technical advisor was engaged to determine the Project's capital, operating and maintenance costs and a staged approach was adopted for this analysis. The initial analysis was based on Advisian's internal knowledge, experience and data base.

Once initial estimates of capital and other costs had been completed a process of engagement with equipment suppliers was undertaken in order to improve the range of cost estimates. A vendor

identification process identified several potential OEMs from Europe and Asia. Nine of these displayed an interest and were of sufficient substance to warrant further engagement.

Once the listed OEMs were identified an evaluation process was undertaken to assess pricing and technical performance of the different options. The purpose of this analysis was to identify and rank vendors by electrolyser delivered costs and the analysis included Alkaline and PEM manufacturers. The results of this analysis are summarised and the range of installed and delivered costs for both PEM and Alkaline are provided in **Table 1: Range of electrolyser supplier costs: PEM and Alkaline** below.

Electrolyser technology type	Range of quotes for installed and delivered capital cost (A$/kW capacity at start of life)	
PEM	Minimum 1,850	Maximum 2,750
Alkaline	Minimum 1,100	Maximum 1,950

Table 1: Range of electrolyser supplier costs: PEM and Alkaline (To nearest $50)

As a result of this RFQ, thyssenkrupp was selected as the reference technology for the feasibility study. Thyssenkrupp is a German multinational engineering company with a broad set of technological expertise. Thyssenkrupp is the number one supplier for electrolysis (including chlor-alkali) plants and equipment globally. Its engineering team have significant experience in installing and commissioning its principle electrolysis design in more than 600 electrochemical projects across the globe.

Based on the analysis, Advisian recommended that Stanwell pursue sourcing an Alkaline (ATMS) electrolyser as the baseline for further engineering and analysis and that it be used as the basis for the required cost estimates. If the Project progressed, final selection of the technology provider will be based on a rigorous competitive procurement process.

Key performance metrics

The key performance characteristics of the electrolyser are summarised below in Table 2: Key performance metrics.

Performance characteristic electrolyser	Metric
Electrolyser size MW	10 MW
Electrolyser type	Alkaline (ATMS)
Annual hydrogen production (tonnes per annum)	1,632
Assumed MWh of electricity consumption (12 months standard operating conditions)	82,489
Electrolyser capacity factor (%)	98
Cost (A$/L) of water used for production of hydrogen	0.002
Volume (L/kg) of water used for production of hydrogen	9.10

Table 2: Key performance metrics

c. Capital cost estimates

The Project's technical advisor was engaged to determine the Project's capital, operating and maintenance costs and a staged approach, based on the Association for Advancement of Cost Engineering (AACE) cost estimate classification system, was adopted for this analysis. The AACE cost estimate system is summarised below in **Table 3: AACE cost estimate classification system.**

Estimate class	Name	Purpose	Project definition level	Estimate range
Class 5	Order of magnitude	Screening or feasibility	0% to 2%	L: -20% to -50% H: +30% to +100%
Class 4	Intermediate	Concept study or feasibility	1% to 15%	L: -15% to -30% H: +20% to +50%
Class 3	Preliminary	Budget, authorization, or control	10% to 40%	L: -10% to -20% H: +10% to +30%
Class 2	Substantive	Control or bid/tender	30% to 70%	L: -5% to -15% H: +5% to +20%
Class 1	Definitive	Check estimate or bid/tender	50% to 100%	L: -3% to -10% H: +3% to +15%

Table 3: AACE cost estimate classification system

The cost estimates that were developed for the reference project were based on AACE Class 4 estimates and these would move to Class 3 at the next stage of the project. To achieve the required class of estimate, the initial analysis was based on OEM engagement and Advisian's internal knowledge, experience and database information.

Project budget item	(A$M) $2020 Real	(A$M) $Nominal
Electrolyser Capital Cost	18.0	18.8
Site development	4.83	5.04
Steel, structural, balance of plant	13.60	14.21
Compression, truck loading	8.86	9.25
FEED and contingency	21.21	22.15
Total Project Capital Cost includes capital costs for compression of hydrogen on-site, truck loading and transportation.	74.0	77.3

Table 4: Project capital cost estimates

A summary of the Project capital costs is provided **Table 4: Project capital cost estimates**. The project budget includes all eligible costs expected to be incurred to execute the Project.

d. Requirement for Front End Engineering and Design (FEED)

Were the Project to proceed, it would be necessary to further refine the capital cost estimates to reflect a narrow range of estimates.

The technical definition currently attained by the Project allows for the calculation of an estimate with ±30 per cent accuracy (equivalent to Class 4 Association for the Advancement of Cost Engineering, AACE). As such, this indicates that approximately 10 per cent of all engineering required by the Project has been completed.

To date, all engineering disciplines have completed preliminary designs, enabling the completion of mechanical and electrical equipment lists, as well as material take-offs for large bore pipes, concrete and steel. Site selection has been finalised, and Process Flow Diagrams and a high-level 3D-model have been prepared.

To progress engineering for the Project to complete FEED, technical definition which enables a ±10 per cent accuracy estimate is required. This entails completed Piping and Instrumentation Diagrams (P&IDs), firm vendor quotes on all mechanical and electrical equipment, a completed 3D-model, a full Hazard and Operability Analysis (HAZOP), and complete definition of civil and structural engineering.

e. Project schedule

Figure 7: Project schedule below provides an indicative project schedule based on achieving a financial investment decision by late February 2021. Stanwell notes that this schedule was predicated on the Project receiving sufficient grant funding by November 2020 to proceed. It will require revision if funding becomes available.

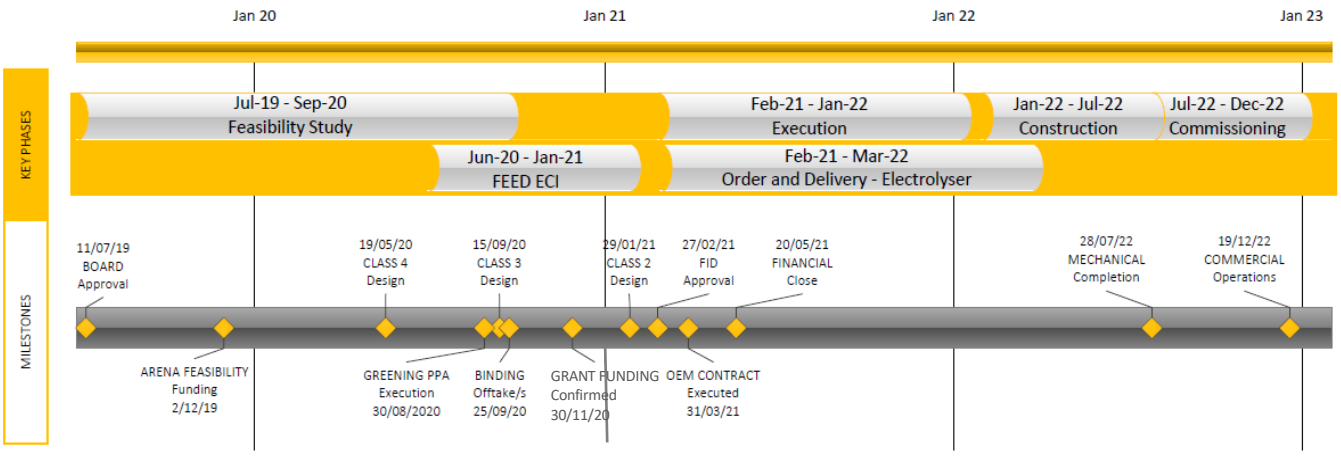


Figure 7: Project schedule

f. Services and connections

Electricity supply

The Project would be physically connected to the Powerlink Queensland 275kV network via a Stanwell Power Station unit and will source renewable energy and LGCs through a PPA. A significant benefit from siting the Project at Stanwell Power Station is that by physically connecting the plant to an intermediate voltage between a Stanwell generating unit at the Powerlink network, connection capital costs are minimised through the sharing of high voltage infrastructure between the Project and the power station.

The electrical connection required for the Project is expected to be made to the 20 kV bus between a generator at Stanwell Power Station and the step-up transformer connecting that unit to the Powerlink network.

