Supporting Paper: Background to Decarbonisation Innovation Hub

NSW Decarbonisation Innovation Study

Background

In September 2019, the Minister for Energy and Environment, the Hon. Matt Kean MP, requested the NSW Chief Scientist & Engineer (CSE) undertake a Decarbonisation Innovation Study to assess and provide advice on the challenges and opportunities for meeting emissions targets and adapting to climate change. The Terms of Reference for the Decarbonisation Innovation Study focused on identifying the benefits of decarbonisation and climate adaptation in generating economic development, prosperity and jobs growth in NSW, as well as considering best practice approaches to transitioning industry, including skills development and market access. The Decarbonisation Innovation Study considered a range of decarbonisation technologies and services that offered dual benefits in emissions reduction and economic development. The Decarbonisation Innovation Study focused on commercially attractive solutions that are more likely to be widely adopted and was not an exhaustive survey of all decarbonisation technologies and services. This is important because solutions that are widely adopted will generally deliver greater emissions reductions and economic benefits than those that struggle to compete in the market.

The *Decarbonisation Innovation Study*[1] was published in August 2020 and identified the technologies and services that offer the greatest economic and emissions reduction benefits for NSW based on factors including:

- current maturity and competitiveness
- research capabilities
- investment priorities
- policy frameworks.

The Study noted that these factors are expected to change over time and timelines are likely to be highly sensitive to technology breakthroughs, adoption curves, learning curves, technology interdependences, and network and ecosystem effects. The CSE has been asked to update the Decarbonisation Innovation Study every two years, reporting on emerging technologies that reduce emissions and are commercially competitive.

Consultation

To assist with addressing the Terms of Reference, the CSE established an expert panel with significant experience in energy, infrastructure, innovation, sustainability, climate change and economics. The expert panel membership was: Professor Hugh Durrant-Whyte (Chair), Professor Michael Dureau, Professor Frank Jotzo, Ms Meg McDonald, Mr Roger Swinbourne.

In developing the Decarbonisation Innovation Study, the Office of the Chief Scientist & Engineer (OCSE) undertook a comprehensive consultation with a wide range of organisations in assisting the development of:

1. Scoping paper published in March 2020. The scoping paper provided context on the pathways and challenges for decarbonisation and climate resilience, and a preliminary

[1] NSW Government (2020). Opportunities for prosperity in a decarbonised and resilient NSW: Decarbonisation Innovation Study.

survey of potential decarbonisation opportunities for all sectors of the NSW economy. The purpose of this phase of consultation was to gather a wide range of potential opportunities from a diverse range of stakeholders.

2. Final report published in August 2020. Following the release of the scoping paper, further consultation and discussions were held with a broader set of stakeholders, with the aim of seeking feedback on the potential opportunities, including understanding the challenges and actions necessary to realise the opportunities. Throughout the consultation the opportunities were refined, with existing opportunities further developed and additional opportunities identified. This consultation process identified that some opportunities were best driven by government, such as through government procurement to drive demand for sustainable or decarbonised products and services. Government also plays a role in driving research and accelerate commercialisation of new technologies through investment. Other opportunities were better addressed by industry, consumers or other stakeholders. For example, industry bodies and businesses can be proactive in forecasting what skills they require in all parts of their business to enable decarbonisation and climate adaptation, and industry plays an important role in skills training.

Findings and validation

One of the outcomes of the Decarbonisation Innovation Study was a refined list of 65 decarbonisation opportunities for NSW (summarised in Table 1). In the report, these decarbonisation opportunities were also qualitatively assessed for their relative potential emissions reduction and economic benefits for NSW.

