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Infrastructure Western Australia

Work Order 001

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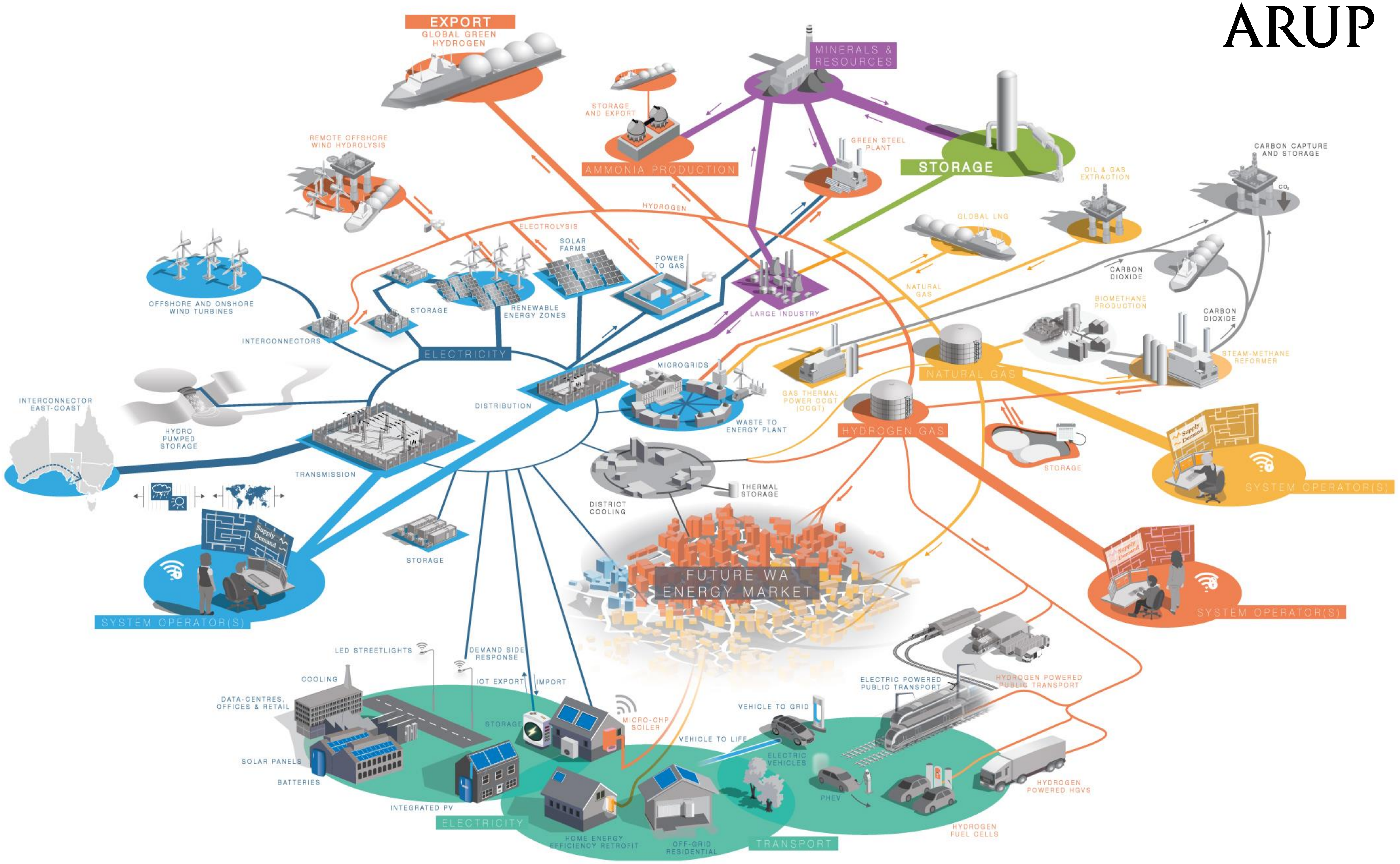

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Document Control

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Approvals

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1.0 Scope and Contents

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This document summarise the technical and policy advice provided by Arup under Work Order 001 for IWA to support the development and refinement of the State Infrastructure Strategy content and recommendations focused around the Energy sector, and in particular, Renewables and Hydrogen.

- Renewables – A resource that can be used repeatedly and does not run out because it is naturally replaced such as Solar Energy, Wind Energy, Hydro.
- Hydrogen – By "Hydrogen', Green Hydrogen (produced mainly by renewables) is meant in this document. Hydrogen is an important energy carrier since it can be made safely from renewable energy sources and is non-polluting.

1.2 Key Concepts

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Hydrogen Hubs – Hubs are regions where various users of hydrogen across industrial, transport and energy markets are co-located. In other words, they bring together industry, local businesses, local stakeholders and local authorities to develop and deploy hydrogen and fuel cell projects in a way which meets the energy and transportation needs of the local community.

Renewable Energy Zones (REZ's) – A component of NSW's and Victoria's Electricity Strategy, REZ's are a modern day power station, combining renewable energy generation with storage (batteries) and high voltage transmission infrastructure to facilitate energy delivery to homes, businesses and industries. REZ's centralise the generation and storage of renewable electricity, capitalising on economies of scale to deliver cheap, reliable and clean electricity. The coordination of REZ's is facilitated by a Government controlled statutory authority.

Micro-grids – Small-scale power grid that runs independently or it can be connected to the main electricity network. Micro-grids very similar to REZs however don't have the overarching authority that organises and coordinates the various proponents required to deliver the electricity generation, storage and transmission components.

Distributed Energy Resources (DER) – Distributed Energy Resources, or 'DER', are smaller– scale devices that can either use, generate or store electricity, and form a part of the local distribution system, serving homes and businesses. DER can include renewable generation such as rooftop solar photovoltaic (PV) systems, energy storage, electric vehicles (EVs), and technology to manage demand at a premises.

Glossary of Terms

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Abbreviation	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AGIG	Australian Gas Infrastructure Group
ARENA	Australian Renewable Energy Agency
BESS	Battery – Energy Storage System
CCS	Carbon Capture and Storage
CEFC	Clean Energy Finance Corporation
CO2	Carbon Dioxide
COAG	Council of Australian Governments
DBNGP	Dampier – Bunbury Natural Gas Pipeline
DER	Distributed Energy Resources
EPBC	Environment Protection and Biodiversity Conservation Act 1999
ERA	Economic Regulation Authority
FCEV	Fuel Cell Electric Vehicles
FMG	Fortescue Metals Group
GHG	Green House Gases
GW	Gigawatts
H2	Hydrogen
HDPE	High Density Polyethylene
I&C	
VRE	Variable Renewable Energy
WA	Western Australia
WEC	World Energy Council
WEM	Wholesale Energy Market
WOSP	Whole Of System Plan

Abbreviation	Definition
IEA	International Energy Agency
IMO	Independent Market Operator
ISP	
IWA	Infrastructure Western Australia
LGC	Large-scale Generation Certificates
LRET	Large-scale Renewable Energy Target
MW	Megawatts
NEM	National Energy Market
NGER	
NSW	New South Wales
NWIS	North - West Interconnected System
PPA	Power Purchase Agreement
R&D	Research and Development
RE	Renewable Energy
RET	Renewable Energy Targets
REZ	Renewable Energy Zones
SRES	
SWIS	South – West Interconnected System
UK	United Kingdom

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2.0 Opportunities and Challenges

2.1 Western Australia Opportunities - Macro

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Natural Resources

WA has a significant wealth of renewable energy sources including mineral resources. Recent demand for greener supply chains links well with available RE resources. In addition, the state has well established trade relationships and export facilities allowing the streamlining of establishment of a renewable energy export market.

Political Stability

Western Australia and more broadly Australia is a global location of choice for foreign investment due to the stability of its government, livability of its communities, quality of life and clean environment.

Global RE demand projections

A suite of nations across the globe have made a commitment to reducing their carbon emissions through signing the Paris Agreement. As a result, many nations are expected to have considerable demand for hydrogen and renewable energy. Japan and Korea are two of these nations who are strategically located for WA to serve as export partners.

Geographic location

Japan and Korea are two nations who have indicated they will have significant demand for low-cost hydrogen in the future. Western Australia is strategically located to serve these nations with hydrogen.

Net zero 2050 WA commitment

Western Australia has made a commitment to low carbon economy and to zero emissions by 2050. Achieving this target will require considerable investment into the RE space to reduce emissions associated with energy production.

2.1 Western Australia Opportunities - Micro

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Blending

A number of gas operators have expressed interest in establishing gas blending infrastructure in WA. Studies are happening across the state to assess the feasibility of hydrogen blending into existing assets. Additionally, hydrogen blending pilot programs are being undertaken across

Existing infrastructure

Western Australia has a large natural gas industry due to its wealth of natural gas assets in its northern extremities. There is potential for repurposing of these assets to serve the hydrogen industry providing the technical feasibility of such operations is proven. A study is current underway to convert APA's Parmelia Gas Pipeline, extending from Dongara to Kwinana, into a 100% hydrogen pipeline. This would be a considerable activator for the hydrogen industry as an industrial feedstock for use in Kwinana.

Skilled population

Western Australia has a highly skilled population and an established manufacturing base. This can be leveraged to develop the renewable energy and hydrogen industries in the state.

R&D tax incentive schemes

A series of major resources companies undertake large scale operations across WA, exporting the states natural resources across the globe. The size and profitability of these operations leave these companies with a considerable tax bill at the end of each financial year. To incentive innovation and investment from these companies into the state, the WA government has R&D tax incentive schemes, where these companies can reduce the tax, they owe to the state by undertaking innovative, cutting edge projects that benefit their operations and the state. RE generation could be added as one of these tax incentive projects to encourage private investment.

Decarbonising policy

Western Australia is expected to introduce city-led and state-led policy to decarbonise the transport industry in WA. Hydrogen has been touted a key input for decarbonising the transport industry, particularly for heavy vehicles. This policy should increase the demand for renewable hydrogen.

2.2 Western Australia Challenges

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Chinese trade relationships

Western Australia's economy has become increasingly reliant on its trade relationship with China. This has becoming increasingly concerning with the recent tariffs placed on a selection of Australian industries. The need to diversity the states and nations economy away from China is becoming more prominent.

Hydrogen production costs

Hydrogen technology is still very early in its development phase. Due to this, the technology is not mass produced and as such very expensive. These costs are projected to fall considerably as time progresses, however projects looking to establish imminently require government assistance to achieve commerciality.

High cost of labour and goods

Western Australia is known as an expensive place to do business, with high salaries and costs of goods (electricity / other inputs). This can be a challenge when trying to establish new industry as competition can establish in other geographic location for a far cheaper price.

Fuel tax revenue

The government currently has a 38% fuel tax (of total retail cost) which generates a substantial revenue each year. Applying this tax to a renewable fuel such as hydrogen would increase its lack of commerciality and provide yet another barrier for the industry's establishment, however removal of this tax to fuels will see the state take a considerable loss to revenue as the hydrogen transport industry gains traction.

Pilbara fuel subsidy

There is currently a subsidy for fuel consumed in the Pilbara to reduce the cost of operations to the major resource's companies operating in the region. This subsidy increases the relative commerciality of diesel compared to hydrogen which will act as a barrier to adoption of the new technology if it is not removed.

2.2 Western Australia Challenges

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Safety & policy frameworks

With respect to the hydrogen industry, there are no safety or policy frameworks in place to govern the industry, Establishment of these frameworks will reduce the challenges associated with large scale adoption of hydrogen technology.

Regulatory standards

There is a lack of clear regulatory standards associated with the hydrogen industry. It is unclear what effects this industry may have on the environment and community, particularly in consideration of the culturally significant land where some of these exceptional RE resources are located. Establishment of these standard will remove barriers for the private sector to develop projects of this nature.

Supporting Infrastructure

Identifying and addressing infrastructure gaps in potential supply chains. The creation of ports, access to low-cost renewable energy with transmission lines, water supply facilities and networks, gas distribution networks. Creation of hubs will make the development of infrastructure more cost-effective, promote efficiencies from economies of scale. Long transmission distances to connect to National Electricity Market (NEM) & Singapore/Indonesia

Low-Cost Energy Environment

The creation of an attractive and competitive environment for manufacturers, hydrogen suppliers, energy companies and transport operators to invest in large-scale hydrogen applications. Provision of the lowest-cost renewable generation in the world?

Expertise, Research and Development

Provide targeted support to drive technology development and develop industry expertise. The introduction of incentives for authorities and operators to invest in new technologies, technology transfer, innovation, research and planning such as new and different technologies for haulage fleets, models how bus routes are run and operated, etc..

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3.0 Western Australia Hydrogen Analysis

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3.1 Western Australia Hydrogen Analysis

3.1.1 Energy transition with batteries, hydrogen and storage

The Western Australian hydrogen sector has progressed minimally to date however recent interest has been shown by private and public entities.

