SOUTH AUSTRALIA

Government of South Australia

South Australia

A global force in hydrogen

Hydrogen export prospectus
Summary version

www.hydrogen.sa.gov.au

Foreword

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Shaping a future hydrogen market for South Australia.

The potential for growth in the global hydrogen market is exponential.

South Australia has already taken early steps to harness the potential of our renewable energy resources and more recently, to generate hydrogen for domestic use. Now the State is ready to make the most of the opportunities to expand hydrogen use domestically and for export markets.

The South Australian Government has been an early mover, including the award of more than A$15m in grants and A$25m in loans to three megawatt-scale hydrogen projects across the State.

The South Australian Hydrogen Export Study, Modelling Tool and Prospectus is the next major stride in identifying the market potential for locally produced hydrogen and how the Government can assist in accelerating the development of a South Australian hydrogen industry.

The South Australian Government has identified support mechanisms that can assist the industry to develop and overcome potential development barriers as the world seeks to decarbonise their industrial processes and transport fleets.

As South Australia emerges from the COVID-19 pandemic response, the emerging opportunities, such as hydrogen, provide a new area for growth that has the potential to create future jobs and attract new investment.

Overall, analysts forecast global demand for hydrogen to increase more than eight-fold by 2050, giving South Australia a short time to establish this emerging industry so it can seize a share of what will be a large but competitive market.

The evolution pathway for new hydrogen industries will require strategic thinking and analysis to ensure efficient and effective development.

South Australia has played, and will continue to play, an active role in supporting its evolution through investment attraction, development approval processes and regulatory standards that keep pace with the speed of expansion.

The South Australian Government expects this Hydrogen Export Study, Modelling Tool and Prospectus to be a catalyst for international investment, as well as sending a strong signal to overseas markets of the seriousness of our commitment and intent.

There is no doubt that hydrogen production could be a transformative technology. It will challenge industries to rethink their current processing, trigger close examinations of our gas pipelines and ports, and inspire a different mindset on how we fuel our transport sector.

The development and growth of clean hydrogen for domestic and export can, through job creation and increasing investment, be implemented in line with South Australia's international reputation for a clean and green environmental and sustainable future. We have established a Hydrogen Regulatory Working Group (RWG) to deliver a world-class hydrogen regulation framework to ensure the industry develops in a safe, reliable manner.

South Australia has already initiated steps down this pathway through its support for blending green hydrogen into domestic gas networks, and studies into the commercial scale and required capacity to justify clean hydrogen production for export.

Our Electric Vehicle Action Plan encompasses a role for fuel cell vehicles that use hydrogen rather than batteries to power passenger vehicles and the infrastructure that is required to support that addition to the national fleet.

There are substantial advantages for a jurisdiction that moves early to target these economic opportunities. South Australia's abundant wind and solar resources have already attracted massive investment in renewable energy generation and storage.

The investment will assist with the South Australian Government's aspirations to cut emissions by more than 50% of 2005 levels by 2030, to achieve net zero emissions by 2050, as well as to achieve 100% net renewable electricity generation by the 2030s.

This investment has also put South Australia in a strong position to attract further technology and equity partnerships needed to transform its excess clean energy into hydrogen. Hydrogen production can also help to address security and stability issues within the local electricity grid by allowing storage of excess energy during periods of low demand.

Our thanks go to KPMG and WSP for their work in collaboration with the Department for Energy and Mining and the Department for Trade and Investment in developing South Australia's Hydrogen Export Study, Modelling Tool and Prospectus.

Highlights

Investment destination focused on innovation

With a highly skilled workforce, cutting edge research and development, competitive labour costs and a superior lifestyle, South Australia provides for a compelling investment opportunity for potential investors.

The State has a rich history of advancing new technologies including renewables that has resulted in over 50% of the state's energy requirements being supported by clean renewable technologies.

A rising force in hydrogen

Over A$7 billion has been invested into South Australia's world leading renewable wind and solar resources. These resources are well-suited to

large-scale green hydrogen production, while the State also has the necessary feedstocks for blue hydrogen.

Multiple investments in hydrogen projects have already been made with Australian Gas Infrastructure Group (AGIG), H2U and Neoen progressing domestic and export projects.