The physical connection will be with Stanwell owned assets and the only expected interaction with Powerlink's assets will be a revision of the electrical protection scheme associated with the connection of that Stanwell unit. This is illustrated in **Figure 8: Electrical distribution diagram** below.

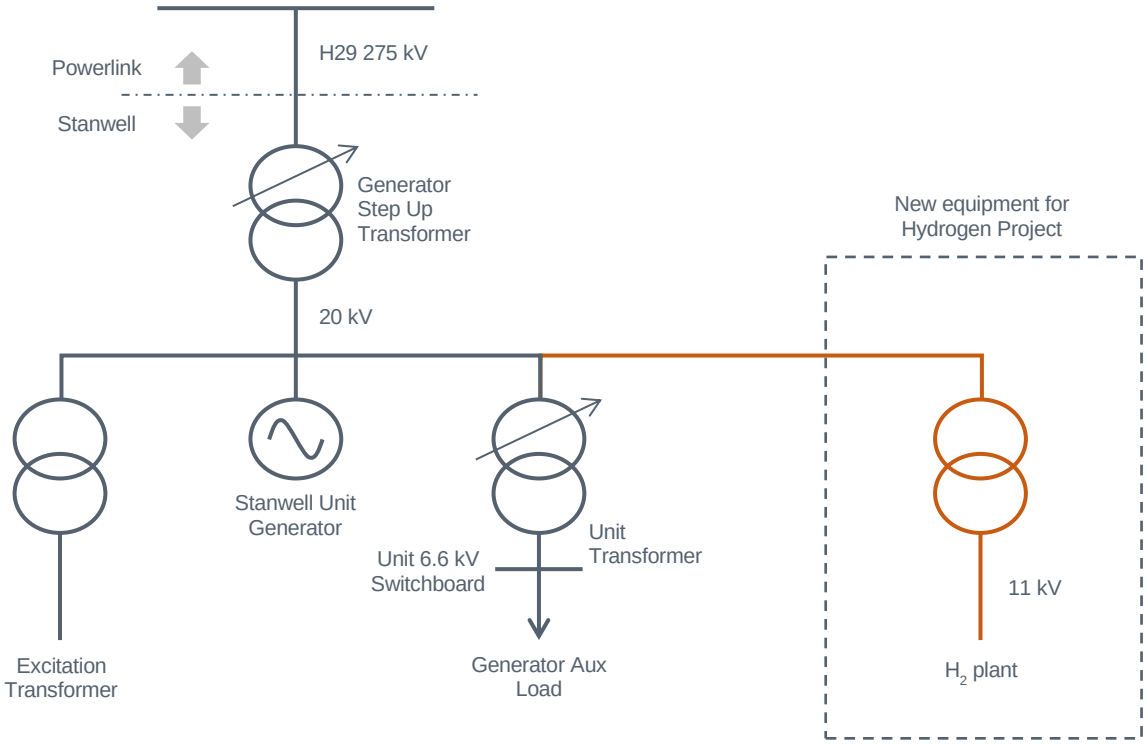


Figure 8: Electrical distribution diagram

Water supply

Design work so far on the proposed 10 MW hydrogen electrolyser plant has identified a requirement for approximately 15 megalitres per annum of demineralised water and up to an additional four megalitres per annum of potable grade water for cooling and ancillary purposes depending on detailed engineering design decisions. It is intended to provide these streams to the plant from the equivalent treatment processes within Stanwell Power Station.

Stanwell Power Station is located within the Fitzroy River basin and Stanwell has a high priority water allocation of 24,000 megalitres per annum held in the Fitzroy River. Stanwell has commercial arrangements with Sunwater who own and operate off site infrastructure to make this water available on site at the Stanwell Power Station.

Actual water usage at Stanwell Power Station is influenced by generation levels and salinity levels in the Fitzroy River. It has typically been in the order of 15,000 to 20,000 megalitres per annum with the bulk of this used in cooling systems. Operations at Stanwell Power Station have never been constrained due to limitations in the water supply or supply infrastructure. The provision of up to 19 megalitres per annum to the Project would be completely immaterial to the overall water supply system. Stanwell estimates that the cost for the supply of demineralised water is A$2 (2020 dollars) per kilolitre.

The demineralised water produced at Stanwell Power Station is of a quality suitable for use in the hydrogen electrolysers although the design will include a polishing plant within the Project's scope. The additional demand for demineralised water due to the Project would increase the utilisation factor of Stanwell Power Station's demineralised water plant by two per cent. No augmentation of plant capacity is required to maintain operations at Stanwell Power Station while providing demineralised water to the hydrogen project at a very high level of reliability.

Similarly, the impact of the demand for four megalitres per annum of potable water increases the utilisation of the Stanwell Power Station by four per cent with no augmentation work required.

As outlined above, the Project water demand is negligible in the context of the Stanwell Power Station water usage. Extended droughts have caused Fitzroy River storages to drop to low levels, but there are no historical records of circumstances where water supply to Stanwell Power Station or the Project would be endangered or curtailed. Current modelling of future climate scenarios for Central Queensland do not flag a significant change in overall rainfall levels although events are likely to be more extreme. The current storage structures will smooth the impact of these events given current water demands. Additional storage infrastructure (Rookwood Weir) is currently in the early stages of construction and whilst Stanwell will not hold allocations in the weir, the added storage volume will improve overall system reliability to the region.

Stormwater and wastewater management

While the nature and amounts of wastewater associated with the Project are still being resolved, it is expected that it will be of similar quality to streams generated within Stanwell Power Station but at a much smaller scale. It is proposed that logistical measures to deal with wastewater will be shared with Stanwell Power Station.

The stormwater and wastewater management of the Project, although under a separate EA, are intended to be integrated with Stanwell Power Station's analogous systems. Areas of plant where hazardous materials are located will be drained to a closed site collection system while clean area drainage will flow off-site through a controlled dam system where interventions can be carried out should an incident occur.

The Neerkol Creek system is strongly influenced by surrounding agricultural and industrial activities, including the licensed discharge of cooling system blow-down water and stormwater from Stanwell Power Station. The process water flows into a tributary of Quarry Creek and then into Neerkol Creek which becomes Scrubby Creek further downstream. The Stanwell Power Station Water Management Plan states that only water streams designated in the EA and meeting quality requirements set out in the EA may be discharged off-site through the designated discharge point, and that the rest must be contained on-site and recycled. It is expected that this ruling will apply to the electrolyser facility.

Monitoring is completed quarterly at nine monitoring points along Quarry, Neerkol and Scrubby Creeks to understand background conditions as well as the impacts of Stanwell Power Station process water. The monitoring program includes flow and on-site observations, water quality, sediment quality and biological monitoring.

The Stanwell Power Station Water Management Plan states that rainfall run-off can be released from site provided that it is clean, while any contaminated run-off is captured in dams. The dams are maintained at normal operating ranges throughout the year with specific care taken prior to and during the wet season to ensure levels remain within the operating range. Additional care will be required with the incorporation of run-off from the Project.

Groundwater

The Project stands within the footprint of Stanwell Power Station and its extensive network of groundwater monitoring activities and baseline dataset. This allows any impacts the plant might have to be detected with minimal additional monitoring effort.

A total of 66 boreholes are currently installed in and around Stanwell Power Station site and Ash Storage Area (ASA) to measure, assess and respond to groundwater conditions potentially impacted by the operation of the facility. It has been identified that the relevant environmental values applicable to groundwater monitoring are farm use / supply, stock water, and aquatic ecosystems. Concentrations of potential contaminants are compared against site specific trigger levels, revised in 2019, which are based on all available groundwater data. Historical monitoring comparisons are completed annually. The sampling schedule outlined in the Stanwell Power Station Groundwater Monitoring Program includes testing to detect releases of contaminants from the ASA, coal stockpile area and run-off ponds, effluent dam, drains reclaim dam, chemical drains pond, and onsite sewage treatment plant and holding ponds.