The State has pledged to establish a dedicated Renewable Hydrogen Unit to coordinate the State's work on growing industry with a domestic and international (export) focus. The unit is proposed to act as a central point of contact, coordinating activities across various levels of government to embed the hydrogen strategy's vision.

A key opportunity for Hydrogen in Western Australia is the resources/minerals and transport sectors. Current understanding suggests that the heavy transport and manufacturing sectors are most suitable for hydrogen use. Collectively, these sectors consume over a third of the states energy. For WA (Australia) to achieve the Net Zero target by 2050, use of hydrogen / renewable energy for greener supply chains for raw materials can play a major role.

The establishment of green minerals supply chains could assist WA with market diversification. Inherently, it is expected that there will be a premium associated with green goods due to higher input costs, making the goods more attractive to consumers operating in countries with progressive carbon policy.

The Western Australian market has shown both considerable interest and concern with the adoption of hydrogen blending across the State's natural gas network. A number of current gas infrastructure operators have expressed interest in trialing gas blending in the states gas networks. Coupled with this interest lay two key concerns consistently raised in discussions about hydrogen gas blending. Firstly, hydrogen has a lower energy density than its natural gas counterpart, therefore requiring a higher gas throughout to achieve the same energy supply annually.

The second issue is more specific and associated with one of the key end users of gas passing through the Dampier to Bunbury Natural Gas Pipeline (DBNGP), an LPG refinery. In this companies' operations where gas is used as the feedstock, hydrogen acts as an inert gas. Because of this, a blended gas feedstock would increase the annual volume of feedstock required.

Policy needs to be established that addresses these concerns and sets a framework around how hydrogen blending can be managed within the gas pricing scheme. Given that hydrogen is considerably more expensive to produce by unit energy output, policy that incorporates carbon reduction mechanisms should be investigated to incentivise its uptake by private industry.

EXAMPLE PROJECTS

- From an infrastructure perspective, WA is looking to develop two hydrogen refueling stations, one in Christmas Creek to serve FMGs proposed new hydrogen bus fleet and one in Jandakot to serve ATCO's proposed new hydrogen vehicle fleet.
- AGIG are undertaking a study to assess the ability for the DBNGP to facilitate hydrogen blended gas. The main concern for this pipeline is in its welds where there is no lining. It is believed that due to the molecular size of hydrogen, the pipeline may suffer from embrittlement at the weld locations.

3.1 Western Australia Hydrogen Analysis

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Hydrogen should be viewed as an opportunity for diversification for the major gas players in WA rather than something that will compete with or close their businesses. It is crucial that the state enables these major players to make the transition to maintain their market share of gas production globally. There will likely be large opportunity for export of gas from Western Australia, particularly in northern hemisphere winter due to their heating needs and reduced energy production capacity.

3.1.3 Policy reform and strategic fit

Western Australia has no policy directly governing the hydrogen production industry. However existing gaseous goods frameworks and policies / licencing processes related to power generation (in any form) are being allowed to govern the development of hydrogen projects enabling faster progression.

The state has developed a high-level hydrogen strategy, most recently updated in 2021, that outlines the key goals for the state's hydrogen uptake. The strategy outlines a vision but provides little insight into how the state will achieve this or regulate this market once developed.

3.1.4 Regulation & Infrastructure barriers

Little market regulation currently exists in Western Australia governing hydrogen production and storage specifically. There are frameworks of technical regulations regarding production and transport of gaseous goods, however, the risk of hydrogen is quite different. Hydrogen has been in use for many decades across many industries. Adapting our current regulations to ensure safe use, not just to protect the public but to make sure that the market and use perception is susceptible to this change is crucial.

The Western Australian government is currently reviewing the relevant existing regulations, legislations and standards affecting the hydrogen industry in a bid to reduce barriers and enable the industry's emergence (as mentioned in the WA Hydrogen Roadmap).

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ONGOING PROJECT EXAMPLES

Fortescue Metals Group has moved its carbon neutrality target forward by 10 years to 2030 as the company advances its emissions reduction projects. The ambitious target follows a series of announcements involving Fortescue's trials of battery technology, hydrogen and green ammonia as a power source for mining equipment. Fortescue is currently developing a ship design powered by green ammonia and testing the use of renewable energy to convert iron ore to green iron without coal in Western Australia's Pilbara region. It is also testing large battery technology in its haul trucks, hydrogen fuel cell power for its drill rigs and technology that enables its locomotives to run on green ammonia. The company announced that is focused on working towards decarbonising its entire mobile fleet and fixed plant through the next phase of hydrogen and battery electric energy solutions. Furthermore, Fortescue aims to establish that the major steel, truck, train, ship and mobile plant industries can be operated with renewable, environmentally friendly energy. Source

3.1 Western Australia Hydrogen Analysis

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3.1.5 Hydrogen hubs

Western Australia doesn't appear to have any explicitly designated 'hydrogen hubs' however there are precincts with very similar characteristics.

There are studies undertaken by the Murdoch University Hydrogen team and Energy and Hydrogen Society of Australia for the city of Karratha proving certain regions in Western Australia such as Karratha that is a potential hydrogen hub site that satisfies the criteria.

In addition, WA has recently announced its first remote micro-grid using renewable hydrogen generation, built by Horizon Power and owned by the WA government in Denham. The project will utilise solar and renewable hydrogen and storage to power 100 residential homes.

The WA government has granted a major project – Asian Renewable Energy Hub - that aims to generate 26,000 MW of wind and solar energy out of which 23 GW of generation reserved for the production of green hydrogen and green ammonia.

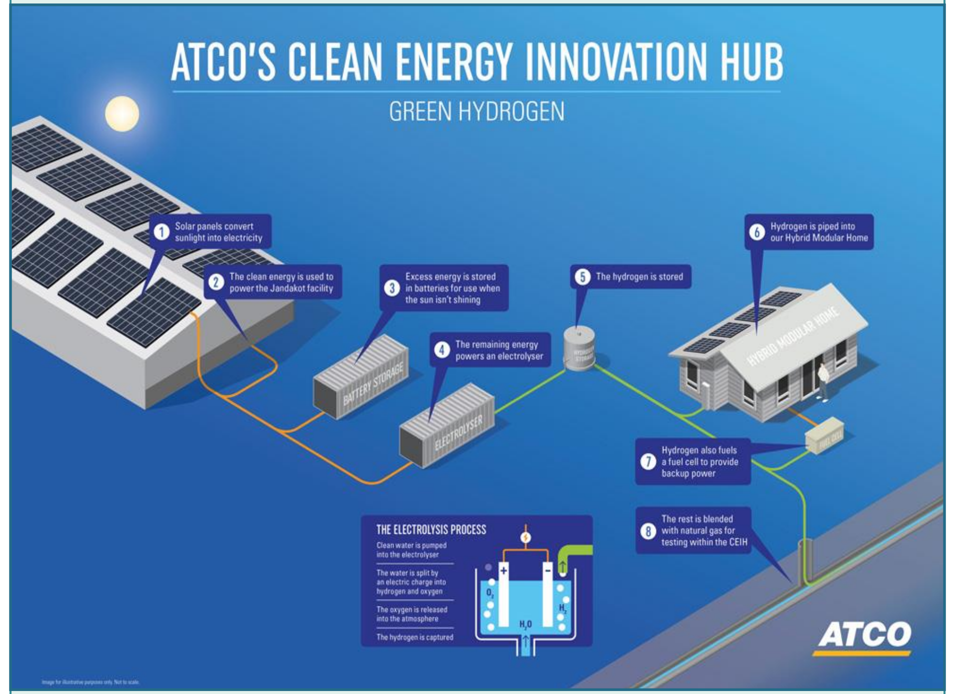
3.1.6 Funding

Projects in Western Australia have received / are eligible for funding from commonwealth sources such as ARENA and CEFC. These funding sources will be discussed in the Australia analysis section of the report

The WA renewable hydrogen strategy (2019) allocated $10m, in support of the strategy, to a renewable hydrogen energy fund to facilitate private sector investment and leverage financial support. In 2020, under the WA Recovery Plan, the WA Government allocated another $5 million to a second round of the Fund to support the development of the renewable hydrogen industry.
To date, seven organisations have been allocated a share of $1.7million to conduct feasibility studies into renewable energy projects across Western Australia.

ONGOING PROJECT EXAMPLES

In 2019 ATCO opened its new Clean Energy Innovation Hub at ATCO's operation facilities in the Perth suburb of Jandakot. The hub creates 'clean' hydrogen through solar powered hydrolysis and will investigate how ATCO can blend hydrogen within their existing natural gas network. This project and its associated componentry received $1.5m in funding from ARENA and $375,000 from the Western Australian Renewable Hydrogen Fund.



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4.0 Western Australia Renewable Energy Analysis

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3.2.1 Energy transition with batteries, hydrogen and storage

The Western Australian electricity sector accounts for 29% of WA's net carbon emissions and it's the cheapest and fastest to decarbonise. Western Australia has made progress enabling the transition to renewable generated electricity, with 16% of energy on the SWIS being generated from renewable energy sources which accounts for 8% of the state's total energy use. In comparison to other states and territories across the nation, Western Australia has the second lowest mix of renewable energy, but have also made the commitment to be net zero emissions by 2050.

For WA to achieve their net zero emission target will require work and may be a tad ambitious. Nonetheless, it can be accomplished with a clear path and strategy. This transition will not happen automatically and a lot of action and direction will be required to keep up with the global transition. Studies have been conducted that show the SWIS could transition to 100% renewable electricity as early as 2030 with the correct incentives. These studies are founded on very ambitious uptake targets, requiring an 80% increase in renewable energy uptake rate from the 2017 observations.

One of the key barriers identified in Western Australia's transition is renewable energy intermittency. The grid will require considerable energy firming to facilitate large scale adoption of RE assets and decommissioning of fossil fuel power stations.

Battery costs are projected to continue to reduce however their incorporation in the grid is crucial. The use of cost effective storage will facilitate the integration of high percentages of renewable energy into our grid network. The Western Australian government through the Energy Transformation Taskforce have released a Distributed Energy Resources (DER) roadmap, a five-year plan to guide the better integration of all distributed energy resources, including solar panels, battery storage and electric vehicles to ensure a successful transition to use of cleaner energy in the community.

3.2.2 Micro-grids and Electricity Markets

Micro-grids – Microgrids are becoming increasingly prominent in Western Australia and are a solution increasing in popularity when it comes to the issue of rural power supply. Regional WA is not well-suited to a grid connected electricity system due to long distances resulting in costly and unstable networks. Micro-grids are a good solution to solve this issue.

Electricity markets –
The IMO was established to administer and operate the Wholesale Electricity Market and ensure adequate reserves of electricity supply to Western Australian consumers within the South West Interconnected System (SWIS). There is a drive to establish one in the North West Interconnected System (NWIS), however this will likely require a 'connected' NWIS which is pretty challenging due the long distances and may potentially not happen in the near future.

ONGOING PROJECT EXAMPLES

There are currently several microgrids in WA, some of which include: Kalbarri, Perenjori, Bremer Bay and Ravensthorpe which increase reliability of service to isolated towns.

In the example of Kalbarri, the town has a large seasonal load associated with tourism. Prior to establishment of the micro-grid, the town frequently experienced black outs during peak tourism seasons, making the holiday experience less comfortable and posing danger to the towns tourism industry. These blackouts where due to the town having:

- Insufficient generation of renewable energy to power its base and seasonal load
- Transmission line issues associated with the build up of dust, salt and moisture causing a phenomenon called 'tracking' which was invoking outages on the local network infrastructure.

To address this issue, Kalbarri have developed a microgrid with considerable battery storage that will significantly increase the reliability of the towns power. This is an example of the benefits a micro-grid can bring remote communities, a consideration particularly important in Western Australia due to the state's vast remoteness.

4.0 Western Australian Renewable Energy Analysis (cont'd)

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Electricity markets (continued) – In WA there is only one network operator, the state -owned Western Power, in control of the SWIS. he wholesale price of electricity is variable due to the deregulated nature of the market. As a result, market price fluctuates pending an array of factors, including fuel price shocks, availability of generation capacity, unexpected outages, demand inelasticity, exogenous demand variation and transmission constraints.

Variability in the wholesale price of electricity induces variability in revenue for energy suppliers which adds a layer of risk to long-term renewable energy. This risk has been addressed across the globe through provision of feed-in tariffs or the enabling of power purchase agreements, providing renewable energy investors with confidence in the projected revenue streams.

It is thus expected that an inverse correlation exists between the variability in price of electricity and the percentage grid power supplied by renewable energy, provided that there is adequate firming capacity. Renewable energy technologies enter the power generation mix as non-dispatchable generation which needs to be supplemented by dispatchable generation or storage to ensure a stale balance between supply and demand.

Where grid demand exceeds the renewable energy generation at the time, production facilities that can ramp up and down as required, such as coal and gas fired power stations, can be turned on to address the momentary marginal energy demand. Because of this, the equilibrium price of electricity (the balance of supply and demand) remains more consistent

In addition to this, the marginal cost of renewable electricity production is considerably cheaper than the marginal cost of fossil fuel based energy production. The root cause of this is the cost of inputs into non-renewable energy generation. Because of this, it is again more advantageous to use renewable energy where available before using other facilities whose marginal cost of production is higher.