Table 1: Summary of key decarbonisation opportunities for NSW identified in the Decarbonisation Innovation Study

Sector	Summary of key opportunities for NSW
Services: *Global services powerhouse*	• Becoming a major global sustainable finance hub. • Attracting local and international capital, and directing it towards promising sustainable industries and infrastructure in NSW. • Improving investment practice by encouraging the widespread adoption of climate change risk management initiatives. • Growing jobs in carbon, resilience and sustainability services.
Electricity: *A distributed and low emission electricity system*	• Deploying low cost renewables and storage to lower electricity costs for businesses and households. • Developing and deploying innovative electricity generation, storage, grid and management technologies and services for a future low cost, low emissions, distributed, reliable, secure, digital and flexible electricity system. • Improving consumer confidence, participation in new electricity markets and adoption of low cost energy technologies.
Industry: *Low carbon industrial transformation*	• Developing and deploying new technologies and services to increase energy productivity, electrification and material efficiency in industrial processes. • Leveraging low cost renewable energy and energy productivity technologies to grow new and expanded energy-intensive industries in precincts and regions. • Reusing, recycling and repurposing materials in industrial supply chains. • Growing industries in hydrogen, alternative heat and bioenergy, and deploying these energy platforms across other industrial processes and economic sectors.
Built environment: *A sustainable built environment*	• Developing and deploying new technologies and services to increase energy productivity, electrification and material efficiency in the built environment. • Growing the market for efficient and modular designs that incorporate sustainable materials, energy generation and storage, and efficiency improvements. • Growing local supply chains in sustainable, reused and recycled construction materials.

	• Building net zero industrial, commercial and residential precincts and public infrastructure that showcase best practice design, construction and operation.
Land: *Sustainable agriculture and land use*	• Promoting best practice sustainable land management, and growing sustainability markets and ecosystem services to provide complementary decarbonised income sources for landholders, including indigenous landholders. • Improving agricultural productivity and resilience through technologies including controlled environmental horticulture, renewables, bioenergy, water efficiency and recycling, gene technologies and synthetic biology. • Growing local demand and supply chains in agricultural goods and tourism services.
Transport: *Electrified and efficient mobility*	• Increasing productivity in transport through digital connectivity, automation and new decarbonised modes of transport. • Growing availability and uptake of decarbonised energy sources in transport, including renewable electricity, green hydrogen and synthetic fuels. • Increasing awareness and uptake of Mobility as a Service solutions.

The Decarbonisation Innovation Study also assessed a range of critical technologies that underpin the decarbonisation opportunities now and into the future and their technical and commercial readiness, cost-effectiveness and potential timeframe to adoption (Figure 1).