Discover more at renewablessa.sa.gov.au.

At the leading edge of hydrogen export

South Australia has the capability to produce clean hydrogen at rates competitive with the lowest global estimates as a result of the world-class resources and their proximity to suitable port locations.

Four optimised supply chain configurations have been identified as favourable routes to market following a detailed assessment of South Australia's resources.

World class government guidance and support

South Australia has seen bipartisan support for the hydrogen industry and has established a Hydrogen Regulatory Working Group (RWG) to deliver a leading hydrogen regulation framework to enable South Australia's safe hydrogen economy.

South Australia has a dedicated case management team that will provide information and help to navigate through approvals and identify avenues for State and Commonwealth support.

South Australian overview

South Australia – an investment destination and clean energy powerhouse.

South Australia is the southern central state of mainland Australia. It has a total land area of 983,482 square kilometres (13% of Australia). It shares borders with all other mainland states and territories. Its landscape varies from rugged outback wilderness and desert, to scenic mountain ranges and a coastline that stretches more than 3,700 kilometres.

The state has a population of more than 1.75 million people, 77% of whom live in the capital city of Adelaide and surrounding metropolitan areas. South Australia's rural regions are an integral part of its community and economy, offering diverse work and lifestyle opportunities.

South Australia's capital city, Adelaide, consistently ranks as one of the world's most desirable cities to live. It is a clean green city, and a national leader for renewable energy uptake.

The commercial centre has advanced manufacturing, technology and research bases. Many of the world's leading companies are represented, including those involved in defence, resources and technology. South Australia also has a large agricultural industry and is a major wine producer (Adelaide is internationally renowned as one of the world's wine capital cities). Health, creative and service industries are also important to the economy, together with education with thousands of international students' studying at the city's secondary schools and acclaimed universities every year.

South Australian advantage

Competitive business environment

South Australia offers a range of cost advantages that no other state in Australia can match, with potential to improve your company's bottom line.

Private sector labour costs in South Australia are 8.5% below the Australian average as a result of investment favourable tax policies and drivers. Further, the Adelaide market continues to be one of the most cost-competitive city centre markets nationally when it comes to setting up business and leasing office space.

An enviable lifestyle

Our capital city, Adelaide, is ranked in the top 10 most liveable cities in the world in 2019, and in the top five must-see regions by Lonely Planet in 2017.

South Australia's high quality of life and low cost of living combines to create high employee retention rates for businesses, providing business stability, continuity and bottom-line benefit by minimising staff turnover and re-training costs.

Favourable energy generation policies

South Australia is the nation leader in renewable energy with over 50% of the state's electricity provided by renewable assets, with a policy intent to enable this to reach 100% by 2030. Further, a new inter-state electricity grid interconnection is planned to be built in the coming years which will include storage technologies. This will provide significant capability for future hydrogen opportunities to be developed.

South Australia is transforming into a Growth State

By working extensively with industry to identify and unlock key areas of growth, the South Australia Government is determined to foster investment by maintaining a competitive business environment and by proactively targeting key growth sectors.

These sectors include:

- **Energy and Mining**
- **Defence**
- **Space**
- **Hi-Tech**
- **Food Wine and Agribusiness**
- **International Education**
- **Tourism**
- **Health and Medical industries**
- **Creative Industries**

Energy and Mining

Blessed with rich, natural assets, South Australia has provided high quality minerals and energy resources to the world for more than 150 years.

The State's energy strategy also targets hydrogen export as a key growth initiative to complement South Australia's already advanced clean energy transition strategy.

Defence

Over the next 20 years, South Australia will be home to the largest share of Australia's total in-country defence material spend. Adelaide hosts the headquarters for most of the nation's defence manufacturing capability and technology research, development and investment.

Space

South Australia is Australia's space state and has a rapidly growing space innovation ecosystem that will become the nation's hub for future space industry development.

Already home to over 80 space-related organisations, South Australia is committed to developing strategies to grow the local industry and to increase research and development collaboration as well as international engagement.

Lot Fourteen

Sitting at the forefront of technology, bold ideas, new ventures and creative thinking, Lot Fourteen is being developed by the South Australian Government into a global innovation neighbourhood of entrepreneurship, research collaboration and cultural activity.