8. Finance and funding plan

Stanwell recognises that funding for the Project would have to be sourced from a number of financiers and stakeholders and that the funding mix would require an equity contribution from Stanwell itself.

a. Potential funding sources

Several organisations have been approached to assess their appetite for participating in the Project including:

- CEFC – CEFC has committed $300 million of concessional finance through the Advancing Hydrogen Fund toward hydrogen projects. Stanwell would commence negotiations with CEFC once an in-principle decision has been made to proceed with the Project;
- NAIF – Stanwell pursued concessional debt financing options with the NAIF, held early stage discussions regarding financing the Project and provided Project information to enable an initial review of the Project. NAIF noted that the Project appeared to fit within the parameters of its mandate and noted that an assessment would proceed more efficiently once the Project had been approved in principle;
- QTC – As a GOC, Stanwell raises debt financing from QTC. Stanwell notes that any proposal to secure debt funding from sources other than QTC such as NAIF or CEFC would require consultation with and approval from Queensland Treasury;
- Queensland Government – Stanwell has engaged with the Queensland State Government seeking support for the Project. This engagement is continuing;
- ARENA – Stanwell engaged extensively with ARENA, noting also that ARENA had agreed to partially fund this Feasibility Study. Stanwell developed and submitted an EOI in securing ARENA funding from its recent Renewable Hydrogen Deployment Funding Round. Stanwell's EOI was unsuccessful and Stanwell was not shortlisted to the next stage of the process; and
- The Federal Government recently announced additional funding of $1.43 billion for ARENA including $70 million for the deployment of a hydrogen hub.

b. Funding structure

To identify, assess and prepare a funding plan for the Project, a commercial analysis and financial model was developed.

The total capital requirements for the Stanwell project are estimated at A$74 million ($2020), which equates to A$77.3 million in nominal terms. Stanwell developed and optimised a funding plan that would deliver a potentially viable commercial outcome for the Project by funding the Project through a combination of equity, concessional debt and grant funding.

Planned funding sources

Stanwell investigated concessional debt financing options with NAIF and has had early stage discussions with NAIF regarding financing the project. Project information to enable an initial review of the project was provided to NAIF.

Stanwell notes that CEFC has committed A$300 million of concessional finance through the Advancing Hydrogen Fund toward hydrogen projects. Stanwell would expect further engagement with CEFC after completing the feasibility study, should the Project proceed.

As a GOC, Stanwell currently obtains debt financing from QTC. Any proposal to obtain debt funding from different sources such as NAIF or CEFC would require consultation with and approval from Queensland Treasury.

Stanwell engaged with potential co-financing partners as noted in **section** Error! Reference source not found. above.

Based on these assessments and discussions, Stanwell developed a funding plan that would combine equity investment, grant funding and concessional debt, this funding mix is illustrated below at **Table 5: Project source and application of funds summary.**

Project budget item	(A$M) $Nominal
Total Project Cost	**77.3**
Project Funding	
Total Grant Funding	25.0
Total Debt Funding	25.0
Total Equity Funding	27.3
TOTAL Project Funding	**77.3**

Table 5: Project source and application of funds summary

The Project's cash flow would initially utilise equity funding to place orders to accommodate the long lead time for equipment and site works and the last stage of spend would include the equipment installation, site integration and plant commissioning. This would be funded through debt.

Funding assessment

Stanwell undertook a financial assessment of the project on both geared and ungeared basis and a summary of the conclusions of this analysis are presented below in **Table 6: Funding Scenarios.**

	Scenario 1	Scenario 2
Funding mix	100% equity	Equity $27.3m Concessional debt $25m Grant funding $25m
Purpose	Assess the Project's underlying commercial viability with neither debt nor concessional funding	Assess an optimised funding structure which combines equity with concessional debt and grant funding
Project cash flows IRR	1.09%	1.09%
Project cash flows NPV	($31.7m)	($31.7m)
Pre-tax equity IRR	1.09%	6.40%
Pre-tax equity NPV	($31.7m)	($6.2m)
Post tax equity IRR	0.44%	3.49%
Post tax equity NPV	($28.5m)	($8.5m)
Debt Service Cover Ratio	-	1.76

Table 6: Funding Scenarios

The commercial analysis for the Project shows a modest equity rate of return (3.49%). This was as expected due to the high capital cost of electrolysers. However, the project could provide a strategic pathway to a large-scale green hydrogen and ammonia industry in Central Queensland.

To realise this long-term potential for Central Queensland to be positioned as an export hub, Stanwell would consider partnering with other equity investors, concessional debt providers (CEFC and/or NAIF)

and ARENA to deliver the project, with an understanding that Stanwell's equity contribution would have a relatively low expected rate of return.

However, the lack of availability of ARENA (or equivalent) grant funding of $25 million for the Project means the project is uncommercial for Stanwell.

Commercial arrangements

To support the Project's sources of funding, a number of commercial arrangements will be required. These would include commitments with technology suppliers, contractual arrangements with renewable energy suppliers, funding and development agreements with investor partners and an offtake agreement with an offtaker. These arrangements are represented below in **Figure 9: Contractual arrangements to support funding**.

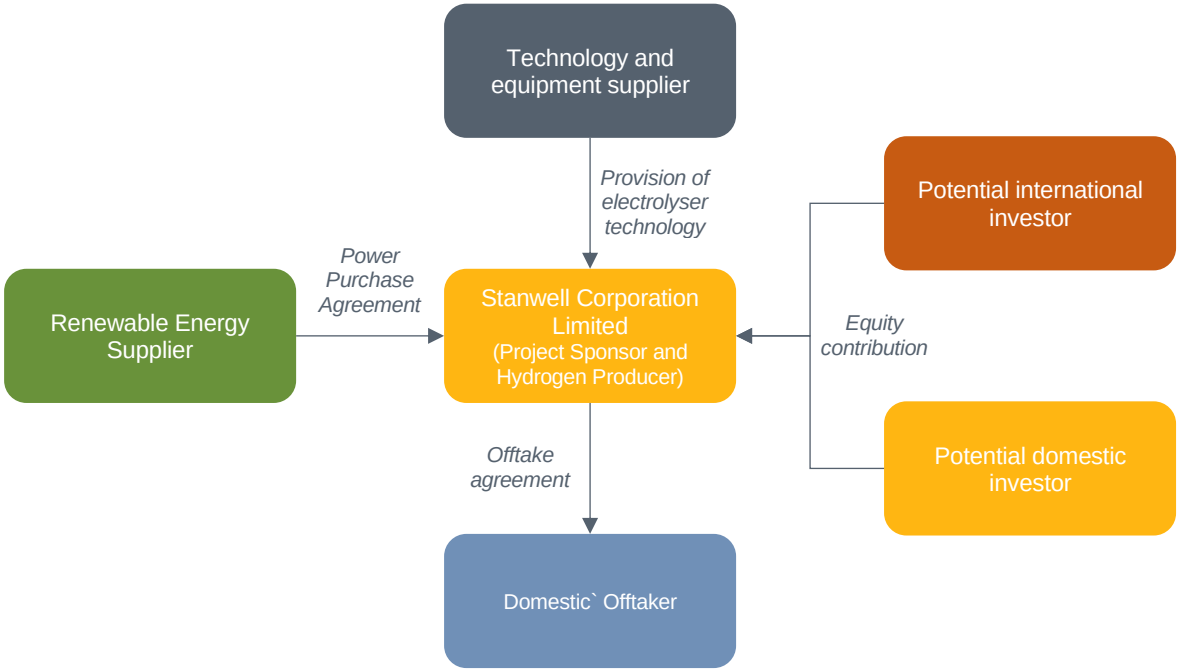


Figure 9: Contractual arrangements to support funding

9. Risk analysis and risk management plan

Stanwell seeks to actively manage all responses to its risk environment and acts, where necessary, to ensure that risks are contained at acceptable levels, consistent with Stanwell's risk appetite outlined in the Stanwell Risk Appetite Statement. This statement incorporates systems, structures, processes and people that identify, measure, monitor, report and control/mitigate sources of internal and external risk.

The specific risk management process for the Project is being undertaken in accordance with Stanwell's Risk Management Policy and Framework and Enterprise Risk Management and Business Resilience Policy, which adopts the principles of ISO:31000.

A project-specific risk management plan has been developed for the Project to enhance the analysis of potential risks and evaluate opportunities and includes:

- a Hazard Identification (HAZID) summary;
- an approach to completing Hazard Operability (HAZOP) analysis which is to be undertaken prior to financial close;
- a Workplace Health and Safety management plan approach; and
- a Project risk and opportunity register.