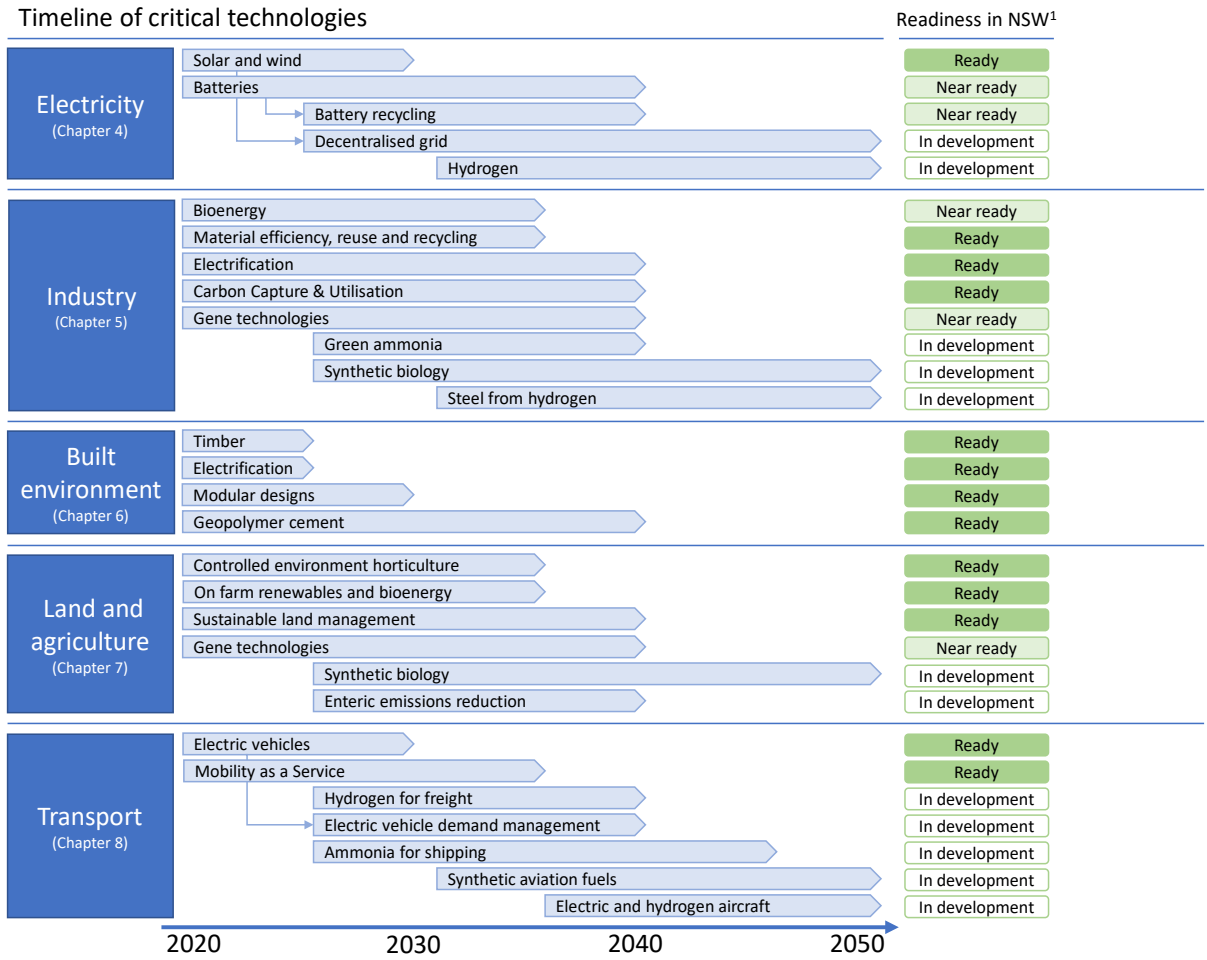

Figure 1: Timeline of critical technologies underpinning the economic opportunities identified in the report

Note 1: 'Readiness in NSW' refers to NSW's capability and preparedness to deploy the technologies. 'Ready': technologies that are technically and commercially ready and cost-effective in NSW, but are not adopted to their maximum potential. 'Near ready': technologies that require some incremental progress before entering in the NSW market. 'In development': technologies that require further research and commercialisation.

Based on the 65 decarbonisation opportunities and the timeline of critical technologies, the Decarbonisation Innovation Study proposed the 'next steps' for NSW Government in assisting with realising selected opportunities. Table 2 lists those of relevance to the NSW Decarbonisation Innovation Hub and priority areas. In the table, the next steps are grouped in sectors, themes and in relevance to the programs under the NSW Net Zero Plan (NZP). These next steps were validated by the expert panel.

Table 2: Key 'next steps' from the Decarbonisation Innovation Study of relevance to the Hub

Next steps	**Opportunities (numbers refer to section in the study)**
Sector specific	
Services	
The NSW Government works with NSW universities to promote collaboration between businesses and universities to expand the pool of expertise in decarbonisation and climate adaptation available to the private and public sectors.	3.2 Carbon, resilience and sustainability services
Electricity	
The NSW Government works with industry to support the development of local battery manufacturing facilities and to grow the market in utility-scale and behind-the-meter batteries.	4.6 Energy storage
Industry	
The NSW Government works with businesses and investors to identify and pursue opportunities to co-locate new and expanded energy-intensive industries in the Renewable Energy Zones (REZs) or in other regional areas with significant renewable energy potential.	4.1 Renewable Energy Zones 5.12 Export industrial productivity and sustainability services
Land	
The NSW Government facilitates the availability and quality of open data to support the greater adoption of sustainable and low carbon land management practices.	7.1 Knowledge sharing
The NSW Government works with landholders and service providers to assist them to navigate and participate in sustainability markets. The NSW Government continues working with the Commonwealth Government and stakeholders in the finance and sustainability markets sectors, on a Natural Capital Assessment Methodology to integrate natural capital into government investment and financial markets.	3.3 Establish Sydney as a major global sustainable finance hub 7.2 Sustainability markets 7.6 Sustainable land management 7.7 Ecosystem services
The NSW Government continues to work with other Australian jurisdictions on updating regulatory frameworks for gene technologies and synthetic biology.	7.11 Gene technologies and synthetic biology
Cross sectoral	
Precincts	
Programs under the NSW Government's NZP Stage 1: 2020-2030, such as the Clean Technology and Hydrogen Programs, encourage precinct-based approaches to the development and piloting of industrial decarbonisation technologies and services. Future eco-industrial precincts in NSW implement measures to achieve carbon neutrality in both operation and construction.	5.1 Eco-industrial precincts