3.2.3 Policy reform and regulations

The Western Australia Energy Transformation Strategy has been developed to ensure delivery of secure, reliable, sustainable and affordable electricity to Western Australia. The strategy is delivered under three work streams:

- Distributed Energy Resources
- Whole of System Planning
- Foundation Regulatory Frameworks

One of the key challenges the strategy works to account for is the recent, large scale adoption of solar PV across the state.

Reviewing the Energy Policy Annual Report suggests that whilst the state has a clear vision on the future energy supply, there is little governing policy that pushes / forces the implementation of that strategy. The state would likely benefit from a more stringent framework that asserts its presence across investment reviews to ensure alignment of new projects with the strategy and ensure that emission targets are met. The more time that is allowed to pass without implementing policy of this nature, the more aggressive the transition to renewables will need to be in order to meet existing emission targets established by the state.

4.0 Western Australian Renewable Energy Analysis (cont'd)

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WA's transition to renewables has been held back by large coal and gas reserves, the state's incumbent thermal generators, an over-supplied main electricity grid, and ultimately by indifferent leadership.

3.2.4 Renewable Energy Zones (REZs)

REZs are aimed to ensure the development of strong backbone grid infrastructure to enable better integration and transmission of large amounts of renewable energy to major load centres.

REZs have been implemented by the New South Wales government to streamline the development process and align the energy production of the state with its over arching vision.

Western Australia has no explicit REZ's and typically requires investors establishing renewable electricity generation to coordinate the transmission of their own assets with the relevant power authority. This additional work required to establish RE projects is a challenge for establishment and delivery of RE assets across the state in comparison to NSW.

3.2.5 Funding

The WA government has launched a $66.3 million package focused on renewable energy technologies to help kick-start the state's economy. The package is split into components, with $44.5 million worth of infrastructure to be installed in the north west of WA, including 50 standalone power systems, nine Battery Energy Storage Systems (BESS) and infrastructure upgrades in remote indigenous WA.

$10 million of this package was allocated to the Clean Energy Future Fund and additional funds were spent elsewhere around the state on projects with strategic alignment to the states clean energy policy.

In April 2020, Western Australia launched the Clean Energy Future Fund to support the implementation of innovative clean energy projects in Western Australia. For projects to gain access to the funds, they must offer public value through contribution to at least one of the following:

- Significant, cost effective reduction in greenhouse gas emissions below projected (or baseline) emissions as a direct result of the clean energy project
- Design, deployment, testing or demonstration of innovate clean energy projects likely to deliver community benefits or lead to broad adoption and significant reductions in greenhouse gas emissions.

The fund has $16 million available with a $4 million maximum for any one project.

A report, Energy2030, by WA Greens modelled the transition to 100% renewable energy by 2030 which demonstrates a heavy mix of wind and solar PV. An example of one of the scenario no.2 which includes a heavy mix of wind and solar PV, the total amount of energy required for WA to reach 100% renewable energy approximately shown below:

Wind Farm 6500MW capacity (assuming an estimate of $2m per MW)
Solar PVs 2000MW capacity (assuming an estimate of $1m per MW)

Estimation of total investment in renewable needed: $15bn (Without an increased hydrogen demand which seems it can induce a further $20 – 30bn required on top of this estimated amount. This dwarfs the <0.1bn allocated for renewables. In order to mention a realistic amount allocated for the investment of renewables a total of $10 – 30 bn is required to highlight the seriousness.

5.0 Western Australia Proposed Energy Transformation strategy

5.0 Western Australia Proposed Energy Transformation Strategy

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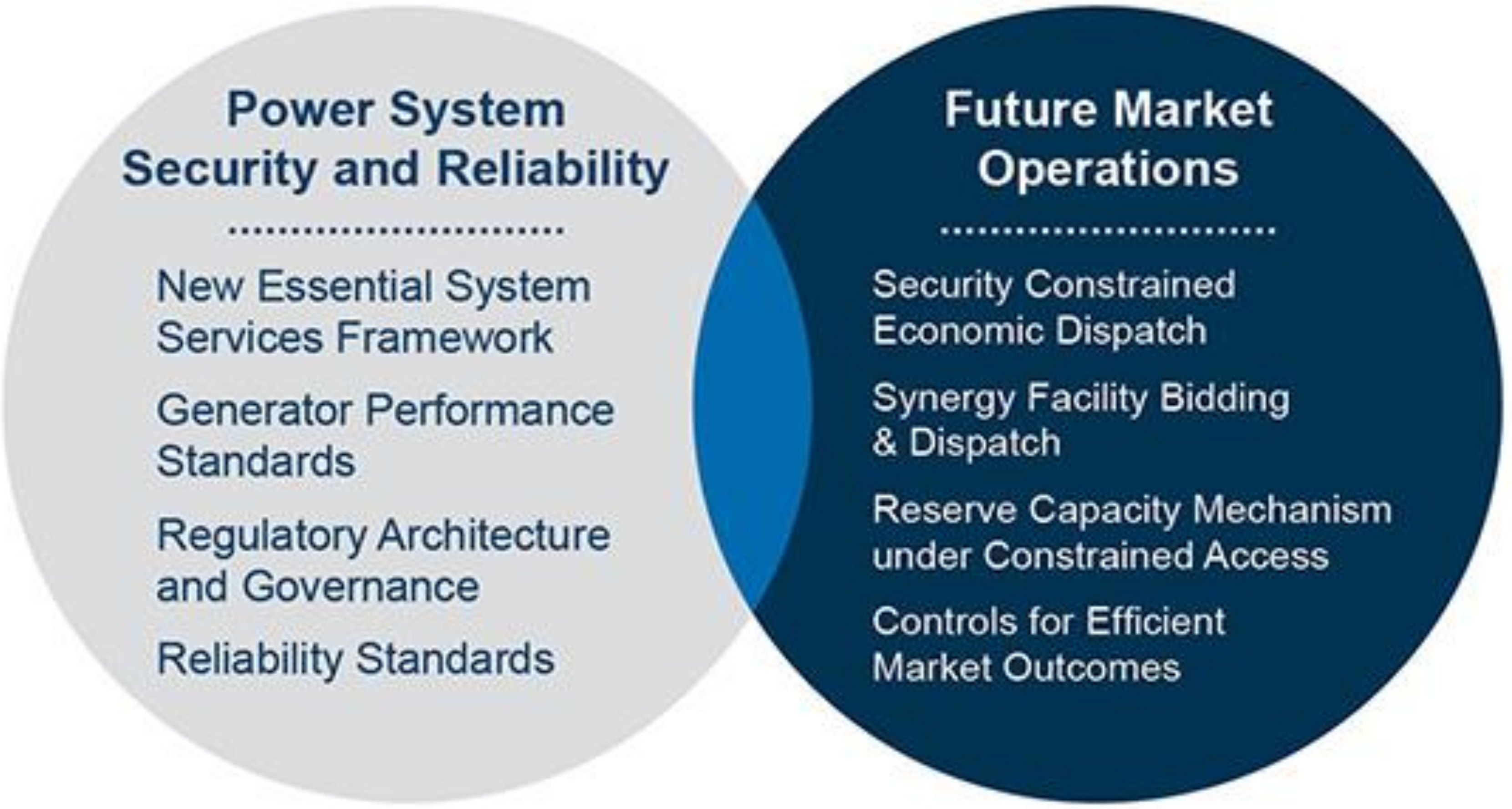
The Energy Transformation Strategy is the Government's program to ensure sustainable and affordable electricity to Western Australia in the years to come. The delivery of the Strategy will be overseen by the Energy Transformation Taskforce, which was established on 20 May 2019. The Taskforce is being supported by the Energy Transformation Implementation Unit, a dedicated unit within Energy Policy WA.

The Strategy will be delivered under three work streams

1. **Distributed Energy Resources (DER)** – to find best ways to overcome technical, regulatory and market barriers along with integrating DER to the grid
2. **Whole of System Planning** – Informed view on what SWIS (South West Interconnected System) might look like in the coming years – (regional WA not included)
3. **Redevelopment of Regulatory Frameworks**
   - **Improving Access to the SWIS** – Measures to transition existing network access arrangements, new process for allocating reserve capacity credits under the Reserve Capacity Mechanism and new arrangements for dispatch of generators in the WEM. All to be consistent with a constrained network access model.
   - **Delivering the Future Power System -** Two major streams a) Power System Security and b) Future Market Operations



5.0 Western Australia Proposed Energy Transformation Strategy

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A very brief overview is iterated below to state the proposed changes to delivering the future power system. The changes involves developing arrangement to enhance the security and reliability of the power system, and improving the operation of the WEM. The Delivering the Future Power System work stream has two major elements: **Power System Security and Reliability** and **Future Market Operations**

Power System Security and Reliability

Ensures that the regulatory frameworks and tools available to the Australian Energy Market Operator (AEMO) are there to make certain the system security and reliability is maintained. The related workstreams are as follows:

- **New Essential Systems Services Framework** – Also referred to as Ancillary Services, will be designed around the current and future needs of the power system
- **Generator Performance Standards** – New standards will be designed and implemented to help maintain power security and reliability
- **Regulatory Architecture and Governance** – Roles and responsibilities between AEMO, Western Power and market participants will be clarified and change management and governance arrangements will be improved.
- **Reliability Standards** – Currently there various reliability targets to different elements of planning and operating the SWIS. Common reliability standards and their governance will be prioritised

Proposed Changes In Electricity Markets

Future Market Operations

Ensures improvements to the design and operation of the Wholesale Energy Market (WEM) at lowest sustainable cost. The related workstreams are as follows

- **Security Constrained Economic Dispatch** – The current dispatch of generators around network constraints in the WEM is managed manually leading to inefficiencies in the market, along with dispatch not being co-optimised resulting in increased costs for customers. The proposed changes includes a 'security-constrained' market design with a co-optimised dispatch across the energy markets
- **Synergy Facility Bidding** – Synergy will be required to bid its generation on an individual facility basis (not as a portfolio) to enable the proper functioning of new security constrained market.
- **Reserve Capacity Mechanism under constrained access** – The implementation of a framework for constrained access of Western Power's network will require changes to the way capacity credits are assigned under the Reserve Capacity Mechanism to ensure it continues to incentivise investment in capacity while providing locational signals to new facilities
- **Controls for efficient market outcomes -** Throughout the Delivering the Future Power System work stream, consideration will be given to the extent to which market design changes confer market power on individual or groups of market participants which can potentially be exploited to affect market outcomes. Scenarios where controls for efficient market outcomes may be required include rules for rebidding after gate closure, definition of short run marginal cost and situations where a market participant may have market power.

5.0 Western Australia Proposed Energy Transformation Strategy

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The Energy Transformation Taskforce also released a paper on proposed changes to the Electricity Networks Access Code 2004 to support the Energy Transformation Strategy. The Access Code has remained unchanged since it was first developed. Therefore, it was essential to make new changes to the code that reflects the new Energy Transformation Strategy. Following are the list of proposed changes.

Increased opportunities for new technologies -
Changing the New Facilities Investment Test (NFIT) -
Change in Access codes will:

- remove bias for investments made through regulated capital and/or operational expenditure; ensure that Western Power accounts for market costs, including costs emerging in the Wholesale Electricity Market (WEM) due to network issues, when assessing net benefits;
- promote investment decision transparency while minimising regulatory compliance costs

Introducing non-network / Alternative options solution obligations –

- DER mentions the opportunity to enhance the processes through which third party service providers can deliver non-network services
- requiring Western Power to produce a Network Opportunity Map, an alternative options strategy and vendor register

Facilitating the deployment of stand-alone power systems and distribution connected storage

- Recent changes to the *Electricity Industry Amendment Act 2020* enables Western Power to invest in and earn regulated revenue in relation to new technologies, specifically stand-alone power systems and distribution connected storage. Proposed changes to the Access Code will ensure the cost of these new technologies can be recovered through regulated tariffs.

Introducing 'multi – function' assets
Multi-function assets are those that can be utilised to provide both regulated network support services and other services. Access Code changes will enable the sharing of benefits from multi-function assets, to ensure that:
the network service provider is incentivised to increase the use of the existing network; and
a share of benefits of this increased utilisation are passed through to end-use customers, who ultimately pay for the shared network.

Streamlining the regulatory approach for Whole of System Plan (WOSP) priority projects
For WOSP projects identified as a 'priority project', Western Power will not be required to undertake a regulatory test and the ERA will only review the unit costs of expenditure. For other projects, Western Power may rely on the WOSP for inputs to the regulatory test.

Amending the Technical Rules change management process – Proposed changes to the access code will allow any person to submit a proposal to amend Western Power's Technical rules, whereas previously Western Power was the only party that could submit a request change.