The Project's risk register and risk management plans are currently being reviewed and refreshed as part of the Project's ongoing evolution. The following table and sections provide a summary of the most critical risks identified for the Project outcomes against the following categories:

- technical risks;
- financial risks;
- operational and delivery risks;
- climate and environmental risks; and
- potential impact of COVID-19.

Stanwell has highlighted the Project's key risks in **Table 7: Summary of key risks** below as being critical to the Project's success and has put in place the associated relevant mitigation strategies.

Risk ID.	Type	Description	Consequences	Mitigation
2.	Delivery	• Project delivery suffers significant delays due to COVID19 control measures, impacting key delivery milestones; especially ARENA funding milestones and development of suitable commercial arrangements.	• Inability to secure funding for the Project.	• Establish effective Work From Home (WFH) structuring with Stanwell and its advisors • Continue engagement with domestic and international partners • Continue engagement with funding partners to communicate timeline challenges • Explore online/virtual consultation options and other engagement strategies for key stakeholders.
3.	Delivery	• Leadtime for major plant equipment does not align to project delivery timeframes.	• Project delay or non-ideal equipment purchased.	• Engagement with OEM's to fully understand delivery time frames • Timeline uncertainties to be included in commercial negotiations with off takers.
6.	Operational	• Uncertain electrical supply reliability requirements for the Project. A high reliability requirement for the hydrogen plant has potential to drive a complex and costly electrical connection configuration.	• Increased costs reduce commercial viability - e.g. higher capital for more complex connection assets and/or operational expenditure costs through TUOS.	• Engage with Powerlink to arrive at a landing on whether TUOS will be payable on power supplies to the hydrogen plant • Engage with Powerlink to obtain a quote for TUOS charges.
39.	Financial	• Inability for domestic offtake partners to make commitments beyond their own core business.	• Inability to secure sufficient domestic off taker contracts for the demonstration project.	• Develop structure and communications for the long-term strategy to provide vision beyond the Project within formal commercial arrangements.

Table 7: Summary of key risks

a. Technical risks

Risks associated with the design, construction and commissioning of the Project include:

- design specificity (fit for purpose);
- health and safety risk;
- assumptions (e.g. confidence levels);
- resourcing (e.g. skilled labour);
- site suitability;
- approvals;
- production costs;
- supply chain;
- legislative and regulatory risk; and
- insurance.

b. Financial risks

In respect of the financial risks, contingency and potential cost overruns will be governed by Stanwell's change management process in accordance with Stanwell's capital project governance framework.

Project reporting, including any cost overruns or contingency allocations, will be reported as part of the monthly capital reporting process to Stanwell's project governance committee.

Contingency costs shall only be used for the purposes intended and controlled separately from the rest of the Project costs. The drawdown of contingency costs will be managed and reported separately to avoid its use in "financing" or "balancing" over expenditure. The reporting of contingency costs will be carried out to separately capture drawdown or commitments in the Project Cost Report.

Contingency costs shall not be drawn down (or allocated) at a faster rate than the improvement rate for the level of definition of uncommitted work and shall be included in the progressive estimate for "to completion" reporting.

Accuracy in ongoing contingency forecasts will rely on continuing judgement for the quality of the improving definition of the scope, drawings and schedule, all on a moving time basis. Forecasting contingency costs shall occur on a monthly basis with rolling monthly forecasts "to complete" in addition to quarterly detailed re-forecasts, followed by internal reviews and audits, where appropriate.

c. Climate and environmental risks

Stanwell has actively engaged with numerous stakeholders over many years to understand the impacts of future climate change on operating assets including Stanwell Power Station. The key concerns identified by these actions have been:

- Increased duration of heatwaves – largely to be addressed through the engineering of any plant constructed (e.g. specification and margin in cooling systems).
- Isolation of sites due to flooding – historically this has been a problem for the Stanwell Power Station site in terms of road access from Rockhampton and Rockhampton airport. Recent road upgrades have significantly reduced the risk of isolation from Rockhampton although the airport itself remains vulnerable. Alternatives are available being road transport to Gladstone and the use of Gladstone airport.
- Water supply - the operational water requirements for the Project are minimal and within Stanwell's allotment. Future climate scenarios modelled for Central Queensland do not identify significant change in overall rainfall levels, while noting events may be more extreme. The construction of Rookwood Weir will improve the regional reliability of water supply.

d. COVID-19 risks

Stanwell has undertaken additional risk analysis based on the present COVID-19 pandemic to identify the areas of the Project where the pandemic is likely to have an impact on project delivery and commercial engagement. Through this analysis Stanwell has identified risks to the Project and several existing risks where COVID-19 has impacted the likelihood and/or severity.

Stanwell has incorporated any additional risks and any changes to existing risks related to COVID-19 into the Project's risk register as part of the project risk management plan.

Examples of the COVID-19 management plan are illustrated in **Figure 10: COVID-19 risk assessment examples** below.

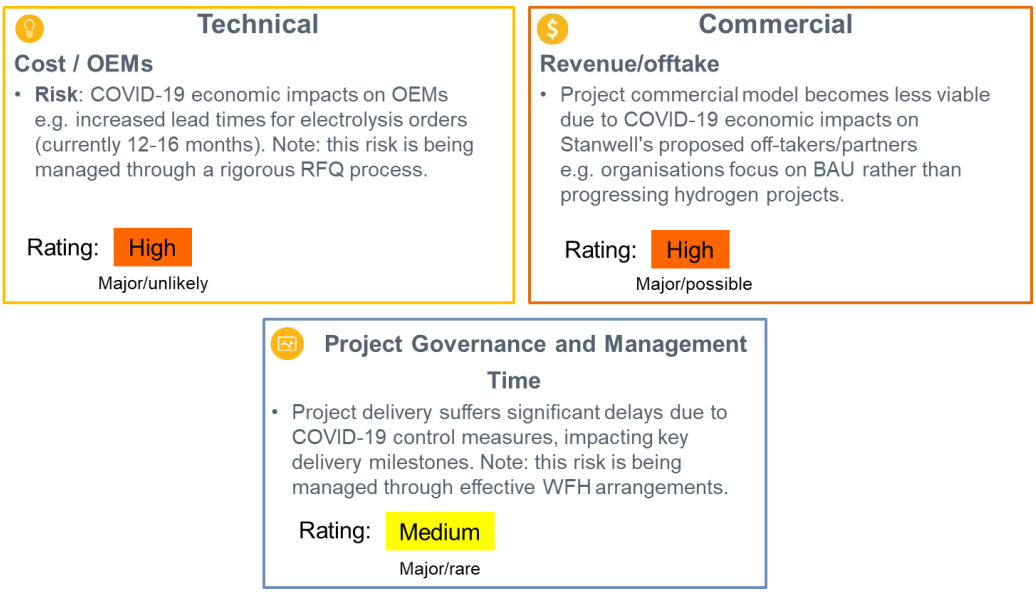


Figure 10: COVID-19 risk assessment examples

Stanwell's two main areas of concern in relation to project delivery impacted by COVID-19 include:

- a potential increase in lead times for electrolyser supply from technology suppliers; and
- potential delays resulting from enforced control measures that may impact the ability to effectively govern and manage the Project.

Stanwell has developed mitigation strategies to reduce the risk ratings for both delivery risks. Stanwell has worked with its technical advisors to create a portfolio of potential technology suppliers through a RFQ process thus reducing reliance on a single potential supplier in moving to the next phase of project delivery. To reduce any increased risks attributable to COVID-19 regarding the Project's governance and management strategy, Stanwell has positioned its WFH strategy to ensure reliable channels exist for regular communication between key project teams, personnel and advisors.

COVID-19 has also posed several commercial risks to the Project, particularly in relation to engagement of international partners in the demonstration phase. Stanwell has worked to address any commercial risks by building strong commercial relationships with potential international partners. Letters of support have been provided by potential partners expressing their ongoing interest and support for the Project in a post-COVID-19 environment.