Next steps	Opportunities (numbers refer to section in the study)
The proposed Clean Technology Innovation Hub, under the NZP, demonstrates and communicates: • Best practice in energy, water and material efficiency and low carbon materials • Costs and benefits for developers and providers of sustainable finance.	6.2 Sustainable precincts
Skills	
Skills development is considered in the implementation of the NZP, for example initiatives under the NZP engaging with relevant skills advisory bodies (such as relevant Skills Service Organisations and NSW Industry Training Advisory Bodies) to identify potential future skills needs in decarbonisation and climate adaptation.	4.11 Future energy systems and markets skills 5.4 Decarbonisation and climate resilience skills 6.5 Decarbonisation and climate resilience skills 7.4 Decarbonisation and climate resilience skills 8.10 New skills and services
Clean Technology Program	
The Clean Technology Program considers supporting more efficient, lower cost and safe: • Solar technologies • Hydrogen and battery storage technologies • Energy efficiency and demand management technologies • Material efficiency, reuse and recycling technologies, including technologies to improve asset utilisation, material durability and longevity • Electrification, alternative heat and bioenergy technologies • Modular building designs and construction approaches • Renewable and bioenergy technologies and services for landowners, including farmers • Mobility as a Service technologies. The Clean Technology Program also considers supporting: • Battery repurposing and recycling technologies • CCU technologies and processes that have the potential of becoming commercially viable without financial incentives to reduce emissions • Innovative and cost-effective low emission construction materials • Innovative digital technologies for optimising infrastructure and building performance, for example advanced sensors, digital twins and AI • Applications of gene technologies and synthetic biology that aim to improve productivity and climate change resilience, and reduce emissions, in the agriculture and industry sectors • New components and systems for novel decarbonised vehicles and infrastructure, • Vehicle-2-grid (V2G) technologies and services.	4.5 Solar generation 4.6 Energy storage 4.8 Energy efficiency and demand management 5.6 Material efficiency, reuse and recycling 5.7 Electrification, alternative heat and bioenergy 6.6 Efficient and modular designs 7.9 Renewables and bioenergy 8.6 Mobility services 4.10 Battery repurposing 5.9 Carbon Capture and Utilisation 6.8 Low emission construction materials 6.9 Digital technologies 7.11 Gene technologies and synthetic biology 8.11 New components and systems 8.12 Future EV battery services
Hydrogen Technology Program	
The Hydrogen Technology Program preferences hydrogen technology development and commercialisation in a hydrogen hub model, where production, storage and use are co-located alongside transport, industrial, water and renewable energy infrastructure.	5.8 Hydrogen 6.11 Hydrogen hubs 8.9 Strategic hydrogen and electrification hubs and routes

KPMG Report – NSW A Clean Energy Superpower (Industry Opportunities)

Background

At the request of the Minister for Energy and Environment, OCSE worked with KPMG to undertake an analysis of various decarbonisation opportunities in a range of industries in NSW, that would be enabled by NSW Electricity Infrastructure Framework to deliver cheap, clean and reliable electricity. The report produced, *NSW: A Clean Energy Superpower (Industry Opportunities)* (the 'KPMG report')[2] was a key component of NSW Electricity Infrastructure Roadmap. This Electricity Infrastructure Roadmap had bipartisan agreement in the NSW Parliament and was passed as the Electricity Infrastructure Investment Act 2020 and will set the direction of NSW energy policy into the future.

The CSE Decarbonisation Innovation Study was a qualitative study that identified a range of market opportunities across different industries and technologies (Table 1). The KPMG report, using the Decarbonisation Innovation Study as a starting point, then undertook further and deeper quantitative economic and technical analyses of a range of specific industry opportunities that had been identified by OCSE as being particularly promising. It also examined industry opportunities and analyses of cost pathways, resource and infrastructure needs, and location and potential timeframes.