5.0 Western Australia Proposed Energy Transformation Strategy

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Maximising Network Utilisation

Changes to the Electricity Networks Access Code 2004 (Access Code) are required to maximise the use of the existing Western Power network and ultimately ensure efficient pricing for end-use customers

Changing the Access Code objective

To reflect the changing nature of electricity networks, the Access Code objective is proposed to be split into three 'limbs' that deal with:

- the regulation of access to the services of networks,
- the quality, security and reliability of covered networks to better facilitate the governance of the Technical Rules; and
- the environmental implications of the supply of electricity via networks.

Enhancing price signals

- Western Power will decide on types of reference tariffs through a Framework and Approach process.
- Western Power will be required to submit Tariff Structure Statement (TSS), emulating the national regulatory regime, in conjunction with its Price List obligations.

Streamlining pricing objectives

The proposed changes seek to review and streamline the pricing principles in the Access Code, to better enable the provision of appropriate pricing signals for utilisation of, and therefore efficient investment in, the network. The changes incorporate concepts under the national regime, and intend to provide greater clarity for Western Power and the ERA on the elements to be considered in structuring and setting reference tariffs.

Avoiding price shock

Due to the changes in volume and costs of new technologies and renewable energies the tariff rate I subject to increase. One of the objective is to reduce the price shock or sudden dramatic tariff movements. It is proposed the Access Code be amended to require the difference between expected revenue and target revenue in the last pricing year of an access arrangement to be minimised.

Enabling cost recovery for Advanced Metering Infrastructure (AMI)

It is proposed that it is beneficial to include a specific provision for AMI as an input to the building block process

Improving access to the Western Power network

Current barriers to investment in newer and more efficient forms of generation capacity are costs required for new generators to augment the network themselves. The proposed changes does not include the need for this augmenting cost and provides a greater return on investment for existing network infrastructure by optimising use of grid.

Enabling cost recovery for constraint-related functions

The new constrained access framework and WEM arrangements require AEMO to use Constraint Equations to calculate dispatch outcomes and to inform allocation of Capacity Credits. AEMO will develop the Constraint Equations based on information ('Limit Advice') provided by Western Power.

Proposed amendments to the Access Code will enable Western Power to recover the efficient and prudent costs of providing Limit Advice to AEMO and associated activities

5.0 Western Australia Proposed Energy Transformation Strategy

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Improving the access arrangement process

The Electricity Networks Access Code 2004 (Access Code) provides the framework for preparing, approving and reviewing an access arrangement for a regulated network. While progressing other changes to the Access Code, it is opportune to progress measures that improve the access arrangement process.

Introducing a framework and approach – The ERA will produce a Framework and Approach document that sets out which services will be regulated and the broad nature of any regulatory arrangements when it comes to the access arrangement for western power. The objective of the Framework and Approach process is to facilitate early public consultation and stakeholder agreement on incentive mechanisms and reference services

Providing flexibility in the access arrangement timeframes - Under the proposed Access Code changes, instead of setting prescriptive timeframes for each stage, minimum timeframes for public consultation and a date for the final decision will be defined.

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6.0 Australia Hydrogen Analysis

6.0 Australia Hydrogen Analysis

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4.1.1 Hydrogen Overview

Clean hydrogen is categorised into types of hydrogen - blue hydrogen and green hydrogen. Green hydrogen is produced using renewable energy to produce power which is used to electrolyse water. Separating the hydrogen from the oxygen, resulting water as its only by product.

Several countries across the world have committed to Paris Agreement, to reduce their carbon emission by 2050. Hydrogen can play an important role in decarbonisation of countries. Green hydrogen production can help to capitalise and utilise the complete potential of renewable energy such as solar and wind energy which could further bring down the carbon emission.

4.1.1 Energy transition with hydrogen and storage

The rapid change across Australia's energy sector, stemming from the requirement of clean and sustainable energy, has encouraged the recent development of the Australian hydrogen industry. The intermittent nature of renewable energy calls the need for storing the variable energy in the form of hydrogen which allows transition to a sustainable hydrogen economy.

Australia has a national hydrogen strategy developed to guide the nations transition to a more hydrogen dependent future. The strategy sets a vision for a clean, innovative, safe and competitive hydrogen industry. The strategy takes an adaptive approach, trying to increase the flexibility of Australia to adopt hydrogen-based power supply as its commerciality and prominence increases.

The key role of hydrogen is seen in transport and manufacturing industries where gas or oil-based fuels are used for heat and power generation. Feasibility assessments for the use of hydrogen in gas fired turbines is promising, with early literature suggesting that the changes to existing natural gas power turbines is minimal to enable hydrogen gas, or some blended equivalent, to be the feedstock.

Fuel cells in there current capacity are not as commercial for shorter term, peaking power requirements as their battery counterpart. Where fuel cells will likely play a future role is in the longer duration, critical asset loads due to a cheaper cost of hydrogen storage than electricity storage.

However there is no clear business case in the market for establishment of assets in this manner due to high costs of fuel cells, risk exposure to wholesale market trends and policy not penalising gas fired turbines for their carbon emissions, which serve as a more commercial long duration power supply.

Around Australia there are a number of hydrogen projects being established, all at the pilot level. Considerable interest is being expressed by industry in large scale hydrogen generation, however the lack of commerciality of current technology and lack of stringent global policy forcing uptake of hydrogen are serving as major barriers to establishment of such industry.

6.0 Australia Hydrogen Analysis

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4.1.1 Energy transition with hydrogen and storage (continued)

Woodside has signed an agreement with TasGas to explore hydrogen possibilities in Bell Bay, Tasmania. The project, H2TAS proposes to build a 4.5tpd hydrogen facility in the North of Tasmania.

Another project underway is being developed by AGIG, called HyP SA. The project proposed to develop green hydrogen and blend it into the existing gas network for distribution to domestic customers. The project received $4.9 million in grant funding from the South Australian Government.

4.1.2 Hydrogen Markets

The industrial hydrogen global market is estimated at 70Mtpa in 2018 as a primary industrial material for refineries and ammonia production. The current projection for hydrogen demand in Australia is minimal. However, the right policies and increased investments will promote potential hydrogen applications. More government support for hydrogen infrastructure is essential. Increasing the domestic demand can increase the commercial readiness index for renewable hydrogen production which eventually leads to rapid scale-up when global hydrogen export is established.

4.1.3 Policy reform and strategic fit

The Australian Hydrogen Council introduced a policy framework that includes three licences to operate: an economic licence, a social licence and a regulatory licence. The framework is established to ensure a balanced progression of the hydrogen industry across the three key areas identified. Projects and advancements across the hydrogen industry should collectively address these licenses.

An economic license is realised by projects that are looking to unlock the economic benefits a hydrogen economy can bring Australia through export markets, decarbonising the economy and supporting energy security. This area of the policy is aimed at aggregating hydrogen demand both domestically and internationally to increase the viability of the business case to develop electrolysers on a mass scale and drive the associated costs down. The need for policy and funding support to progress the economic case remains high if Australia is to develop the large scale hydrogen economy it is capable of.

A social license is aimed at developing trusted and positive relationships with consumers and with communities living near hydrogen infrastructure. This license is required due to the relatively limited public understanding of the hydrogen industry. Policy makers must develop policy and regulatory regimes that are targeted to avoid harm and promote the advantages of the industry.

A regulatory license will serve as the foundation for economic and social progression of the hydrogen industry. The regulation will serve as a baseline for community and stakeholder trust in operations along with allowing streamlined and targeted investment into the industry.

6.0 Australia Hydrogen Analysis

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Current Policy drivers for developing the hydrogen industry in Australia include fuel standards, emission standard for vehicles, renewable technology targets, planning regulations related low emission zones and alternative fuel infrastructure provisions.

The National Hydrogen Roadmap was developed in November 2019 to set a vision for Australia for a clean, innovative and competitive hydrogen industry that benefits all Australians with an aim to position the hydrogen industry as a major player by 2030. The report informs strategic pathways to an economically sustainable hydrogen industry in Australia.

In review of the nations policy and strategy for the emerging hydrogen industry, there is a lack of policy and regulation guiding how the nations strategy will be achieved. Organisations, both public and private, have outlined what their goal is however not provided any indication of how they will achieve it. Private industry is calling out for government funding assistance and policy development to enable their justification of investment. There is some funding assistance for pilot scale projects however nothing of significance to activate a large-scale project. It is crucial that some firm hydrogen policy is established to enable progression of the industry.

4.1.4 Regulations

Robust regulation is a crucial component of the establishment of an Australian hydrogen industry. Hydrogen gas is highly combustible with air and as such must be treated with extreme caution. Currently, there are **no targeted regulations** for hydrogen production facilities or hydrogen market regulation in Australia. Australia is looking to develop a set of hydrogen specific regulations, however as an interim measure, the existing framework of technical regulations regarding transport / production of gaseous materials can be modified and applied to hydrogen developments. These frameworks and adjustments are listed below:

1. Gas Supply Act- To promote efficient and economical processed natural gas supply and the interests of customers are protected

2. National Gas Law – Mandates the commercial regulation of gas in the National Gas rules within the defined gas market for Northern and Eastern Australia. A separate national gas law is applicable in WA

3. Storage and Transport Regulations - On-site storage of hydrogen post-production and subsequent transport off-site is governed by multiple laws, regulations and codes at both the federal and state levels. Substances other than hydrogen may be present during the production process and these may also be subject to such regulatory requirements. A list of such applicable regulations, codes and licences are :

- The Australian Dangerous Goods Code; Technical standards applicable to storage and transportation depending upon type and volume of dangerous goods / substances, specification standards for storage tanks and conditions

6.0 Australia Hydrogen Analysis

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- Licencing - Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007
- Applicable legislation : *Dangerous Goods Safety Act 2004*
- Other regulations that may apply - Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007 (If Hydrogen is classified as a Major Hazard Facility)
- The Dangerous Goods Safety (Road and Rail Transport of Non-Explosives) Regulations 2007 adopt the Australian Dangerous Goods Code (ADG7.3)

4. Technical regulations - relate to ensuring that the design, construction and operation of relevant assets meets appropriate safety and environmental standards. There exists a set of technical regulations for transport of gaseous materials that provide broad coverage regarding use of hydrogen and related technologies, however hydrogen specific regulations will be required in the future.

5. Workplace Health and Safety Regulation – While variations exist across the states, the main objective is to provide a balanced and nationally consistent framework to protect workers and against harm to their health, safety and welfare

6. Environmental Laws – Any production facility that engage in any activity that may have a 'significant impact' on a matter of environmental significance and whether the project requires any approvals (such as the EPBC Act 1999) or licenses (environmental Protection license) can be applied to any hydrogen production facility.

7. Water for hydrogen electrolysis use – As it takes 9 litres of clean water to obtain 1 kg of hydrogen, a key challenge of production is sourcing and securing sufficient volume of quality water. Relevant considerations include:

- any licensing or approval requirements for connecting to the relevant water network in the state or territory where the facility is located;
- and if using seawater, the relevant state licensing requirements regarding the operation of a desalination facility (including limitations on water temperature increases at the point of discharge, and brine management and disposal).

4.1.4 Regulations (continued)

These measures provide a work around for hydrogen developments in the interim, however hydrogen specific laws and regulations need to be implemented to properly address every stage in the hydrogen supply chain. Establishment of these regulations will enable the supply chain for hydrogen related goods and infrastructure to be developed and provide confidence to the private industry, incentivising their investment.

In July 2020, **Standards Australia** adopted eight international standards relating to hydrogen quality, storage, transportation and usage. Regulators need to implement them soon when creating hydrogen specific regulations.

6.0 Australia Hydrogen Analysis

ARUP

4.1.5 Infrastructure Barriers

The main barrier for the hydrogen industry is the capital cost of establishing the asset, particularly electrolysers. This cost impedes the commerciality of the business case to establish hydrogen production facilities. Currently this is addressed at the pilot plant scale through small government grants, however it has been the major barrier to any large scale commercial development. Electrolysers are projected to decrease in cost as they become manufactured at scale in the future and more efficient as the technology develops iteratively.

Early findings and pilot programs in Australia and other countries (such as the UK) indicate that existing gas distribution networks should capable of facilitating hydrogen blending in the order of 5 to 15% by volume without any infrastructure changes. Australian Gas Infrastructure Group (AGIG) has mentioned that the high-density polyethylene (HDPE) pipe suitable for transporting hydrogen is well under way in Australia.

A case study commissioned by COAG Energy Council and led by South Australian Govt is well underway to identify any technical or regulatory barriers to blending at volumes up to10% hydrogen.

4.1.5 Hydrogen Hubs

According to IEA (International Energy Agency) and the WEC (World Energy Council), Australia has the potential to be the world's largest hydrogen producer. Hydrogen hubs could bring down the cost of low-carbon hydrogen pathways. 'Hubs' refers to a region that has the potential to aggregate demand for hydrogen. They could be coastal industrial clusters or co-located near ports. Over 30 locations have been identified through desktop research (Study undertaken by ARUP, commissioned by COAG). There is preference to develop hubs where there is existing domestic demand and infrastructure to reduce associated transport and establishment costs respectively.