Culture of innovation

South Australia is home to numerous, specialised, world-class research and innovation districts. These include the Tonsley innovation district, Techport naval industry hub, the South Australian Health and Medical Research Institute (SAHMRI), the Lot Fourteen innovation precinct and the Waite agricultural research precinct; all of which create high performance, collaborative environments.

Skilled and educated workforce

South Australia prides itself on being the nation's Knowledge State. With two of the world's Top 100 universities, South Australia produces an extensive range of graduates per year, ready to enhance your workforce. South Australia has approximately 102,000 students enrolled in university courses.

In 2019, Adelaide was ranked the most cost competitive city in Australia, in Mercer's 25th Annual Cost of Living Survey.

South Australia: A clean energy powerhouse

South Australia has been on an energy transition journey and is now ready to enable other countries to do the same.

South Australia has already integrated over 50% renewable energy as part of its total electricity generation mix, supporting the decarbonisation of the State's economy. By 2030, the State aims to achieve net 100% renewable electricity generation, exporting large volumes of clean energy to other Australian states.

Harnessing excess green energy in electrolyser solutions has the potential to create a green hydrogen industry within the State in the near future. In addition, the State's available natural gas reserves also provide a route to hydrogen production via traditional methods such as Steam Methane Reforming (SMR) with Carbon Capture and Storage (CCS).

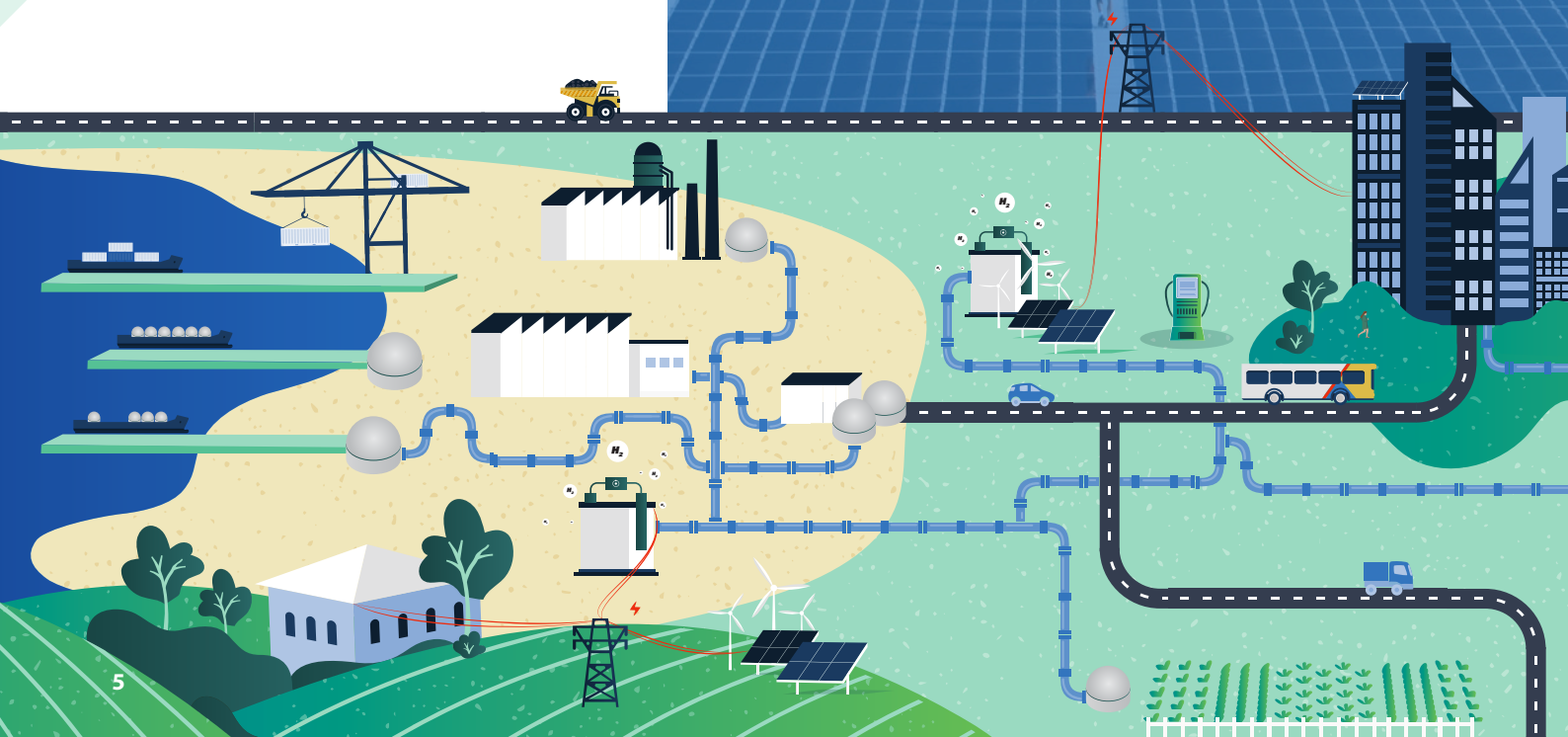
Geographic advantages supporting excellent clean hydrogen resources