10. Regulatory approvals

Stanwell engaged the assistance of a technical advisor to determine the expected regulatory approval requirements which may need to be addressed prior to commencing the Project. An approvals strategy was formulated as follows:

- establish a separate approvals pathway for the Hydrogen Production Facility (HPF) rather than seeking approvals under the existing Stanwell Power Station EA; and
- seek required development approvals under the *Planning Act 2016* rather than the State Development and *Public Works Organisation Act 1971* (SDPWO Act) which would require "co-ordinated project status".

A summary of the expected regulatory approval requirements for the Project and their current status can be found in **Table 8: Regulatory and approvals anticipated**.

The Stanwell Power Station site is owned as freehold land by Stanwell; as such the limited tenure actions required to facilitate the Project include:

- reconfiguring a lot to create a new lot for lease longer than ten years, providing an access easement from the new lot to the Power Station Road frontage, and easements for connecting various services to Stanwell Power Station; and
- registration of new survey plans with the Titles Registry.

Due to the date that the freehold property was created, it is likely that Native Title has been extinguished.

Stanwell has arrangements in place which act to ensure its Duty of Care under the *Aboriginal Cultural Heritage Act 2003* is met. Stanwell will separately consider the applicability of these arrangements to the Project.

Legislation	Approval/Consent	Potential trigger requirement	Administering authority	Indicative assessment timeframe (from lodgement)	Status
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	Approval to carry out land disturbance impacting on Matter of National Environmental Significance (MNES)	**Unlikely to be required:** Vegetation clearing and earthworks at risk of causing a significant impact on MNES due to loss of habitat for protected species.	Department of Environment and Energy	4 months	Desktop assessment completed
Environmental Protection Act 1994 (QLD) (EP Act)	EA for an Environmentally Relevant Activity (ERA)	**Expected to be required:** • ERA8 Chemical Manufacturing • ERA9 Chemical Storage	Department of Environment and Science	3 to 6 months	Desktop assessment completed
	Amendment to existing EA	**Potentially required:** Amendment to the existing Stanwell Power Station EA may be required	Department of Environment and Science	If a **minor change**: 1 to 2 months If a **major change**: 6 months	Desktop assessment completed
Planning Act 2016 and Regulation 2017 (QLD)	Material Change of Use Rockhampton Region Planning Scheme	**Expected to be required:** Code Assessable: subject to being compliant with relevant planning scheme codes.	Rockhampton Regional Council	Expected Code Assessment: 3 months (Note: For Impact Assessment: 6 – 12 months)	Desktop assessment completed
	Reconfiguration of a lot (RoL)	**Expected to be required:** Subdivision (of HPF site from existing lot) of lease greater than 10 years or a new lot and creation of easements for services and access.	Rockhampton Regional Council	To be done in conjunction with Material Change of Use (above)	Desktop assessment completed. Draft property boundaries and easements.

Legislation	Approval/Consent	Potential trigger requirement	Administering authority	Indicative assessment timeframe (from lodgement)	Status
	Operational Work	**Potential to be required:** Construction involving excavation and filling	Rockhampton Regional Council	3 months	Awaiting final engineering footprint.
	Material change of use for an environmentally relevant activity	**Expected to be required:** Refer EP Act above	DES	In conjunction with MCU (refer EP Act above)	Desktop assessment completed.
	Material change of use on contaminated land	**Unlikely to be required:** The site is not listed on the Contaminated Land Register. Known historical contamination has been remediated.	DES	In conjunction with MCU (above)	Desktop assessment completed.
	Landowner's consent	**Potentially required:** The Project site is owned by Stanwell Corporation. Should Stanwell not be the applicant, they will be required to provide owner's consent.	Stanwell Corporation	Not applicable	Not applicable

Table 8: Regulatory and approvals anticipated

a. Regulatory issues

In addition to its review of planning and regulatory approvals potentially required for the Project, Stanwell has also investigated and sought advice on whether it needs to obtain any regulatory licences for delivery of the Project and / or ongoing operation of the electrolyser.

Stanwell has been advised that the Project would not be subject to the provisions of the *Petroleum and Gas Act (Production and Safety) 2004* (P&G Act). While the P&G Act section 3(2) definition of petroleum activities encompasses production of a fuel gas, hydrogen does not meet the definition of petroleum under section 10 and therefore, a hydrogen production facility would not be considered as petroleum facility or require a petroleum facility licence under the P&G Act (Chapter 4, Part 3 and Chapter 11, Part 1, section 803).

The Project is not likely to constitute a "Material Particular" requiring notification or licensing under *Work Health and Safety Act 2011 (Major Hazard Facility)*. Major Hazard Facilities (MHFs) are locations that store above threshold quantities of chemicals listed in schedule 15 of the *Work Health and Safety Regulation 2011 (WHS Regulation)* or are determined as MHF after an inquiry process.

These include places such as oil refineries, chemical plants and large fuel and chemical storage sites where large quantities of hazardous materials are stored, handled or processed. In Queensland, MHFs also include facilities that store above threshold quantities of explosives and undertake some processing activity.

Although notification or licensing may not be required for the Project under this act, Stanwell will consider engagement with the relevant regulator, Workplace Health and Safety Queensland, to ensure all necessary requirements have been met.

Several additional pieces of legislation and potential approval requirements were considered by Stanwell and its advisors but are unlikely to be applicable or required for the Project:

- destruction / removal of protected species, habitat and/or breeding places: Nature Conservation Act 1992 / Nature Conservation (Wildlife Management) Regulation 2006 (Qld);
- vegetation clearing permit: Vegetation Management Act 1999 (Qld);
- offset requirements: Environmental Offsets Act 2014 (Qld);
- riverine protection permit for destroying vegetation, excavating or placing fill in a watercourse, lake or spring: *Water Act 2000*; and
- quarry material sales permit: *Forestry Act 1959 (Qld)*.

11. Stakeholder engagement

Stanwell's Strategy and Engagement team led a strategic work stream building upon ongoing current stakeholder engagement activities. A strategic approach to engaging both internal and external stakeholders, understanding potential community and social impacts and identifying other potential stakeholders is recognised as a significant prerequisite to the success of the Project's outcomes.

Stanwell developed a comprehensive stakeholder engagement plan for the Project. The Project's Stakeholder Engagement Framework provides a proposed approach to stakeholder engagement, including proposed communication tools and engagement activities.

Stakeholder engagement activities undertaken in relation to the feasibility study have included regular engagement with internal stakeholders, community leaders and groups, near neighbours, government, potential domestic and international investors, partners and customers, and OEMs in order to:

- understand stakeholder perspectives;
- shape the direction of the Project;
- build advocacy and support for the Project;
- position Stanwell as a key player in hydrogen development; and
- support project approval pathways.

Table 9: Current status of community and stakeholder engagement below provides a high-level overview of the community engagement activities undertaken to date.

Type of engagement	Description of activities undertaken to date
Stakeholder and industry engagement	Stanwell attended a range of events during the Feasibility study to engage with stakeholders including government, regulators, industry, community leaders, and potential offtake partners, suppliers, investors and supply chain proponents, and share insights on hydrogen. Events included: • Centre Annual Research Review 2019 (Centre for Natural Gas, University of Queensland) Panel session – Transitioning to a low carbon future - a mix of different energy resources (12 December 2019); • Hydrogen Industry Briefing: Gladstone Engineering Alliance – Creating a Central Queensland Hydrogen Industry (26 February 2020); • Central Queensland Hydrogen Forum – Starting a Central Queensland hydrogen industry (27 February 2020); • Future of Hydrogen Investment in Australia Roundtable – the future of hydrogen in Australia (4 March 2020); • Department of Industry, Science, Energy and Resources Hydrogen Certification Workshop (1 September 2020); • Gladstone Economic Development Forum briefing the Queensland Governor and community leaders on hydrogen development opportunities within Central Queensland (9 September 2020); • Local Government Association of Queensland Forum on hydrogen development in Central Queensland (15 September 2020); and • Australian Hydrogen Forum – Stanwell Hydrogen Project (16 September 2020).
Public education	To support community understanding and address concerns, Stanwell has developed a range of educational materials on hydrogen, the hydrogen opportunity and the potential creation of a Central Queensland hydrogen industry.