4.1.6 Funding

The Clean Energy Finance Corporation, an Australian backed fund responsible for investing $10b (AUD) of public money, has up to $300m available to support growth of a clean, innovative, safe and competitive Australian hydrogen industry.

Research and Development / Market Introduction and deployment
Due to global decarbonisation efforts, large oil & gas, multinational energy companies and heavy industries are diversifying their company portfolios by investing millions into the hydrogen industry growth. Members of the Hydrogen Council, currently invest a combined AU$2.2 billion per year in hydrogen solutions. Previously this investment had been heavily weighted to R&D. Now however, council members are planning to increase this investment to at least AU$3 billion per year over the next five years and change the prioritisation of funding to focus on market introduction and deployment.

Australian Renewable Energy Agency (ARENA), an Australian government department aimed at improving the competitiveness of renewable energy technologies and increase the supply of renewable energy through innovation that benefits Australia consumers and businesses. ARENA announced a Renewable Hydrogen Development Funding Round of up to $70 million to help fast track development of renewable energy projects in Australia.

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7.0 Australia Renewable Energy Analysis

7.0 Australia Renewable Energy Analysis

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4.1.1 Energy transition with batteries, hydrogen and storage

As a representation of Australia's total energy generation, renewables accounted for 21% in 2019. The nation added 2.2GW of large scale renewable electricity in 2019 with 4000 new jobs created as a result of these capital works projects.

The Clean Energy Council has noted that despite the large increase in renewable energy projects in recent times, the industry is facing ongoing uncertainty due to the continued lack of federal energy policy and transmission and connection challenges. Quantitatively, this has seen reduction in new investment commitments by more than 50 percent in 2019.

Across the nation, there have been examples where several wind and solar farms were forced to curtail their output to maintain grid stability. The government at all levels, but particularly federal and state, needs to ensure their investment in the state owned network is adequate to ensure industry has confidence in the ability for their project to reach its revenue potential.

Declining costs of batteries has seen increased investments in large-scale batteries in Australia. South Australia has turned to battery technology as a grid firming measure after a series of events that saw extreme power outages across the state. Successful implementation of these projects has seen increased grid stability. In addition, the private corporation that developed the assets have produced record profits, leveraging energy arbitrage opportunities to capitalise electricity market price variability.

Investment in energy storage is going to increase over the coming years to balance the supply and demand within the NEM. A number of pumped hydroelectricity projects in Australia are being considered / under construction which are relatively

large and capital-intensive.

4.1.2 Micro-Grids and Electricity Markets

Micro-grids – In Australia, microgrids offer a means of addressing challenges with remote energy supply and ageing and insufficient transmission infrastructure. The requirements for microgrids are relatively well understood across the nation with a number having been developed. There are clear benefits associated with development of REZ's and the streamlining of approvals processes, alignment of overarching strategies and coordination of facilitative infrastructure such as transmission lines. REZ's are touched on later in this section of the review.

Electricity Markets - Most electricity in Australia is generated, bought, sold and transported in markets that need to match supply and demand in real time. The National Electricity market (NEM) fills this role for east and southern states. The NEM interconnects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia. Western Australia and the Northern Territory are not connected to the NEM. They have their own electricity systems and separate regulatory arrangements.

The NEM facilitates the exchange of electricity between generators and retailers. The Australian Energy Market Commission (AEMC) develops the rules by which the market must operate.

7.0 Australia Renewable Energy Analysis

ARUP

4.1.3 Policy reform and strategic fit

The Australian Federal Government

The LRET requires high-energy users to acquire a fixed proportion of their electricity from renewable sources. This is facilitated through large-scale generation certificates (LGCs), which are created by large renewable energy power stations (such as solar or wind farms) and then sold to high energy users who must purchase LGCs and surrender them to meet their obligations.

The SRES provides a financial incentive for individuals and small businesses to installs small-scale renewable energy systems such as rooftop solar, solar water heaters and heat pumps. Small-scale Technology Certificates are issued up front for a systems expected power generation (based on its installation date and geographical location) until the SRES expires in 2030. Like LRET, high end energy users are required to purchase a fixed proportion of STCs and surrender them to meet their obligations.

These measures are a sound step forward to ensuring high energy users pay a price for their power consumption, reflective of the emissions they are producing through their operations.

In addition to this, the directives of organisations responsible for distribution of government funds to facilitate the uptake of renewable energy have their own strategies. These strategies typically focus on increasing economic and financial viability of renewable energy to achieve the lowest possible renewable energy production cost.

4.1.5 Renewable Energy Zones

There are currently five REZs in NSW, six in Victoria and three in Queensland. The state owned Energy Corporation responsible for coordination of REZs will facilitate the following core functions:

- Leading community and stakeholder engagement
- Contribute to strategic, holistic planning for each REZ
- Administer an access framework for the REZs that delivers benefit to generators
- Administer a competitive process to coordinate generation in the REZ
- Coordinating technical design of the REZ in consultation with program partners and generators.
- Promotion of local development opportunities, engaging with local community and industry.

Successful development of REZs are expected to deliver the following:

- More reliable energy, with a significant proportion sourced from new energy supply
- Energy bill savings from reduced wholesale electricity costs and lower electricity market price variability
- Emissions reduction from a cleaner energy sector
- Community partnership from strategic planning and best practice engagement and benefit sharing.

7.0 Australia Renewable Energy Analysis

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4.1.5 Renewable Energy Zones (continued)

The Australian Energy Market Operator (AEMO) has released the 2020 Integrated System Plan (ISP), which forecasts that over 26 Gigawatt (GW) of new grid-scale renewables will be required by 2040. The ISP forecasts that most of this will be met by REZs which are suitable for large-scale generation. The 2019 Australian Infrastructure Audit found that coordinating investment in REZs will lead to lower wholesale and network costs for users over time.

The *Infrastructure Priority List* separately includes a High Priority Initiative for the future connectivity and reliability of the NEM, which includes transmission infrastructure to the REZs. AEMO has identified 35 candidate REZs by considering a mix of resources, current and future transmission network capacities and cost, and other technical and engineering considerations.

Transmission or energy generation projects proposed in REZs must be approved under the state-significant assessment pathways and associated regulatory framework.
Project proponents will be required to prepare a full environmental impact statement, undertake thorough community consultation, and provide detailed justification for environmental and social impacts.

4.1.4 Regulation & Infrastructure [existing]

Clean Energy Regulator – Oversees the administration of the large-scale renewable energy target and the small-scale renewable energy scheme to encourage additional generation of electricity from renewable energy sources. The Renewable Energy Target legislation provides an incentive for investment in renewable energy power stations and smaller systems while ensuring the energy sources used are ecologically sustainable.

Emissions Reduction fund legislation – A piece of legislation developed, building upon the backbone of the Carbon Credits Act 2011 that enables the Clean Energy Regulator to register projects and issue Australian carbon credit units for emission reduction projects across the economy.

National Greenhouse and Energy reporting scheme – A single national framework for reporting and disseminating company information about green house gas (GHG) emissions, energy production, energy consumption and other information specified under NGER legislation.
The objectives under the NGER scheme are to:

- Inform government policy;
- Inform the Australian public;
- Help meet Australia’s international reporting obligations;
- Assist Commonwealth, state and territory government programmes and activities; and,
- Avoid duplication of similar reporting requirements in the state and territories.

Australian National Registry of Emissions Unit – to track the location and ownership of carbon credit units issued under the Emissions reduction fund.

4.1.6 Funding

Investment in renewable energy increased over the years due to govt policy incentives, elevated electricity prices and reduced costs of renewable generation technology. Improved access to finance for developers has been significant in supporting increased investment. A range of grants exist to help businesses and organisations fund renewable energy projects. The two main finding program are the Australian Renewable Energy Agency (ARENA) and Clean Energy Finance Corporation (CEFC) which is an Australian Govt statutory authority formed to facilitate increased flows of finance into clean energy sector.

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8.0 Global Hydrogen Best Practice Policy

8.0 Global hydrogen best practice policy [Existing]

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In our experience, there are key milestones for the development of an H_2 market. These are not necessarily sequential with considerable overlap, typically they run in this order, but all are necessary to develop a hydrogen economy. The critical question is which of these elements can WA influence? The following milestones are discussed in detail in the subsequent pages, with a few of the many examples of where they have been successfully implemented in countries around the world:

5.1 Reducing technical barriers

i. Research and Development:
   - Hydrogen solutions
   - Integration with existing infrastructure (e.g. Hy4Heat, HyNTS)

ii. Pilot Projects for different uses
   - I&C customers (SNAM (Italy), Chiyoda)
   - Domestic customers

iii. Transportation and Storage Solutions
   - Hydrogen storage to balance daily demand
   - Hydrogen storage to balance seasonal demand
   - Short term CO_2 storage/transportation solutions
   - CO_2 long term storage

5.2 Reducing the cost of hydrogen production

i. Project Development funding

ii. Funding of Research and Development into hydrogen solutions
   - Green hydrogen
     - Link with/access to low cost renewable energy
     - Water supply
   - Blue hydrogen
     - CCS site
     - Suitable fossil fuels

5.3 Engaging the public

i. Proof of solutions

ii. Demonstration of benefits

iii. Reassurance on costs

5.4 Policy support

i. Hydrogen strategy & vision

ii. Clear policy timeline

iii. Minimum supply requirements

iv. Regulatory change

5.5 Financial & fiscal support

i. Capex of plant

ii. Capex of transportation and storage

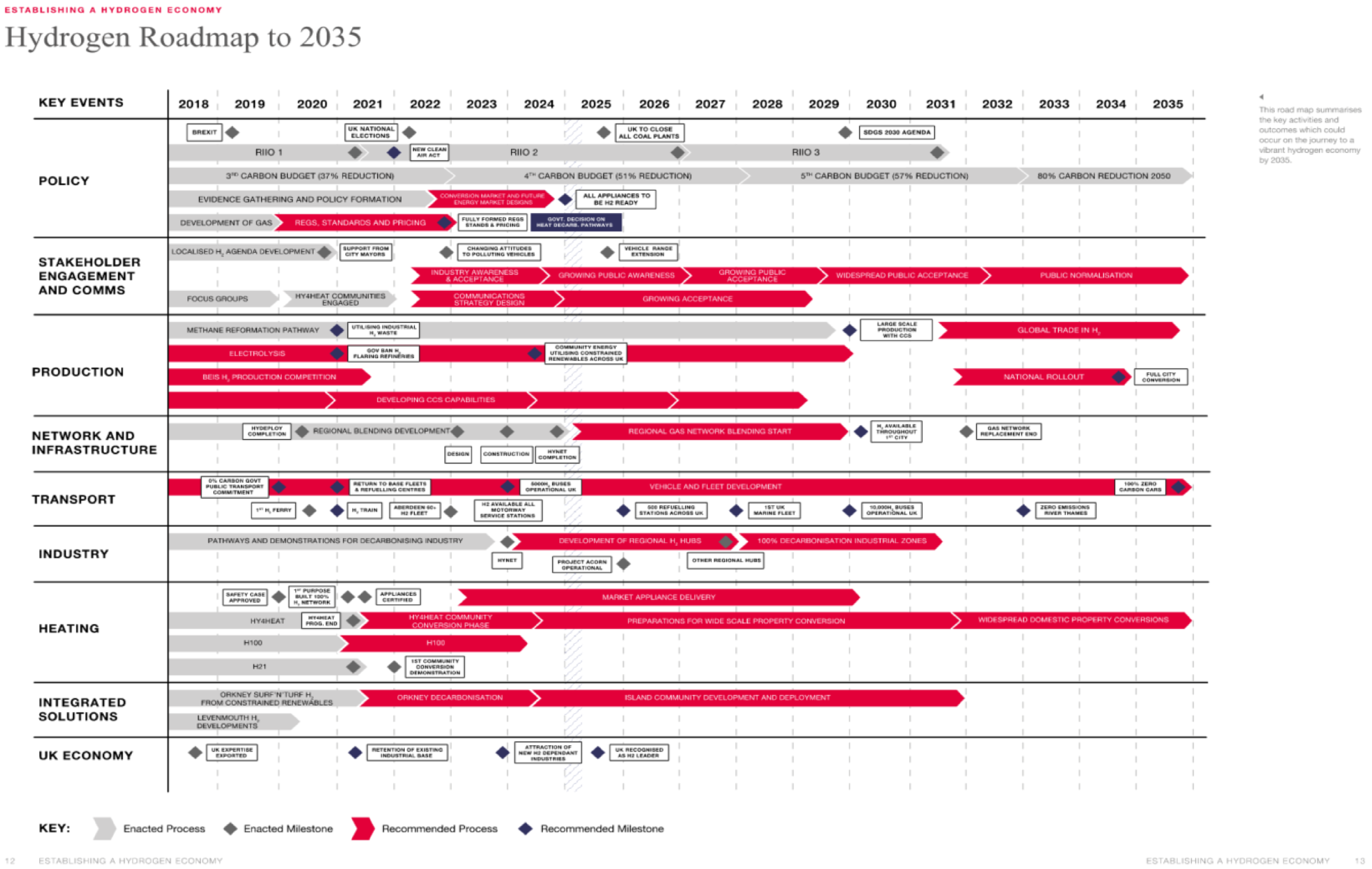
iii. Production support (Feed-in-Tariff or Contract for Difference)

iv. Carbon price

8.0 Global hydrogen best practice policy [Existing]

ARUP

An example of a the timeline for the development of the different milestones mentioned above can be seen opposite.
Arup created a hydrogen roadmap for the UK that blends existing policy process and instruments with planned and potential programmes outline how a hydrogen economy could be developed by 2035.
The following sections outline the different elements needed to create a similar, comprehensive roadmap to develop a hydrogen economy.