South Australia is almost 1 million square kilometres, with an extensive coastline providing a route to desalinated water, expansive areas to harness the world-class wind and solar resources that support green and blue hydrogen development. Solar irradiation levels have been recorded at >23.5 MJ/m^2 with wind capacity factors in excess of 45%. In addition, there is also significant gas reserves enabling opportunities for blue hydrogen.

Driving a hydrogen export industry

South Australia has commissioned a bottom-up supply chain study which demonstrates its capability to produce clean hydrogen at rates competitive with the lowest global estimates.

Four optimised supply chain configurations have been identified and presented in this document as favourable routes to market, following the detailed assessment of South Australia's resources.



Track record of investment in hydrogen industry development

More than A$15m in grants and A$25m in loans has been invested by the SA Government in hydrogen projects to advance the industry. South Australia is committed to supporting the establishment of the hydrogen industry.

World class government guidance and support

South Australia has a clear policy mandate and efficient regulatory regime with the aim of attracting a substantial share of the A$1.7 billion and 2,800 jobs that ARENA have estimated hydrogen exports could contribute to the Australian economy. In addition there is a dedicated case management team that will provide information and help investors to navigate through approvals and identify avenues for State and Commonwealth support to further develop the industry in South Australia.

Proximity to end use markets with established trade routes

South Australia can deliver clean hydrogen to our trading partners to meet their ambitious plans. Trade offices are established across the globe in Japan, Korea, North East Asia, as well as the United States, China and Europe.

These offices provide platforms to promote SA's hydrogen capabilities to international markets and facilitate trade and investment partnerships.