Type of engagement	Description of activities undertaken to date
	The following links provide a summary of the educational materials made available online and via social media: • Creating a Central Queensland hydrogen industry • Types of hydrogen • Stanwell hydrogen project – water • The hydrogen opportunity • Hydrogen explained (factsheet)
Supporting industry development	Stanwell joined the Australian Hydrogen Council in March 2020 and is actively involved in progressing the development of an Australian Hydrogen industry by participating in the Technical, Policy Advisory and Infrastructure committees. Stanwell is also a member of the Green Ammonia Consortium which is dedicated to building a value chain from supply to use of CO_2-free ammonia.
Indigenous communities	Stanwell maintains relationships with Traditional Owners in the areas where our assets are located throughout Queensland. This ensures that any land disturbance activities comply with native title and cultural heritage legislation, and that Stanwell maintains mutually beneficial relationships with Traditional Owners. Stanwell's Central Queensland Community Relations team works with Youth and business development representatives from Darumbal to identify opportunities for economic and employment empowerment programs that align with their aspirations.
Media engagement	Throughout the feasibility study Stanwell has continued to keep employees, local community and local media up to date on the progress of the Project through various internal communication channels, a dedicated public-facing hydrogen project website page, and local media interviews. Stanwell released the following media statements between August 2019 and March 2020: • Central Queensland could be home to Australia's largest hydrogen project (22 August 2019); • International interest in Stanwell's hydrogen project (4 September 2019); • Stanwell hydrogen project moves to next stage discussions (22 November 2019); • A step towards creating a Central Queensland hydrogen export industry (2 January 2020); • ABC Capricornia FM interview: Creating a Central Queensland hydrogen industry (27 February 2020); • Stanwell joins the Australian Hydrogen Council (5 March 2020); • 9 News Central Queensland story: Hydrogen (11 March 2020); • Stanwell Hydrogen Project receives ARENA funding (11 March 2020); and • ABC Capricornia FM interview: ARENA feasibility study funding (12 March 2020).

Type of engagement	Description of activities undertaken to date
	• 7 News Central Queensland interview: Hydrogen's role in Queensland's economy (12 May 2020). • Enlit Australia: CEO interview energy transition strategies and the role of hydrogen (6 August 2020)

Table 9: Current status of community and stakeholder engagement

a. Assessing social impact

As part of the feasibility study, Stanwell engaged Deloitte to undertake a structured social impact assessment. The social impact assessment was completed in September 2020 and incorporated targeted stakeholder engagement activities directly related to the Project.

These activities included consultation with the local communities, employees, unions, Traditional Owners, all levels of government, and industry.

The social impact assessment incorporates a detailed stakeholder analysis, public interest assessment, social impact evaluation and sustainability assessment. The scope of the assessment includes:

- development of a social impact baseline in line with best practice Building Queensland guidelines;
- identification of the social and economic impacts of the reference projects;
- evaluation of the impacts; and
- strategies to mitigate or augment the impacts.

Consultation was conducted through targeted engagements with key stakeholder groups via several COVID-19 safe channels including digital surveys and workshops, semi structured interviews, video conferences, phone calls, presentations, forums, briefings, and targeted correspondence. It provided opportunities for those potentially impacted by the Project to provide feedback and guided the completion of the feasibility study.

b. Public interest assessment and social impact evaluation

The public interest assessment identified that there were no public issues that would prohibit the Project from proceeding to the next stage of development.

While consultation identified some community concerns relating to increased traffic, health and safety (specifically the risk of fire and explosion), potential difficulty sourcing skilled and unskilled local labour, potential to disturb areas of cultural significance, mismatched employment expectations and water resourcing, most concerns could easily be addressed through effective education and communication strategies.

The material positive impacts identified within the social impact evaluation (SIE) include:

- providing proof-of-concept for further development of a Queensland hydrogen export hub – generating long-term investment and employment opportunities;
- the potential to enrich the relationship between Traditional Owners and Stanwell through the process of the Project as a model for future partnerships;
- improved intergenerational outcomes for Queensland residents as the development of the renewable energy sector diversifies Queensland's economic base; and
- contribution of knowledge and expertise to key stakeholders to develop a carbon-neutral hydrogen industry.

The material economic benefits described within the social impact evaluation are long-term in nature and are dependent on the success of the demonstration plant.

The sole material negative impact identified for the operational phase of the Project was increased public reputational risk for government and energy industry stakeholders if regulatory settings are not appropriate.

Key industry development documents (including CSIRO's National Hydrogen Roadmap and Australia's National Hydrogen Strategy) identify further work to be completed to support industry development and address safety considerations. This impact is independent of the Project, as these issues will require resolution even if the Project does not proceed.

Based on the potential impacts identified through the SIE, recommendations for future stages of the project included consideration of the criteria for the tender process to include targets/commitments outlined in the Queensland Procurement Policy, sharing of key learnings with Rockhampton Regional Council and the Central Queensland Regional Organisation of Councils, stakeholder engagement strategies that provide education on hydrogen use and safety management, skills training,

Based on the potential social impacts identified through the SIE, recommendations for future stages of the Project include:

- Consideration of the criteria developed for the tender process to include targets/commitments outlined in the Queensland Procurement Policy for projects valued at greater than $100 million.
- Engagement with Rockhampton Regional Council and the Central Queensland Regional Organisation of Councils to provide relevant key learnings associated with the Project. Issues discussed may relate to the development of the supply chain, community engagement approaches as well as sector trends/market developments for hydrogen and its by-products.
- The design of community engagement strategies which provide education around hydrogen use and safety management, as well as clarity regarding issues including skills training, employment and water consumption. Suggested avenues of community engagement in future stages of the Project include attendance at local events and updates contained in the Stanwell newsletter.
- Confirmation of an arranged site visit for Indigenous Elders. A site visit by Elders would allow the Elders to more fully understand the purpose, benefits and impacts of the Project. Sustainability assessment

A sustainability assessment was conducted to document the processes and arrangements of the Project as they relate to the optimisation of governance, environmental, social and economic outcomes.

The Project supports Stanwell's strategy to create future energy solutions and deliver affordable emissions reduction. These strategies contribute to state, national and international carbon reduction goals. The Project also seeks to develop commercial strategies and technological expertise in order to support the emergence of a renewable hydrogen industry in Australia.

The Project will be located on a brownfield industrial site, which will have limited access or interaction with the public. Cost-minimisation strategies have leveraged existing assets (e.g. sharing of high-voltage infrastructure with the Stanwell Power Station) in order to reduce the levelised cost of hydrogen. The Project is expected to apply for a separate Environmental Authority to Stanwell Power Station's current Environmental Authority. A minor amendment will also be sought for the current Environmental Authority to integrate Project activities.

c. Future work

Based on the findings of the assessments, any future phases of the Project should also include the:

- development of an Indigenous Engagement Strategy to ensure potential enhancements and mitigations for mutual benefit are realised;
- development of a benefits realisation plan;
- completion of social license assessment;
- consideration of resource recovery, environmental impact/toxicity and waste issues as they relate to the finalised Project design; and

- actions to address any identified skills gaps associated with the Project.

Stanwell has also been scheduled to participate in the following activities. Note that many of these events have been rescheduled due to the COVID-19 pandemic:

- Gladstone Engineering Alliance Major Industry Conference on initiatives that support a low carbon future (8 October 2020);
- Australian Energy Week 2020 CEO Panel, Hydrogen Panel and speaking on: Managing the transition from coal-fired generation - how Stanwell is evolving its business (15-18 February 2021);
- Energy Networks 2020 Conference – Stanwell Hydrogen Project (3-5 March 2021);
- EnLit (Formerly Australian Utility Week and Power ± Utilities Australia) Technology strategies/Hydrogen (10-11 March 2021); and
- Hydrogen and Gas Outlook 2030 – Stanwell Hydrogen Project (2021).

12. Reduction in carbon footprint

The estimated carbon emissions reductions from the Project are 20.2 kilograms of carbon dioxide equivalent per kilogram of hydrogen. The associated total emissions reductions are 32,948 tonnes of carbon dioxide equivalent per annum for a 10 MW electrolyser plant. The calculation approach for these figures is outlined below.

The intended end use for this hydrogen is as feedstock to for an ammonia synthesis plant. The hydrogen which would be supplied by Stanwell will be substitutional resulting in less hydrogen being produced in the gasifier, assuming the same level of ammonia production.