The KPMG report provided information on the potential opportunity size and timeframe as well priority actions to assist the NSW Government, industry and other stakeholders to pursue new industry development opportunities to leverage clean and low cost energy in NSW. The KPMG report aimed to:

- Identify industry development opportunities associated with integrated clean energy deployment
- Analyse potential costs and deployment rates of selected clean energy technologies
- Analyse the preconditions (cost and readiness) for existing and emerging industries to leverage clean energy technologies
- Analyse the potential economic size of industry opportunities to leverage clean energy technologies, and
- Prioritise industry opportunities and future considerations with respect to location, technologies and policy needs and potential infrastructure requirements.

The KPMG report identified several key clean technologies that have a high potential for delivering emissions reduction and economic benefits. The analyses in the KPMG report included modelling to quantify the economic benefits of the critical clean technologies using inputs from other work supporting the NSW Electricity Infrastructure Roadmap as well as in-house expertise on hydrogen technology and related economics that was used by KPMG and CSIRO to develop the 'H2city Tool'. The KPMG Report also used a range of domestic and international data from industry and research sources. The H2City Tool calculates the full supply chain cost of hydrogen under a range of potential scenarios.[3] The OCSE worked closely with KPMG on modelling inputs, assumptions and sensitivity analyses in the KPMG report. The report increased our understanding of the economic opportunities for these technologies to decarbonise industry and also importantly the barriers to adoption and

[2] NSW Government (2019). NSW: A Clean Energy Superpower - Industry opportunities enabled by cheap, clean and reliable electricity.
[3] ARENA. Hydrogen Communities & H2City Tool.

uptake. The KPMG report also highlighted the infrastructure requirements to put into operation the technologies in different NSW regions. The KPMG report made a number of recommendations for the NSW Government, in how to accelerate development and uptake of the key clean technologies. The approach of the proposed Hub and Networks aligns with many of the suggested actions of the KPMG Report where the Hub and Networks can facilitate collaboration and coordination in supporting the delivery of those decarbonisation outcomes in other programs under NSW NZP (aligned actions are highlighted in Table 3 below).

Table 3: Key clean technology opportunities, suggested actions proposed by the KPMG report and alignment with Hub and Networks approach

Industry Opportunity	Potential Opportunity Size	Potential Timeframe	Suggested Actions for Consideration by the NSW Government *(actions highlighted are aligned with proposed Hub and Networks approach)*
Green hydrogen industry	The National Hydrogen Strategy estimated that the hydrogen industry in Australia could generate approximately 7,600 jobs and $11 billion per year in additional GDP by 2050.	Short, medium to long term	• Continue to strengthen partnerships across industry, research and all levels of government to accelerate industry development. • Continue to develop and subsequently build on and implement the NSW Hydrogen Strategy.
Green steel production	Every percentage point increase in industry output relative to current levels could deliver up to additional $20 million in annual revenues and up to $7 million in annual direct and indirect wages in today's dollars.	Short, medium to long term	• Continue to engage with industry to understand, monitor and consider actions to address current operational cost pressures of pathways to decarbonising operations. • Partner with industry to assess long term strategic pathways and enabling strategies to support potential greenfield development.
Green aluminium production	Every percentage point increase in industry output (or avoided industry decline) relative to current levels could deliver an additional $50 million in annual revenues and around $14 million in annual direct wages in today's dollars.	Short to medium term	• Engage with industry in respect of current operations and cost pressures. • Engage with industry to assess the economic and technical feasibility of leveraging renewable technology and storage.
Green ammonia production	Every percentage point of global market share able to be captured by NSW is worth approximately $102 million in today's dollars (assuming 2018 market size).	Medium to long term	• Continue to establish and embed linkages to collaborate with existing industry initiatives such as