Prime port facilities and coastline to support export

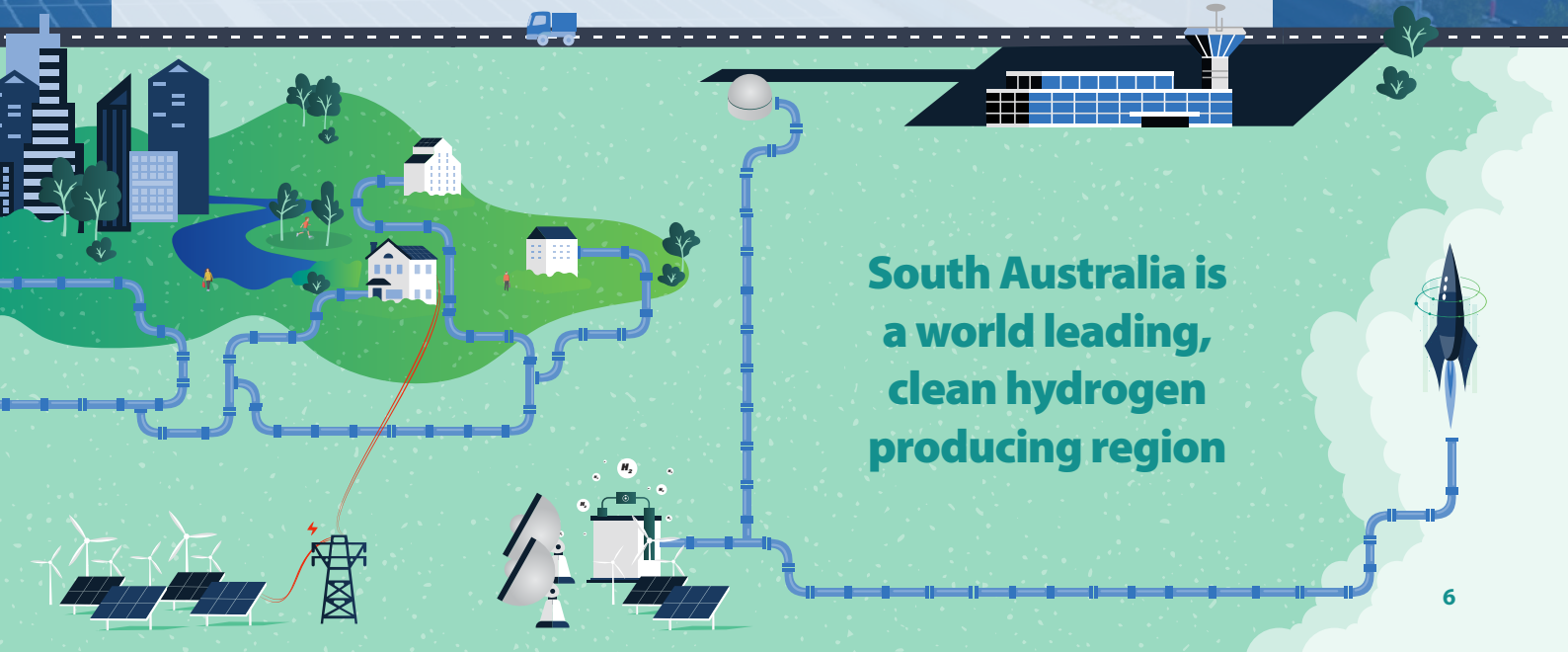
South Australia has existing ports and greenfield opportunities that, with development, are suitable to support export growth. All existing or greenfield sites are located in nearby proximity, <75km, to high quality renewable energy resources and have the necessary coastline to support indicative hydrogen vessels.

SA hydrogen vision of 2050

South Australia is a world leading, clean hydrogen producing region with an integrated hydrogen supply chain exporting internationally and supporting the domestic hydrogen applications.

This leverages the excellent wind and solar resources and favourable port locations to support multi-product, multi-terminal hydrogen export.

South Australia is recognised as a leader and pioneer in hydrogen regulation, safety and development.



The hydrogen export opportunity

As part of South Australia's ambition to be a leading hydrogen export market, the South Australian Government has commissioned a detailed pre-feasibility study of large-scale clean hydrogen production in South Australia to identify the full extent of the state's potential.

The study examined the supply chain infrastructure required to support hydrogen exports from renewable or gas resources. This includes the cost of hydrogen production (via electrolysis or steam methane reformation (SMR)), transport, conversion and storage costs, as well as costs to establish an export terminal and loading onto a vessel within the State. The study analysed South Australia's energy sources and required downstream investment for the State's most prospective regions and potential export port locations. A large number of potential combinations and scenarios have been analysed as part of this study to determine the supply chain configurations and locations which generate the most favourable FOB cost of hydrogen from South Australia for export. This considered the quality of the resource, investment in production, distance from port and associated transportation cost, analysing both product transport and electrical transmission to port for green hydrogen scenarios, and the necessary investment into processing and infrastructure upgrades at the port location.

To date, global estimates of hydrogen export potential have primarily focused on production costs, including the Australian Government's H2 under $2/kg long-term target, with production being the first step in the hydrogen supply chain, excluding any downstream processing or transportation costs. The outcomes of the study indicate that this target may be achievable in South Australia via blue hydrogen, with green hydrogen costs within reach of this target.

The key components of hydrogen supply chain can be split into production, transport, downstream processing and the export terminal. The analysis has been undertaken for a target first export of hydrogen by 2030, with all cost data provided in 2020 Australian Dollars.

The maturity of the technology varies between the elements of the supply chain and presents a different risk profile to investors across the supply chain. Each element of the supply chain has been modelled separately with associated forecast capital reductions, to approximate the forecast improvement of cost and operating efficiencies to the target first export in 2030. Accelerated deployment will continue to drive down the costs of these technologies and, in a competitive sense, these reductions are largely independent of location or jurisdiction.