Source: Arup, https://www.arup.com/-/media/arup/files/publications/h/establishing-a-hydrogen-economyfuture-of-energy-2035.pdf

8.1 Global best policy [Existing] – Technical barriers

ARUP

5.1.1 Research and Development

A centrally coordinated group including academic, public and private industry, and government is needed to determine and identify the knowledge gaps and the readiness of technology and infrastructure for a transition to hydrogen.

Research and Development in the hydrogen space has been ongoing in many countries, so targeting this to the specifics of the WA context should aim to determine amendments to existing strategies and formulation of new strategies required to build a hydrogen economy within existing infrastructure and resource constraints. R&D will should target possible solutions associated with the complete value chain of hydrogen.

- There are hundreds of R&D programmes into hydrogen solutions around the world, for example:
  - SNAM, Italy : Looking for investment in hydrogen technologies (fuel cell, hydrogen production and storage)
  - Hyundai: Export of fuel cell system and commercialisation of hydrogen-fuelled vehicle solution.
- Integration with existing infrastructure
  - Hy4Heat: Exploring hydrogen's use in residential and commercial buildings and gas appliances as a replacement for methane
  - H21 (Northern Gas Networks) : Conversion of the existing gas distribution grid to carry 100% hydrogen and partnering with Equinor and Cadent to set the design of the infrastructure
  - HyNTS: A UK programme to identify the opportunities and address the challenges that transporting hydrogen within the National Transmission System (NTS) presents.

5.1.2 Pilot projects

One of the challenges in building a robust hydrogen economy is the feasibility and viability of available technology for hydrogen production, storage, delivery and end user applications. The implementation of pilot projects helps foresee the barriers in order to meet the strategic need of both small and large, public and private organisations. The technical problems faced can be analysed and identified within a specific context, and innovative solutions are identified to resolve the corresponding problems before the technology is rolled out at scale.

- I&C customers
  - SNAM, Italy : Strategic partnerships to increase production and demand for hydrogen (steel mills, refineries, other energy intensive industries)
  - Chiyoda: Imported hydrogen from Brunei to Japan for power generation (gas turbine)
  - Engie and Anglo American: Decarbonising of mining industry through modifications to existing trucks by replacing the diesel tank and engine with hydrogen tanks and hydrogen fuel cells respectively.
  - Air Liquid and Shell: Installation of fuelling system and hydrogen supply
- Domestic customers
  - Enbridge Gas and Cummins Inc: Blending green hydrogen produced at power-to-gas facility to existing natural gas network
  - H100 Fife, Scotland: Green hydrogen for heating and cooking application to 300 homes in the area

5.1 Global best policy [Existing] – Technical barriers

ARUP

5.1.3 Transportation and Storage solutions - Hydrogen

Hydrogen has two potential benefits, it enables fossil fuels to be decarbonised, through blue hydrogen, and it allows long term storage of renewable electricity (green hydrogen). Storage is therefore not just crucial, it is its 'raison d'etre'.

The key challenge for a hydrogen producer and end user is an adequate storage technology at an effective and market competitive cost. Storage plays an important role in the adoption of hydrogen as fuel and since hydrogen has some unique challenges when using traditional storage methods, so availability of a low-cost storage solution or just in time delivery is paramount.

Long distance transportation hydrogen can double its cost because of the need to convert the fuel into a transportable form (liquified hydrogen, ammonia, other chemical compounds). Therefore, there is a need to de-risk the technological efficiency and infrastructure safety barriers to achieve economies of scale up.

- **Transportation**: hydrogen can be transported in two forms:
  1. As a gas through pipelines or small-scale storage tanks, which does not require conversation and thus does not result in significant energy loss
  2. Where large volume transportation is required and pipelines are not available, conversation, currently with very high energy loss, is required. The solutions currently available are liquefaction, conversion to ammonia (often required for the Petro-chem industry) or another proprietary chemical
- **Short term storage**: There are a wide variety of short-term storage solutions for hydrogen available in the market to balance short term demand, a few examples include:
  - Hexagon: Lightweight vessels for hydrogen transportation and storage
  - Sylfen: Integration of batteries and hydrogen to fulfill buildings demand for power electricity and heat
- **Long term storage**: long-term or large volume storage of hydrogen requires a different solution given the volumetric energy density is about one third that of natural gas and the energy required to liquify it is very high. However, as long as a sufficiently sealed volume can be identified, hydrogen storage does not have the legacy impact of battery storage at end of life. Typical solutions involve subterranean solutions to provide long term storage. A few examples include:
  - Advanced Clean Energy Storage, Utah (Mitsubishi Power – Magnum Development): To build largest storage facility through injection of hydrogen into underground salt caverns for 1000 megawatts. The storage facility would initially have enough energy to power 150,000 households for one year.
  - EWE (German gas provider): Cavern storage for Hydrogen to store 5-6 tons of hydrogen

8.1 Global best policy [Existing] – Technical barriers

ARUP

5.1.3 Transportation and Storage solutions – carbon dioxide

- **Transportation of CO_2**: CO_2 is actually easier than hydrogen, it is easier to compress and transport. Typically it can be compressed and shipped or it can be piped.
- **Short term CO_2 storage**: CO_2 can be stored using traditional tank solutions for short term storage prior to transportation.
- **Long term CO_2 storage**: Blue hydrogen requires the storage of CO2 in perpetuity, for ever, know as Carbon Capture and Storage (CCS). There are a large number of CCS projects under development, but only a few that are operational, a few examples include:
  - Porthos (Port of Rotterdam CO_2 Transport Hub and Offshore Storage), Netherland: Transport CO_2 from industry and store it in empty gas fields beneath the North Sea
  - NRG Energy: Partnering with JX Nippon Oil and Gas Exploration to develop commercial-scale post combustion for carbon capturing and storage

8.2 Global best policy [Existing] – Cost barriers

ARUP

5.2.1 Project development funding

Green hydrogen competes with both, fossil fuels and other shades of hydrogen, but it can also complement it. It is therefore important to understand the factors that determine the cost of green hydrogen. Some of the major cost contributors are cost of electrolysers, their capacity factor and the cost of electricity produced from renewable energy resources. Since the cost of electrolysers is high and their capacity factor can be low, it is therefore very critical to mitigate these challenges to decrease the Levelised cost of hydrogen (LCOH).

Many components in hydrogen value chain have already been deployed on a small scale and ready to be commercialised, which now require funding to scale up. The cost of electrolysers and fuel cells have decreased drastically but new strategies and funding schemes would be required to further bring down the LCOH and support wider adoption. Scaling up green hydrogen production could make those pathways more lucrative and competitive as the production cost decreases.

- EU Innovation Fund: Funding application by Orsted and BP to develop large scale renewable hydrogen project
- Scotland: 12 million euro funding for hydrogen power system production utilizing tidal power in Eday
- Germany: Recovery plan includes 7 billion euro to commercialise green hydrogen technology and 2 billion euro for international partnerships advancement.

5.2.2 Funding Research and Development into hydrogen solutions

With green hydrogen, a few issues could come to surface as hydrogen production. Green hydrogen production, for example, requires water, and thus it could pose risk to clean water supply. Producing hydrogen by electrolysis can require as much as nine kilograms of high purity water to produce one kilogram of hydrogen. This concern can be tackled through the availability of infrastructure (e.g. desalination and reverse osmosis plants to purify sea water). The availability of low cost renewable energy electricity will also play a crucial role in the production of green hydrogen, countries where the capex cost of renewable energy plant is low will have an added advantage and the levelized cost of hydrogen in these countries will be lower than other countries in the region. There are some great examples of tackling these issues by funding R&D to bring down the LCOH around the world:

- Toshiba: Large-scale hydrogen storage (Solid Oxide Electrolysis Cell)
- U.S Department of Energy: 100 million USD to advance hydrogen and fuel cells research
- The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) : Public/private partnership to support R&D in fuel cell and hydrogen technology

8.3 Global best policy [Existing] – Engaging the public

ARUP

5.3.1 Proof of Solutions

Public interest and sentiment plays a very important role in the adoption of any new infrastructure technology. All government across the world understand the importance of community engagement. Public engagement builds robust solutions and eases the overall transitioning phase. Proof of solutions helps in acquiring public trust in the technology, process and the stakeholders involved.

Countries like New Zealand and Singapore have build comprehensive community engagement plans to mitigate the challenges associated with stakeholders transitioning. Public awareness and knowledge about green hydrogen is limited. The decarbonisation benefits of hydrogen are also unknown, proof of viable solutions will enable the government and companies to elaborate and illustrate the pros and cons of green hydrogen integration.

- HyStreet: Demonstration/showcase of safe, efficient use of hydrogen fuelled home appliances (boilers, cookers…)
- HyFLEET CUTE: Demonstration of the next generation fuel cell/battery hybrid bus enable reduction of hydrogen consumption by half

5.3.2 Demonstration of Benefits

As the share of Variable Renewable Energy (VRE) rapidly increases in various market around the world, there will be a need to demonstrate to the public that the power system can remain resilient and provide reliable power. Electrolysers can be designed as flexible resources that can quickly ramp up and ramp down to compensate for fluctuations in VRE production, thus from a acceptance perspective the public needs to know that green hydrogen can be stored for longer period and function as seasonal storage and complement other solutions. The biggest benefits of green hydrogen, apart from being a clean source of energy, is supporting the high share integration of VRE into the grid.

Real project demonstrations are conducted to support the development of policy, business use cases, technology, build consumer confidence and create robust operational supply chain capacity. The benefits of hydrogen needs to be presented in a tangible way both qualitatively and quantitatively, such that public can understand the need of adopting hydrogen.

- Hyundai (H2U: Hydrogen to You): Promoting hydrogen technology through social media influencers engagements
- Michelin: Installations of 20 stations powered by green hydrogen and hydrogen-fuelled vehicles deployment (motor racing, technological showcase)
- Hydrogen Energy Centre: Working with investors to develop long-term strategy of tidal electrical generation demonstration in New England to produce green hydrogen.
- New Zealand: Hydrogen demonstration projects are seen as proactive approach for public engagement.
- Ports of Auckland: A vision to become a leading sustainable port by building a hydrogen production and refuelling facility. Government is also investing in transportation sector (hydrogen fuel-cell vehicles), to decarbonise the transport sector.
- Hyundai NEXO FCEV Demonstration Project: Fuel cell electric powertrain with the capability to travel for 605 km and being refuelled in 6 minutes

8.3 Global best policy [Existing] – Engaging the public

ARUP

5.3.3 Reassurance on costs and safety

Hydrogen has a faster flame speed and is flammable at a greater range of concentration than natural gas, it is also the smallest and lightest element, and so dissipates much quicker. This means hydrogen fires might be more spectacular, but given doesn't stay confined easily they may be less likely. Research under the UK Hy4Heat Programme essentially concluded it has different safety risks from natural gas in the home, but it overall no more dangerous.

Any Government wishing to develop a hydrogen economy needs to reassure the public of the safety risk mitigations to gain their trust before adopting and integrating hydrogen for end-use applications.

Feasibility studies should also be conducted to identify and analyse the safety measures needed for different hydrogen blends without compromising the safety of the overall system which should include the safety standards on injections and transmission and distribution of hydrogen. The major cost driver of green hydrogen is the cost of electricity.

- United States Department of Energy (DOE) HyBlend: The aim of this initiative is to study the life-cycle emissions of hydrogen blends. The study is being conducted in collaboration with industry and academic researchers.
- European Green Hydrogen Acceleration Centre (EGHAC) : Acceleration of technological and infrastructure readiness for green hydrogen.
- DNV GL HyStreet: Conduct necessary safe tests for infrastructure (demonstration through three-ordinary looking houses) to prove safety case of home heating and cooking application.
- First Gas Hydrogen Pipeline Trial Feasibility Study: Gas operator for the transmission of natural gas from Taranaki to industrial consumers. The study was conducted to investigate the viability of hydrogen injection to existing natural gas pipeline for transportation.
- New Zealand has also planned education and training to close public knowledge gaps on hydrogen technologies and applications.