For a substitutional supply, renewable hydrogen would replace hydrogen from gasified coal, which typically has a higher emissions intensity than hydrogen from steam methane reforming. The International Energy Agency estimates 20.2 kilograms of carbon dioxide equivalents are released per kilogram of hydrogen produced via this method. Based on the production rate for the reference case vendor, this is equivalent to 32,948 tonnes of carbon dioxide equivalent per annum.[7]

Only the emissions associated with hydrogen production are included in the calculation. Emissions savings associated with ammonia generation, or the emissions associated with transport of renewable hydrogen, are not considered.

[7] The International Energy Agency, *The Future of Hydrogen - IEA G20 Hydrogen report: Assumptions*, Production Pathways Hydrogen (Table), accessed on 17.05.2020. https://iea.blob.core.windows.net/assets/a02a0c80-77b2-462e-a9d5-1099e0e572ce/IEA-The-Future-of-Hydrogen-Assumptions-Annex.pdf

13. Commercialisation Pathway: Green hydrogen at scale – the concept study

Stanwell recognises the importance of seeking a commercially viable outcome for the hydrogen project and has established that commercial viability is best achieved at significant scale. Further, projects at scale have the opportunity to pursue foreign markets for offtakers of green hydrogen. Given this, Stanwell has undertaken further analysis focussed on examining the commercial, technical and strategic viability of a large-scale green hydrogen and ammonia export industry in Central Queensland.

This commercialisation pathway could support the development of a domestic hydrogen and/or ammonia industry by providing locally produced green alternatives to existing imports. This is particularly strong in Central Queensland where a sizeable portion of local ammonia is imported. The region's generous endowment of renewable resources and existing infrastructure are critical factors in supporting the development of low-cost green hydrogen required to enable a domestic industry to meet the expected growth in international demand of green hydrogen and related products. A high-level schematic of this anticipated opportunity is depicted in **Figure 11: Scaling up a hydrogen export industry in Central Queensland**.

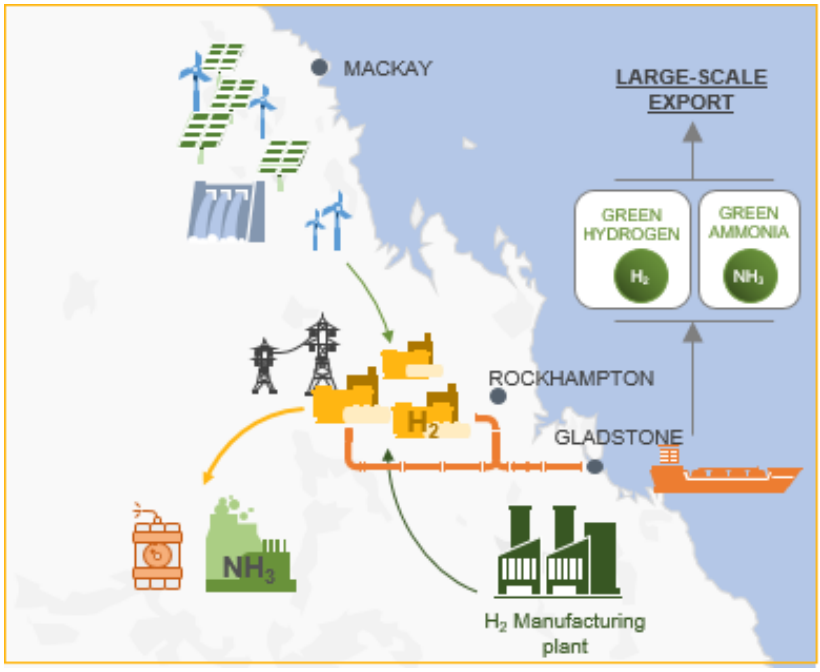


Figure 11: Scaling up a hydrogen export industry in Central Queensland

a. Demand for green hydrogen and ammonia

Through market sounding activities and newly established commercial relationships with foreign partners, Stanwell has identified potential annual demand for green hydrogen and ammonia will require electrolysis capacity in excess of 800 MW by 2026, and in excess of 3000 MW by the early 2030s.

This anticipated international demand for renewable hydrogen products is being driven by two key product streams:

- Green Hydrogen - market analysis has indicated a potential demand to service existing industrial customers as well as the anticipated growing use of hydrogen fuel cell vehicles and power generation markets in Japan.
- Green ammonia – market analysis has indicated a potential demand for approximately 500,000 tonnes per annum of green ammonia by 2025 for co-combustion in existing coal-fired power stations in Japan. Total Japanese demand for green ammonia is estimated to be as large as 10,000,000

tonnes per annum by 2030. This demand is driven by Japanese government policy requiring reductions in electricity sector emissions intensity by 2030.

b. Green hydrogen commercialisation pathway

Overview

Stanwell is considering (subject to approvals) establishing a consortium of international and domestic partners with the technical, financial and market expertise to realise the full extent of the opportunities available. Stanwell has received strong expressions of interest from a range of capable counterparties.

The concept study focussed on assessing the full supply chain costs of linking green hydrogen production in Central Queensland with the transportation of liquefied hydrogen via ship to Asia.

To ensure alignment with the timing and volumes noted by our international partners, progression of the proposed scale-up opportunity will encompass four stages investigating technical, commercial and strategic elements:

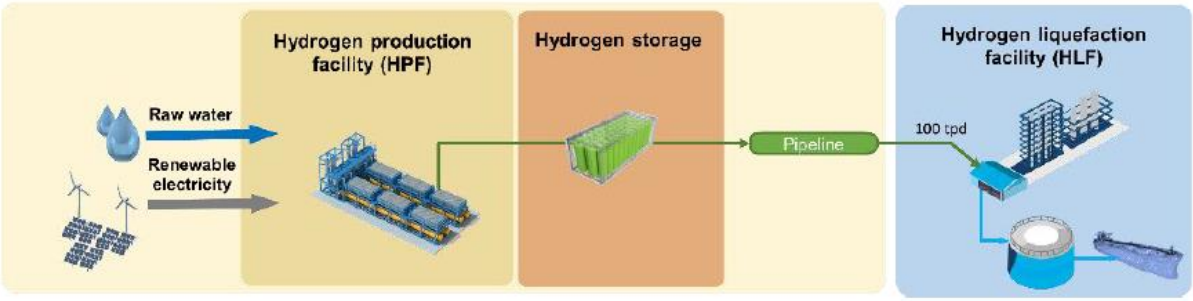
- Concept study – completed
- Feasibility study – to commence in mid-2021
- Final investment decision for scale-up project – end of 2022
- Deployment – 2023-2026.

In executing the scale-up phases, Stanwell will seek to deliver the following outcomes:

- realisation of a green hydrogen and ammonia export industry in Central Queensland (a new low-carbon industry) and establishment of key relationships with international trading partners new to the region;
- attraction of co-located manufacturing to Central Queensland;
- creation of capability and value within the hydrogen supply chain in Central Queensland; and
- based on CSIRO's analysis of key drivers of scale-up economics, Stanwell expects to contribute to the following technical and commercial learnings and improvements:[8]
    - reduction in electrolyser costs through scaling benefits, smaller footprint of stack, lower cost balance of plant, and improved efficiencies through larger-scale manufacturing;
    - improved electrolyser catalyst layers and membranes; and
    - improvement in hydrogen liquefaction efficiency and cost through investment in large-scale liquefaction and shipping.

Green hydrogen

A conceptual schematic of the centralised hydrogen supply chain is outlined in **Figure 12: Illustrative "centralised" hydrogen production model**.



[8] Commonwealth Scientific and Industry Research Organisation (2018). *National Hydrogen Roadmap.*

Figure 12: Illustrative "centralised" hydrogen production model

Analysis of renewable energy resources within Central Queensland as identified by the Australian Energy Market Operator (AEMO)) identified sufficient potential energy sources to meet the requirements of the proposed concept.