The study benefits from the current, record low, interest rate environment, reducing cost of capital assumed applicable to the development of the supply chain, varying between a pre-tax nominal weighted average cost of capital (WACC) of 5.8% for the renewable build and 8.95% average across the remaining elements of the supply chain, assuming that the production would be largely contracted. This is indicative only, and potential investors have the ability to set their rate of return requirements in the online modelling tool. The capital costs presented are for the range of configuration outcomes and export volumes, ranging from 30,000 to 250,000 tpa. Other opportunities to commence smaller scale developments at lower total capital costs may also be available.

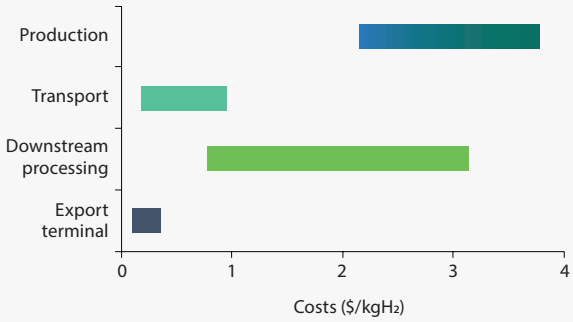
Due to the current immaturity of the industry and breadth of the study, there are limitations to the overall accuracy of the cost estimates. The accuracy of estimates (both capital and operating) varies across the supply chain. The overall level of accuracy on FOB cost is estimated to be in the order of +/- 40% due to uncertainties in emerging technology capital and operating costs, and the variable nature of gas commodity price inputs.

South Australia has the resources to compete globally

The outcomes of the study indicate a range of potential cost estimates depending on the specific configuration:

- **Production:** blue hydrogen represents the low end of production estimates with green PPA the upper bound.
- **Transport:** costs are relatively low due to the proximity of resources to export locations, with renewable resources within 75km of ports.
- **Downstream processing:** LOHC conversion results in lower cost outcome with liquifying hydrogen the upper bound of the range.
- **Export terminal:** costs are consistent across sites and largely driven by scale of export.

Outcomes of supply chain configurations (AUD$/kgH₂)*



*includes upside sensitivities for capex, energy (electricity & gas) and water costs, all other figures are presented without sensitivities

Production: refers to all costs associated with the production of hydrogen

Green Hydrogen: this includes either the development of dedicated wind and solar renewable energy hubs or electricity supply via Power Purchase Agreement (PPA) and electrolyser costs.

Blue hydrogen: comprises of gas as a feed-stock, required capital and operational costs of the SMR plant and CCS costs.

Transport: includes cost of electricity transmission for green scenarios, either a private transmission infrastructure or Transmission Use of System (TUoS) charges or the transport of hydrogen or hydrogen products for blue hydrogen configurations.

Downstream process: includes the conversion to hydrogen products e.g. ammonia, liquid hydrogen or liquid organic hydrogen carriers.

Export terminal: includes the costs to develop and operate the port infrastructure to enable loading of the relevant hydrogen product onto a vessel.

>75%
estimated electrolyser utilisation

The potential utilisation of green hydrogen production directly connected to an oversized renewable resource (typical 1:2 ratio of demand:nameplate capacity). The transmission capacity is sized to process load and leads to some curtailment of the renewable resource. Electrolyser capex contributes approx. 20% of FOB.

$38 – $48 /MWh
estimated cost of electricity for optimal FOB outcomes

Australia already has some of the lowest renewable energy costs globally. Indicative costs in 2030 of a constrained resource is estimated to reach $38/MWh. With an average constrain of between 10-15%. Electricity costs account for 40-50% of FOB depending on product type. South Australia's low electricity costs will ensure a lasting competitive position.

≈$2.5 /kgH2
estimated cost of blue hydrogen production

Average indicative costs of blue hydrogen, with production and CCS located in the Cooper Basin, are around $2.5/kgH2. Values around the H2 under $2/kg target may be possible with further optimisation through technology choice or cost reductions. Cost of gas accounts for 25-35% of total FOB.

≈$3.5 /kgH2
estimated cost of green hydrogen production

The potential cost of producing green hydrogen within South Australia by 2030, with opportunity for further optimisation. This is within leading global production estimates due to the high renewable capacity factors and close proximity to export terminals in South Australia.