Industry Opportunity	Potential Opportunity Size	Potential Timeframe	Suggested Actions for Consideration by the NSW Government *(actions highlighted are aligned with proposed Hub and Networks approach)*
	The economic opportunities could be significantly larger with potential for greater ammonia uptake across a wide range of industries including currently as a fertiliser and into the future as a common feedstock for production and energy storage (for hydrogen fuel).		pilot electrolysis projects in NSW and Australia. • Build the evidence base to size the current and future market and competitive landscape, including demand for future emerging industry supply chains.
Sustainable chemical and synthetic fuel production	There are many potential industry applications for synthetic fuels, including liquid organic hydrogen carriers to transport and store hydrogen and other chemicals made using cheaper green energy. The international markets for chemicals and synthetic fuels, such as ethanol and methanol, are worth tens of billions of dollars and are expected to grow domestically and internationally over time as demand and use applications increase. Increasing NSW's capacity to capture a fraction of the domestic and international market using low-cost renewable energy sources could enable the realisation of significant economic and industry benefits in the state.	Long term	• Partner with industry to understand and clarify the importance of local chemicals and synthetic fuels manufacturing and the economic and strategic importance of different end use cases. • Consider the potential for a precinct approach for sustainable chemicals and fuels manufacturing to maximise circular economy benefits and to lower capital, infrastructure and feedstock costs, and reduce skills barriers. • Investing, incentivising or creating regulatory enablers to stimulate industry investment and development. • Support research and development and small demonstration trials.
Transport and logistics	Every additional one per cent share of Battery Electric Vehicles (BEV) registered as passenger vehicles in NSW has the potential to result in direct cost savings of up to $89.3 million per annum. Based on potential future costs, total future Fuel Cell Electric Vehicle (FCEV) bus operating costs in NSW may be up to $234.8 million lower than Internal Combustion Engine (ICE) bus operating costs in 2030 in today's dollars. Based on potential future costs, total future operating costs of	Short to medium term	• For buses – Use the outcomes of bus trials, such as electric bus trial by Nowra Coaches and Sydney Airport and the H2OzBus project, to inform the development of business case(s) for option to scale low- emissions bus services. • For freight – Work with the industry to model options to optimise and prioritise investment in decarbonisation opportunities and

Industry Opportunity	Potential Opportunity Size	Potential Timeframe	Suggested Actions for Consideration by the NSW Government *(actions highlighted are aligned with proposed Hub and Networks approach)*
	articulated and semi-rigid trucks could be up to $103.1 million per annum and $42.6 million per annum lower respectively than their ICE counterparts in the respective years they attain cost-competitiveness. The operating cost savings for truck operators are projected to grow annually in the years after cost-competitiveness is attained.		associated infrastructure across the NSW road freight network. • For private vehicles – Identify approaches to build on initiatives in the NSW Electric Vehicle and Hybrid Plan, including consideration of incentives, infrastructure and other industry programs.
Controlled environmental horticulture	Combined horticulture contributed around nine per cent of total gross value of production of NSW primary industries in 2016-17 (around $1.4 billion). Efficiency and yield strengths of controlled environmental horticulture and sustained growth in domestic and international demand for horticultural products can see the sector grow significantly. As one example, the Agribusiness Precinct at the Western Sydney Aerotropolis alone is expected to contribute up to 2,500 FTE jobs, 12,000 indirect jobs and $2.8 billion in revenue over a 10-year full scale up. Nine Controlled environmental horticulture facilities will be key components in an integrated Agribusiness Precinct.	Short term	• Build and leverage work underway in the Western City and Aerotropolis Authority in respect of the Agribusiness Precinct at the Western Sydney Aerotropolis. • Continue to support the development of low-cost energy infrastructure, including REZs and water infrastructure to enable the establishment of CEH sites in strategic locations. • Link with industry-led feasibility studies and business cases to confirm the specific location(s), scale and crop focus of new CEH facilities across NSW that can maximise economic impact.

NSW Decarbonisation Innovation Hub –priority areas

The purpose of the Hub is to accelerate the development, commercialisation and adoption of clean technologies and services to reduce emissions by bringing together government, technology developers and researchers, industry problem holders and end-users to collaborate on problems and solutions of mutual interest. The Hub and Networks are not policy-making bodies, nor equipped with large pools of funding to invest heavily in decarbonisation efforts or skills training. They are end-user focused-bodies that will seek to attract and connect private and public investment in decarbonisation technologies and services. The Hub brings researchers, entrepreneurs and start-ups together with investors and end-users, so that from the outset product development leads to technologies that are fit for purpose, and by working together accelerates market adoption and penetration.