8.4 Global best policy [Existing] – Policy support

ARUP

5.4.1 Hydrogen Strategy and Vision

Once technical and commercial barriers have been tested, and public engagement has at least started, it is important to set a clear trajectory for the development of a hydrogen economy.

Government and industries need to coordinate and work together to develop vison and strategy for hydrogen that could support the development of innovative market structures.. A vision is important which helps the to answer the 'why' question and whereas strategy identifies targets and addresses the policy concerns.

Many countries are expected to publish their hydrogen strategies in the coming years. Activities are also taking place at sub national level. California (United States), North of Netherland, and different states in Australia have released their roadmaps and strategy for hydrogen. Development of an optimal zero or net-zero carbon emission strategy, while including the most effective green hydrogen, is a tedious and challenging task.

Government needs to carefully analyse other competing decarbonisation solutions available for most applications and end uses, and as the relative costs and benefits of each solution will be constantly changing according to the pace of innovation and development of each specific technology. Governments, therefore, have difficult choices to make about which technologies will be best suited for the future of their countries based on the availability of resources and demand and GDP growth, while avoiding numerous possible pitfalls, such as locking in slower or less efficient pathways to reducing emissions. For this reason, establishing vision and strategy priorities is an important component of green hydrogen policy making.

- Hydrogen Strategy for Canada: Framework to elaborate opportunities in production and distribution, end use, and exporting of hydrogen.
- New Zealand: The Ministry of Business, Innovation and Employment, engaged Arup as a consultant, has accommodated four workshops to discuss hydrogen potential. Discussions were consolidated into a national strategy; A vision for hydrogen in New Zealand which was published in September 2019. The national strategy includes hydrogen challenges, opportunities and the support of government in hydrogen production, for a resilient energy system, hydrogen for mobility, hydrogen for industrial processes, hydrogen for seasonal power generation, decarbonisation, hydrogen for export, innovation expands job opportunities, and transitioning the job market.
- California: California Energy Commission (CEC) has approved the investment plan of $115 mil for 200 public hydrogen fueling stations and aims to build 111stations by 2027.
- Italy has set out guidelines for a national hydrogen strategy in Nov 2020. The strategy aims to increase the capacity of electrolyser to 5 GW by 2030.
- Russia: Government has established a roadmap for hydrogen development until 2024. The roadmap includes the plan for the implementation of hydrogen pilot projects, starting from production, manufacturing, testing tup to end-use applications.

8.4 Global best policy [Existing] – Policy support

ARUP

5.4.2 Clear Policy and Timeline

Establishment of a clear policy timeline is a crucial step for hydrogen economy and will very likely need to call on multiple different . It is needed to further establish a robust supply chain, encourage new business models and inject investment into infrastructure. Clear policy is needed to regulate and support hydrogen industry; starting from production, transmission, distribution, storage and end-use applications.

Post formation of a policy framework, a follow-up and evaluation metrics is necessary to evaluate and analyse the impact of the introduction of specific policies. The implementation of policy should be evaluated in accordance with the timeline set out in the strategy which will enable the policy makers to assess the fundamental and non-fundamental implementation challenges that need to be addressed to reduce the barriers. Clear and concise policy with well defined targets and timeline, helps in evaluating alternative timelines and scopes, as well as the interactions with other policies.

- **The EU**: Published its hydrogen strategy; one million tonnes of renewable hydrogen production by 2024 and 10 million tonnes of renewable hydrogen production by 2030; and establishment of European Clean Hydrogen Alliance, to accelerate the adoption of hydrogen through investment pipeline/agenda establishment.
- **Chile**: Published its National Green Hydrogen Strategy, goals to reach 5GW of electrolysis capacity by 2025, produce the world's cheapest green hydrogen by 2030, and make the country one of the top three exporters of the hydrogen fuel by 2040.

5.4.3 Minimum supply requirement

New policies and regulations will be required to accelerate the adoption of hydrogen. One such mechanism is a minimum supply requirement on gas suppliers, similar to the minimum supply requirements for renewable energy used to catalyse electricity markets through renewable energy certificates (RECs). A policy could be designed to increase the share of hydrogen in gas supplies, leaving the market to choose where that gas is used, e.g., power generation, general network blending, targeted Commercial &Industrial customers etc.

This policy is adoptable to the local context such as availability of resources, cost of production, existing infrastructure and other fiscal support policies. This policy program could act as a key political and regulatory driver to increase the share of hydrogen in the energy supplied through the creation of a 'Hydrogen Supply Requirement' (HSR), that would ramp up the hydrogen supply requirement at regular intervals over a period of years.

A HSR creates a level playing for all suppliers, and Hydrogen Supply Certificates could be traded as a way to simulate efficiencies in the supply chain. Adopting HSR will accelerate the adoption rate of hydrogen in the initial years.

- **India:** The government is planning to make it mandatory for factories to buy and use a minimum amount of green hydrogen (e.g., minimum of 10% of hydrogen used for refining should be green hydrogen produced in India).
- **The EU:** Suggestion made in the hydrogen strategy to include minimum percentage of green hydrogen in specific industrial sectors (e.g., chemical sector or transportation).

8.4 Global best policy [Existing] – Policy support

ARUP

5.4.4 Regulatory Change

Regulatory framework is needed to support the development of hydrogen value chain and develop hydrogen use cases. Regulatory change will cover permit application, production and consumption regulations, development of infrastructure, hydrogen applications in industry, and creating a supportive and reliable ecosystem to act as a hydrogen economy enabler. It will also impact lots of existing regulation, for example safety standards in the gas networks.

- **South Korea** – To develop a hydrogen economy, South Korea passed the world's first hydrogen law. Their goal is to develop an ecosystem for hydrogen economy and expand the reach of alternative fuel. Government has created hydrogen economy fund of USD 34 million to support hydrogen use and production.
- **French** – A draft hydrogen ordinance has been published to put in place; which covers - taxonomy of hydrogen, government support mechanisms on green and blue hydrogen, guarantees of origin/certification for blue and green hydrogen and hydrogen transportation and storage license requirements in natural gas grid.
- **Portugal** – Legal framework 'EN-H2' is a National strategy for hydrogen and legal framework for the National Gas System, the regulation addressing renewable gases (green hydrogen), the regulation on guaranties of origin of renewable gases and low-carbon gases, a careful stakeholders' management, promotion of research and investment, promotion of the adoption of tested renewable energy community models, promotion energy storage services as flexibility providers at all part of the energy system, other flexibility measures to support variable renewable energy integration.
- **Germany** : A regulatory framework for areas such as electricity procurement from electrolysers, to meet the energy transition target of 2030, along with a National Hydrogen Strategy for the integration of hydrogen.

8.5 Global best policy [Existing] – Financial & fiscal support

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5.5.1 Fiscal support

Hydrogen will always cost more to produce than directly using the energy used to produce it given the inherent inefficiencies of energy conversion. However, the cost mark-up is likely to fall significantly as a hydrogen economy develops. In the short and medium term, hydrogen still provides an advantage over the fuels used to create it, in that it removes CO_2 from fossil fuels and it provides a storage and transportation medium for renewable electricity.

In order for a hydrogen economy to develop, the additional cost of hydrogen production needs to be covered. If hydrogen production is mandated, for example through a requirement for suppliers to use an increasing percentage of hydrogen in gas supply, then this cost would be born by the consumer. If hydrogen supply is not mandated, as is unlikely in the early phases of development of a hydrogen economy, then fiscal and other financial incentives will need to be in place to stimulate its growth from niche pilot projects into a maturing economy that can have a transformative carbon reduction impact.

On Project Cavendish, undertook a study of the regulatory model and fiscal and financial support that would be required to support the project, and a wider hydrogen economy, which was presented to the UK Department for Business, Energy and Industrial Strategy (BEIS). It identified five key areas that required support:

1. Production facility capex;
2. Hydrogen production
3. CO_2 transportation and long term storage (blue hydrogen)
4. Transmission pipelines
5. Distribution pipelines

Although this is not adopted Government policy, it identified different ways in which each of these areas could be supported.

- **Production facility:** this could be funded in a number of ways, but in the short term operated under a RAB (regulated asset base) model, as many gas assets in the UK are operated.
- **Hydrogen production**: this was seen as the crucial area in need of support. Given hydrogen will always be more expensive than the fuel used to create it, a value has to be placed on its use as a fuel given its carbon reduction credentials. In the case of transport fuels, a simple tax-free status might make it competitive. In the case of an industrial gas, grey/brown hydrogen is used, so an incentive is required to make this blue or green. In the case of Project Cavendish, hydrogen is predominately used for power generation in the short term and then gas network blending in the long term. The proposal on Project Cavendish was a auctioned form of a feed-in-tariff, the contract for difference, was proposed.
- **CO_2 transportation and long term storage:** CO_2 is a by-product of blue hydrogen, and its long term sequestration costs need to be covered. On Project Cavendish it was assumed this could be done through the CfD price for hydrogen production, a price that green hydrogen would not have to pay. Another mechanism to deal with this cost would be through a direct carbon price that would incentivise the carbon capture and storage.
- **Hydrogen Transmission pipelines:** separated from distribution pipelines in many markets because of the ownership structures but also the different pressures mean different materials and challenges when it comes to hydrogen., transmission pipelines present a specific funding requirements for conversion to hydrogen. For project Cavendish a type of RAB model (specifically a competitively appointed transmission owner (CATO) model) was proposed, meaning essentially the end users ultimately pay for the upgrades.
- **Distribution pipelines:** given the fully deregulated market of the UK, a RAB model was also proposed.

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9.0 Gap Analysis around Hydrogen policy and Infrastructure

9.1 Gap Analysis Hydrogen Industry

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6.1.1 Energy transition with hydrogen and storage

The transition to renewable, hydrogen based energy has progressed minimally in WA to date. There is ample private interest in the transition, with it noted as a key diversifier for oil and gas producers whom have strong presence in the state. This interest has focus on hydrogen production for export, particularly through ammonia, and blending into the existing WA gas network.

The state appears to lag behind other states and territories in the nation, who have developed more considerable projects in the hydrogen sphere. It is important to note that some of these projects have proceeded under the assistance of commonwealth funding. The funding components should not necessarily be considered which should not be compared at Western Australia

Research and Development in WA – Are there enough R&D programs in WA? Till date there are 5 projects in WA, 9 in Queensland, 2 in Sydney, 3 in Victoria and 1 in ACT

Water Availability – Supply of large amounts of potable water for production can be an issue for WA

Storage – Hydrogen and Battery Energy Storage System (BESS) are both valuable/advantages and have different strengths. Recent competition between the two technologies have created uncertainties. BESS is best used for electricity sector and hydrogen for heavy transport industry

Technology development and policy support should be able to create an enabling environment to unlock the best outcome for the consumer

Micro-grids and Electricity markets

- How to incrementally build demand and supply in the most cost-effective manner?
- How do we support our off-grid user in the energy transition? Policy certainty, government support for green energy and recognition that grid connected systems may be well suited to WA

9.1 Gap Analysis Hydrogen Industry

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Policy Reform and strategic fit

Lack of regulatory targets – WA is one of only two states without a renewable energy target and investment is lagging as a result. Before the Renewable energy target (RET scheme), wind turbines and solar panels were expensive and the cost of renewables were significantly more than coal and fossil gas. Once the regulatory targets were implemented the costs of renewable energy reduced due to a highly competitive and innovative market. This indicates the need for structured regulatory targets to activate the hydrogen industry in WA / Australia.

Hydrogen Blending Mandates to encourage hydrogen blending in existing natural gas pipelines.

Renewable Gas Targets – Similar to the Renewable Energy target, Renewable gas targets can set structured targets to achieve net zero emissions. It will be beneficial to set a target for 2030/2040 for cost-effective renewable energy gas injection to the network A cost- analysis can be done to look into renewable gas to decarbonise the use of natural gas

Need for a National Centralised hydrogen authority

Lack of legal frameworks - The (ongoing) review of legal frameworks (which is one of the mid-term goal 2030 of the WA renewable hydrogen timeline) fails to mention the 'how' or the steps required to reach the goal.

Need for an integrated approach of all sectors as hydrogen applications extend to various sectors.

Frameworks should be coordinated to support the development of standards for the hydrogen industry, consider and evaluate regulatory models to address hydrogen safety and hydrogen industry development. The main goal should be developing a consistent national approach to the regulation of the hydrogen sector, amending the existing legislation and regulations or developing a new legislation to address the gaps.
consumption polices to be implemented to maximise return on investment of grant funding and to invest in consumption capabilities and infrastructure
Health and safety - the public risk of use is mitigated before people will commit to using hydrogen for different applications

To establish Best Practice regulatory standards for Design and metering standards including storage and production needed

Regulation Barriers

- **Commercial Regulation -** Hydrogen is not specifically referenced under the Gas Supply Act and the National Gas Law. Current gas definitions regarding quality and value does not support the hydrogen market. Gas definitions will have to be extended to include hydrogen. Should hydrogen subject to the same regulatory framework as National Gas Law (National Gas Access (WA) Act 2009) supported by jurisdictional based licensing regimes?
- **Safety Regulations -** No specific reference to hydrogen, however the relevant safety regulations are broad enough to include gas, flammable gas, gas storage and chemical hazards (hydrogen carrier ammonia can be included in this category).