20 – 40%
estimated proportion of FOB for conversion

Conversion of hydrogen products account for a significant portion of FOB mainly driven by capital costs. This is not location dependent and all locations will benefit as the cost of these technologies decline.

<7%
estimated proportion of FOB for the export terminal

South Australia has the potential to develop a number of ports. The development potential and required capital investment only account for <7% of the total cost /kgH2.

Compelling opportunities

South Australia – multiple opportunities at the leading edge of hydrogen export.

The detailed modelling identified a number of favourable configuration options to develop highly competitive export supply chains within South Australia. The four configurations included are examples of some of the favourable opportunities to create export supply chains in South Australia. Additional supply chains can be explored on the online tool, including those from Port Macdonnell and Myponie Point for a range of export volumes.

The study built the configurations from the ground up, based on the detailed assessment of each supply chain component. As such, there are variations across the configurations due to the specifics of that supply chain. A range of outcomes are presented inclusive of capital costs for the project. These represent the low-high export volume and alternative export products.

1

Large scale green hydrogen at Port Bonython

A potential large-scale hydrogen export terminal, with favourable volumes between 125,000 - 250,000 tpa. This harnesses potential wind and solar resources in the Upper Spencer Gulf for green hydrogen production. Transmitting electricity via a private transmission network to the port of Bonython approximately 70km away. As scale increases, additional wind resources are required impacting electricity costs.

1.2 – 2.5 GW
estimated electrolyser size

2.3 – 6.5 GW
required generation based on oversizing the renewable resource by approx. 100% compared to total process demand

>75%
potential electrolyser utilisation harnessing renewable energy

$39 – $47/MWh
estimated electricity cost for favourable configurations

≈$3.5/kgH2
estimated cost of green hydrogen production

2

An opportunity in the Cape Hardy/ Port Spencer region

A greenfield port opportunity for green hydrogen with excellent bathymetry. This has the potential for small-scale and large-scale export ranging from between 60,000 - 250,000 tpa. This connects to renewable resources from the Eyre Peninsula with an indicative distance to the port of 60km.

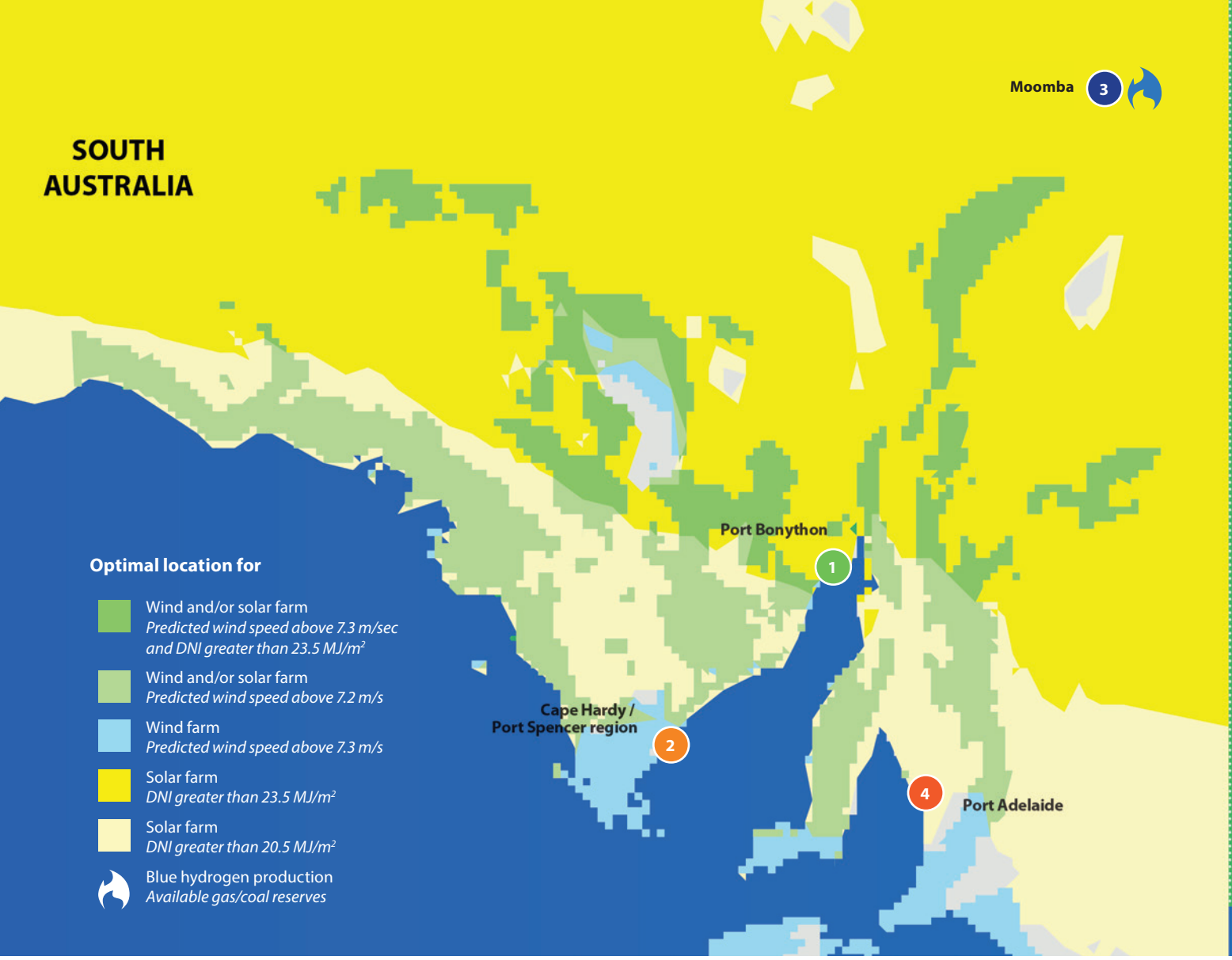
0.6 – 2.6 GW
estimated electrolyser size