Given the need to attract and leverage private and public investment to clean technology projects, it is important that the Hub targets those focus areas that have the most emissions reduction and economic benefits. The Hub will target these focus areas through a structure of Networks connected within the Hub. Based on the findings of Decarbonisation Innovation Study and stakeholder consultations, three initial Networks have been proposed for the Hub:

a) Electrification & Energy Systems – accelerating renewable energy solutions and supporting the uptake of electrification in other sectors.
b) Land & Primary Industries – coordinating and aligning efforts in the next wave of sustainable primary industry and land management practices as the sector contributes significant proportions of NSW emissions.
c) Power Fuels including Hydrogen – growing an environmentally sustainable NSW hydrogen industry and unlocking decarbonisation opportunities for many hard-to-abate sectors beyond 2030, developing mobile fuels that are not fossil fuel-based but rather are generated through the use of renewable energy.

Rationale for the priority areas based on the findings of the Decarbonisation Innovation Study and the KPMG Report NSW: A Clean Energy Superpower (Industry Opportunities)

The Decarbonisation Innovation Study identified key decarbonisation opportunities for NSW across sectors including services, energy, industry, transport, the build environment, land and agriculture based on extensive consultation. The Decarbonisation Innovation Study considered three types of opportunities:

a) Policy & procurement: Opportunities to support the development and deployment of new technologies and services using mechanisms such as government procurement, policies, regulations and standards
b) Technology & services: Opportunities to research, develop, commercialise and deploy new technologies and services for decarbonisation and climate resilience
c) Education & skills: Opportunities to improve skills in, and understanding of, decarbonisation and climate resilience.

These 65 opportunities were assessed for their relative potential 'emissions reduction' and 'economic benefits' for NSW (assigned 'low', 'medium' or 'high' ratings).[4] The NSW Decarbonisation Innovation Hub and Networks are focused on accelerating the R&D, commercialisation and deployment of clean technologies and services. To identify the best focus areas for the Networks, the 'Technology & services' opportunities identified in the Decarbonisation Innovation Study with the greatest emissions reduction and economic benefits were considered (Table 4).[5] Across these high value opportunities, some common themes emerged across all sectors. These themes are well aligned with the three proposed Network areas, as they cover the most significant decarbonisation opportunities across all sectors in NSW.

[4] Refer to the Decarbonisation Innovation Study for detailed scoring of all decarbonisation opportunities assessed, www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0004/321466/Final-Report-Decarbonisation-Innovation-Study.pdf.

[5] In conducting this assessment, the following decarbonisation opportunities were considered: (a) opportunities with a 'high' score in potential emissions reduction and at least a 'medium' score in potential economic benefit; and (b) opportunities with at least a 'medium' score in potential emissions reduction and a 'high' score in potential economic benefit.

Table 4: Alignment of high value decarbonisation opportunity with proposed Network focus areas

Sector	Technology and services opportunities (*Medium to High Emissions Reduction, and Medium to High Economic Benefit*)	Theme	Alignment with proposed Networks		
			Electrification & Energy Systems	Power Fuels including Hydrogen	Land & Primary Industries
Electricity	5. Solar generation – developing and deploying new solar technologies.	Energy Systems	X		
	6. Energy storage – developing and deploying new storage technologies, including for power, control and grid integration, EV and battery storage, hydrogen storage, pumped hydro storage.	Energy Systems	X	X	
	8. Energy efficiency and demand management – developing and deploying energy efficiency and demand response technologies and services to reduce energy costs for customers.	Energy Systems	X		
	9. Digitalised and distributed energy markets – developing and deploying new technologies to optimise future digital energy markets with two-way energy flows, virtual power plants, peer-to-peer trading, high penetrations of distributed and renewable energy and storage, microgrids and large demand response resources.	Energy Systems	X	X	
Industry	5. Energy productivity – improving industrial productivity by developing and deploying novel and mature energy efficiency technologies.	Electrification & Energy Systems	X		
	7. Electrification, alternative heat and bioenergy – improving industrial productivity by developing and deploying electrification and renewable energy technologies.	Electrification and bioenergy	X	X	X
	8. Hydrogen – developing and deploying technologies for green hydrogen in industry through hydrogen hubs.	Hydrogen		X	
	11. Grow local production – leveraging energy productivity improvements to increase local production.	Power to X, Power Fuels, Hydrogen		X	
Built environment	7. Energy productivity – improving energy productivity by deploying mature technologies for heating, lighting, appliance and motor efficiency.	Electrification & Energy systems	X		
Land	6. Sustainable land management – promoting best practice sustainable land management and complementary decarbonised income sources for landholders, including indigenous landholders (e.g. carbon farming and regenerative agriculture).	Land management			X
	8. Controlled environment horticulture – improving agricultural productivity, sustainability and resilience through controlled environment horticulture.	Electrification & Energy Systems	X		X
	11. Gene technologies and synthetic biology – developing and cultivating highly productive and resilient crops.	Gene technologies and synthetic biology			X