9.2 Gap Analysis Hydrogen Industry

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- Broad gaps exist as no hydrogen specific regulations or framework have been developed yet.
- Review and harmonise current standards and regulations to safely accommodate hydrogen in the gas distribution networks

Without existing rules it is difficult to navigate the permitting and regulatory systems, with the process slowed down if the authorities are less familiar with the issues. These issues may induced unwanted delays in development. To make sure WA remains on the forefront of development enables our local business to outperform internationally.

Long term Hydrogen contracts are currently being negotiated and signed. The question is how do we create an enabling environment for our industrial player to do the same? Financial support, infrastructure support, enabling policy and policy certainty can be vital.

Infrastructure Barriers

- Support to convert natural gas plants to actually run on hydrogen. Uncertainty of who will pay for the conversion of equipment to use hydrogen.
- Percentage of hydrogen blending to an agreeable threshold and determine hydrogen blending points
- Map out which distribution pipelines in Australia will need to be changed to HDPE (hydrogen ready).
- Timeline to ensure all new gas networks are hydrogen ready form blends up to 100% - to develop with pipeline operators
- Community understanding of support for hydrogen addressing safety concerns
- Identify and map hydrogen gas infrastructure needs

Hydrogen Hubs

- Transmission and infrastructure – How is energy transmitted to the whole region?
- Environmental approvals
- Project approvals- to encourage new pilot projects

Financing

- Lack of business models and tariff arrangements to sustain a business case for hydrogen specific funding to attract consumers
- High Capex is an issue but equally so is the issue for debt tenors. If your offtake agreement is only 5 years, very view entities will enable you to go for a 20 year repayment term. Providing government guarantees even if only for refinancing support may help unlock attractive financing terms to reduce this capex burden
- To create financial opportunity for renewable/hydrogen gas projects, a method to be created for the Australian Carbon Credit Units for projects that inject hydrogen gas into their gas network / infrastructure.

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10.0 Gap Analysis around Renewable Energy policy and Infrastructure

10.0 Gap Analysis Renewable Energy Industry

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Energy transition with batteries

Implementation of diverse mix of technologies to support the energy market has been identified, hence large scale battery storage systems and pump hydros need to be encouraged. However, high cost and low efficiency of batteries can be a barrier.

Need for support regarding certifications of WA battery minerals

Micro-grids and Electricity markets

The challenge of incrementally building demand and supply in the most cost-effective manner. Micro-Grids are established in WA but not wide-spread. Learnings to be shared.

Policy Reform and strategic fit

Emissions Policy - Present policy approaches to emissions control have been widely criticized as being inadequate to meet the current targets (Australia's 2030 Emissions reduction Target) as it presents as costly way to reducing such emissions. It might be less expensive to introduce an emissions trading scheme or an emissions tax with private sector to find the best way to reduce emissions

No renewables target beyond 2020, Lack of clear and stable long term policy settings required to provide incentive and ensure necessary investment in large-scale renewable sector

RET Scheme – The RET scheme has been through several reviews and numerous legislative changes which adds to investor risk and increased costs. The RET scheme does not guarantee connection to the grid therefore, renewable energy developers must negotiate long-term power purchase agreements (PPAs) with electricity retailers. The availability of these PPAs is hampered by policy uncertainty as energy retailers are wary of committing to long-term contracts.

Regulation and Infrastructure Barriers

Absence of current framework for the preparation of REZs design reports

Commit to Horizon Power not deploying any new standalone diesel generation from 2025.

Renewable Energy Zones

- Transmission and infrastructure – How is energy transmitted to the whole region?
- Environmental approvals
- Project approvals- get pilot projects
- No coordinated efforts within WA government yet that identifies REZs (zoned land, infrastructure availability). Till date this studies been done only by private sector
- Lack of Strategic plan / Development and implementation plan or roadmap for REZs in WA

Financing

- WA is lagging behind the rest of Australia due to significant delay in state investment
- Funding support required by the government to support REZs to potentially offset the retirement of coal-fired power stations in the coming years
- Provide investment attractions to adopt battery technologies and grow Western Australia's future battery industry

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11.0 Western Australia Policy Recommendations

11.0 Western Australia Policy Recommendations

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7.1 Reducing technical barriers

1. Encouraging more Research and Development in WA regarding hydrogen is crucial to develop knowledge base to best develop and support a hydrogen industry .
2. Pilot Projects are important to test the technical and commercial viability of available technology along the hydrogen value chain.
3. State to create a clear foundation plan for green hydrogen by accelerating workforce skills and ensuring the industrial sector is prepared for hydrogen .
4. Map the development pathway and technology needs to support hydrogen based industries (i.e. green steel, green mining / mine sites etc.).

7.2 Reducing the cost of hydrogen production

1. Project Development funding to be supported by state and federal government funding / grants / zero interest loans.
2. Link current renewable energy assets to future hydrogen production for green hydrogen .
3. Integrating hydrogen into energy markets.
4. Conduct a feasibility study into the local manufacture, assembly or maintenance of electrolysers to support the domestic renewable hydrogen industry.

7.3 Engaging the public

1. Proof of solutions and studies should also be conducted to identify and analyse the safety measures needed for different hydrogen blends without compromising the safety of the overall system which should include the safety standards on injections and transmission and distribution of hydrogen.
2. Community programs to reassure safety to the public and ensure the risk of hydrogen use is mitigated.
3. Develop ‘Guarantees of Origin’ scheme
4. Strong safety and consumer protection action plans by government support.
5. Information session on the use and production of hydrogen and how this may impact our use of electricity and liquid fuels in the future.

11.0 Western Australia Policy Recommendations

ARUP

7.4 Policy & Regulation support

1. Implement a clear timeline / steps on how to achieve the strategies stated in the Western Australian hydrogen roadmap
2. Implement targeted policies to stimulate hydrogen demand in WA transport sector – focussing locally
3. Develop hydrogen specific regulations based on best practice global standards. These should be uniform across the States and Territories
4. Establish inter/intragovernmental hydrogen authorities / Collaboration on global trading of hydrogen
5. Planning policy to incorporate zero carbon emission and phasing out fossil fuel subsidies
6. Introduce Green hydrogen certification
7. Evaluate gas pipeline regulations to consider including gaseous hydrogen
8. Policy mechanism to encourage all gas suppliers to include hydrogen blending in existing pipelines
9. Aligning standards and blending targets
10. Regulations concerning transportation of hydrogen and hydrogen stations
11. Manufacturing tax benefits or incentives
12. An appropriate policy framework to invest in infrastructure, production, storage and transport to create a ‘market pull’

<u>APPLICATIONS END USE</u>

Hydrogen fuelled transport

- Implement emissions standards in vehicles and specific incentives
- Develop a Zero emissions vehicles roadmap (including public transport)

Industrial Feedstocks – Employ incentive schemes to encourage use of green/clean hydrogen as an industrial feedstock

Export

- Implement regulations that support use of unutilised land for dedicated renewables
- Engage bodies such as the International Maritime Organisation to ensure appropriate regulatory frameworks for shipping

Set targets for zero-emission vessels and introduce fiscal incentives

Electricity grid firming and reliability – Implement incentives for use of hydrogen in remote mining sites and communities

Heat - Implement clear policy direction for enrichment and subsequent displacement of natural gas

- Legislate manufacture and use of standardised and easily convertible appliances

Synthetic fuels - Mandate local and low emissions fuel supply targets

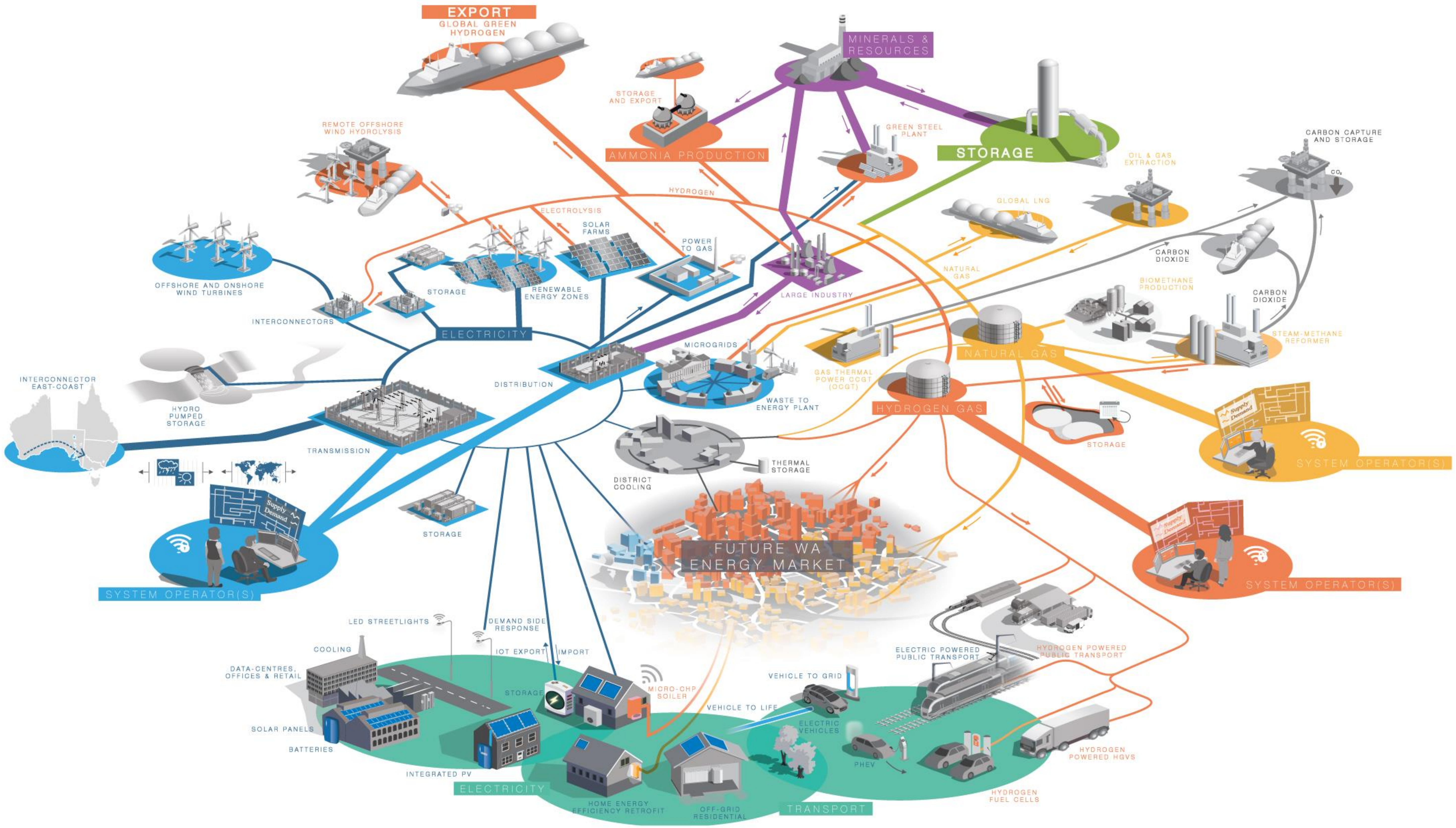
- Implement incentives for use of synthetic fuels in aviation

11.0 Western Australia Policy Recommendations

ARUP

7.5 Financial & fiscal support

1. Tackling high capital costs of electrolysers by government loans, capital grants and other forms of financial assistance
2. Infrastructure enablers such as joint funding or capex funding for electrolysers, research grants for project developments
3. Ongoing support for the supply of hydrogen (e.g., state to put in a feed-in-tariff for green hydrogen
4. Lower tax on green fuels and green supplied electricity and set capacity targets
5. Allow for compensation for grid firming services from electrolysers
6. Energy assessments can be incorporated to stimulate local renewable energy
7. High capex is an issue, but equally so is the issue for debt tenors. If the offtake agreement is only 5 years, very few entities will enable a 20 year repayment term. Providing government guarantees even if only for refinancing support may help unlock attractive financing terms to reduce this capex burden.
8. Provide funding to support investment in the next step of the battery value chain: Cathode Active Materials manufacturing.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OFFSHORE AND ONSHORE WIND TURBINES
STORAGE
RENEWABLE ENERGY ZONES
LARGE INDUSTRY
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ELECTRICITY
MICROGRIDS
GAS THERMAL POWER CCGT (OCGT)
NATURAL GAS
INTERCONNECTOR EAST-COAST
HYDRO PUMPED STORAGE
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HYDROGEN GAS
STORAGE
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STORAGE
FUTURE WA ENERGY MARKET
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LED STREETLIGHTS
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STORAGE
MICRO-CHP BOILER
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