1.1 – 6.1 GW
required generation based on oversizing the renewable resource by approx. 100% compared to total process demand

>75%
potential electrolyser utilisation harnessing renewable energy

$38 – $46/MWh
estimated electricity cost for favourable configurations

≈$3.5/kgH2
estimated cost of green hydrogen production



3

Blue resources exported from Port Bonython

Possibility to create a green-blue hub at Port Bonython, using the gas reserves located in the Cooper Basin at Moomba to produce blue hydrogen. Gas is converted to hydrogen at the resource site with the carbon captured and stored in depleted gas reserves. Favourable hydrogen volumes were identified as 125,000 - 250,00 tpa. Variations in the gas price will have an impact to final cost of production.

24,000 – 49,000 TJ
estimated quantity of gas required per year

$8.00 /GJ
estimated cost of gas and network supply charges

≈$2.5/kgH2
estimated cost of hydrogen production including CCS

4

Localised green production at Port Adelaide

A prospect to utilise the high-quality existing infrastructure to give a kick-start to the hydrogen economy, using grid connected renewable energy via PPAs to produce up to 80,000 tpa of hydrogen.
The volume is limited due to the current potential capacity of the existing grid infrastructure.

0.2 – 0.8 GW
estimated generation required

$40/MWh
estimated cost of electricity based on PPA

≈$3.5/kgH2
estimated cost of green hydrogen production via PPA

Next Steps

The South Australian Government welcomes the opportunity to speak to prospective hydrogen investors about the opportunities and assistance required to deploy projects within South Australia.

Interested parties can use the various **investor resources** access additional information on opportunities within the state, this includes resource and infrastructure maps as well as a hydrogen export supply chain modelling tool. The Online Hydrogen Modelling Tool harnesses the detailed analysis undertaken as part of the pre-feasibility study to assess the impacts of certain inputs across multiple configurations in South Australia. The ground-breaking tool provides insight into potential Free On Board outcomes of hydrogen produced and exported from South Australia.

Users have the flexibility to assess different supply chain configurations based on the optimum identified options resulting from the pre-feasibility study. To access the Online Hydrogen Modelling Tool, visit **hydrogenexport.sa.gov.au**.

To register your interest in any hydrogen projects, please directly contact:

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Image courtesy of Iron Road and H2U

Important Notice

For further details visit www.hydrogen.sa.gov.au

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