Green hydrogen for domestic consumption

While not explicitly explored, the concept study recognises the importance of providing and making available hydrogen to support the development of the domestic market and wider hydrogen industry. Given the variety of applications hydrogen presents across transportation, power generation and industrial applications, opportunities to provide either gaseous or liquefied hydrogen will largely be driven by identified local demand.

c. Green ammonia commercialisation pathway

Overview

The proposed pathway to commercialisation for green hydrogen has prompted further analysis of the potential value in delivering green ammonia as a downstream product of the green hydrogen production. As such, Stanwell has undertaken additional analysis to examine the commercial, technical and strategic viability of a large-scale green ammonia export industry based in Central Queensland.

Stanwell has been in discussions with a large Japanese power utility, and a trading house responsible for its energy procurement, have indicated the potential demand for approximately 500,000 tonnes per annum of green ammonia by 2025 for co-combustion in existing coal-fired power stations in Japan. Total Japanese demand for green ammonia is estimated to be as large as 10,000,000 tonnes per annum by 2030. This demand is driven by Japanese government policy requiring reductions in electricity sector emissions intensity by 2030.

The approach within this analysis has been to design a suitable supply chain concept within Central Queensland, focussed primarily on delivering 500,000 tonnes per annum of green ammonia starting in 2026.

Green ammonia

The green ammonia analysis adopted a similar approach to the hydrogen production concept outlined above. The concept is focussed on producing large volumes of green ammonia from a single ammonia synthesis plant, transported via purpose-built pipeline to refrigeration, storage and offloading facilities at the Port of Gladstone. A high-level schematic of the green ammonia supply chain is illustrated at **Figure 13: Illustrative "centralised" ammonia synthesis supply chain**.

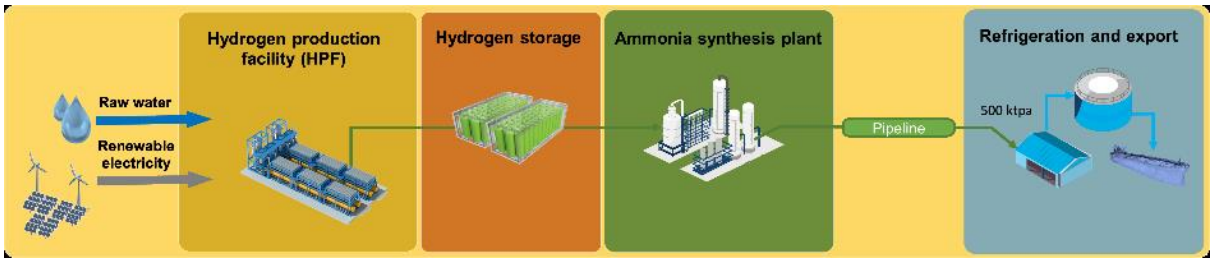


Figure 13: Illustrative "centralised" ammonia synthesis supply chain

The siting of the ammonia synthesis plant utilised previous analysis investigating suitable hydrogen production sites within the Gladstone SDA. It was identified that several benefits and cost efficiencies can be achieved in co-locating hydrogen and ammonia facilities as opposed to being situated at separate locations.

Similarly, green ammonia export facilities have utilised available land at Fisherman's Landing to locate the necessary ammonia refrigeration, storage and offloading facilities. The option of locating the refrigeration facility adjacent to the wharf was assessed as providing lower overall capital costs and requiring less regulatory approvals compared with co-locating the refrigeration facilities with the hydrogen production facility.

A schematic of the supply chain between the ammonia synthesis plant and the refrigeration, storage and offloading facilities is provided at **Figure 14: Green ammonia synthesis, refrigeration, storage and offloading process design**.

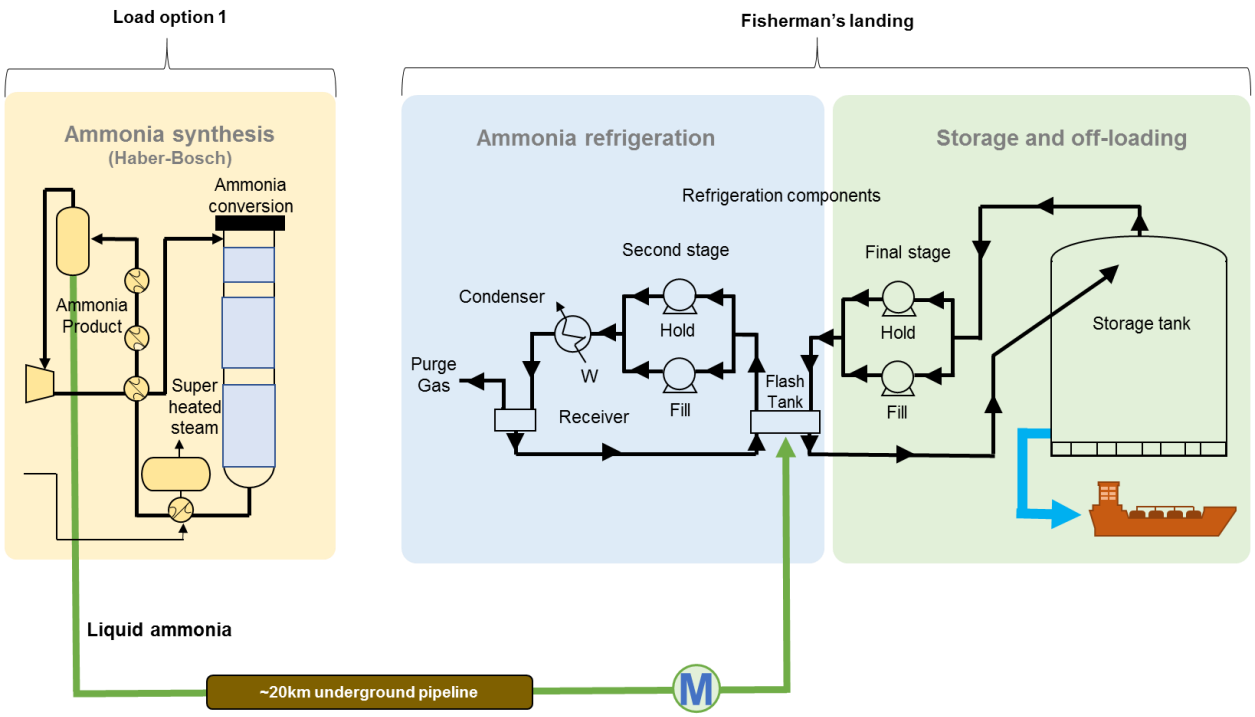


Figure 14: Green ammonia synthesis, refrigeration, storage and offloading process design

Green ammonia for domestic consumption

There is potential to provide green ammonia to the domestic market however this was not explicitly explored at this level of analysis. Additional analysis exploring this is suggested in additional bodies of analysis.

14. Conclusions and Next steps

The study conclusions and findings are:

- the project is technically feasible, with suitable industrial land, electrical connection and demineralised water available at Stanwell Power Station. The regulatory approval requirements are also relatively simple given the project would be on an existing site;
- at the 10MW scale, a hydrogen demonstration project is modestly commercially viable if it is able to attract grant funding for a material portion of its capital costs;
- there is a recognition that green hydrogen and ammonia will need to be underpinned by a 'green premium' reflecting the avoided cost of carbon, but the availability of secure offtake with a significant green premium for a demonstration-scale domestic project in Central Queensland is limited;
- the demonstration project is strategically aligned with the policy objectives of the Queensland and Australian Government;
- the demonstration project could provide technical and commercial learnings to contribute to the commercialisation pathway;
- there is an increasingly strong interest in Australia and globally in green hydrogen and green ammonia to decarbonise a range of sectors including power generation, transport and industrial processes. This is reflected in policy settings and the increasing flows of private and public finance into the development of hydrogen projects;
- the demand for imported green hydrogen and green ammonia is particularly strong in Asian countries; and
- there is potential for green hydrogen to be produced in Central Queensland at a scale to meet offtaker requirements. Meeting offtaker pricing targets will require sustained capital and renewable energy cost reductions in line with the targets put forward by governments and companies globally. However, Stanwell and Central Queensland have a range of competitive advantages which could position the project well on a global scale.

a. Next steps

Stanwell will now consider forming a consortium with international offtakers and government agencies to complete a gated feasibility study and FEED to progress to final investment decision. Stanwell would seek to share the costs of this study between potential consortium members (e.g. offtakers, investors).