	12. Enteric emissions reduction – developing and deploying vaccinations, feed supplements and breeding.	Diverse			X
Transport	8. Electrification – deploying EVs and other electric transport modes in cost-effective applications.	Electrification	X		

The clean technologies identified and analysed in the KPMG Report are also well aligned with the proposed focus areas of the NSW Decarbonisation Innovation Hub and Networks (Table 5).

Table 5: Alignment of clean technologies in the KPMG report to the proposed Networks

Clean technologies included in KPMG report	Economic analysis supporting focus on this technology	Alignment with proposed Networks		
		Electrification & Energy Systems	Power Fuels including Hydrogen	Land & Primary Industries
Green hydrogen	• Levelised cost of hydrogen production modelling 2020-2050. • Sensitivity analysis of electricity prices and electrolyser costs.	X	X	
Green steel	• Industry case cost of steel against green and brown steel 2020-2050. • Sensitivity analysis of hydrogen costs.	X	X	
Green aluminium	• Market size analysis considering electricity price.	X		
Green ammonia	• Ammonia production cost modelling 2020-2050. • Sensitivity analysis of levelised costs of hydrogen.	X	X	
Sustainable chemical and synthetic fuel	• Market size analysis.	X	X	
Transport and logistics	• Cost-competitive analysis of EV and FCEV for private vehicles, buses and trucks. • Sensitivity analysis of hydrogen cost.	X	X	
Controlled environmental horticulture	• Market size analysis with case studies.			X

Validation and refinement of the proposed NSW Decarbonisation Innovation Hub and Networks through stakeholder workshops in February 2021

To validate and help refine the focus of the proposed NSW Decarbonisation Innovation Hub and Networks, three workshops (one for each of the proposed Networks) were held by OCSE in February 2021 with key stakeholders. The workshops aimed to facilitate knowledge sharing and seek feedback regarding the proposed focus areas, objectives, activities, outcomes and structure of the Hub and Networks. Stakeholders from academia, industry and government attended virtually and in-person. One hundred and five participants attended one or more workshops. Workshop participants and invitees who could not attend were invited to provide online submissions and 15 written responses were received.

Workshop participants validated the core mission of the Hub and Networks, affirming that they should seek to connect industry players with decarbonisation challenges to researchers and innovators who can offer potential clean technology and service solutions, and then connect the researchers with commercial partners who can assist with licensing, IP, commercialisation and adoption. Existing innovation Networks, for example the NSW Defence Innovation Network (DIN) and the NSW Smart Sensing Network (NSSN) were supported by the stakeholders as a demonstrated model for engagement and technology development in NSW. Stakeholders also suggested that when considering the governance structure, the Hub be managed by a consortium of leading research and industry organisations, which will ensure that the Network can deliver on the Hub's objectives to decarbonise NSW and that involving the private sector from the beginning will ensure that their goals are aligned. While key opportunities in each of the proposed Network streams were identified, an adaptive management style approach was supported that changes and adjusts to ensure the Hub remains at the forefront of decarbonisation technologies over the decade.

During the consultation process, some stakeholders acknowledged that there are existing organisations and partnerships that are connecting industry, government, researchers and NGOs in addressing decarbonisation challenges and solutions. However, many stakeholders agreed that those existing organisations and partnerships would not (and should not) be duplicated, and in fact could be leveraged in the establishment of a NSW Decarbonisation Innovation Hub and Networks. Stakeholders comments included that:

- Many existing initiatives have a national focus, whereas a NSW Decarbonisation Innovation Hub and Networks could prioritise the needs and challenges of NSW researchers, inventors, industry and local government in clean technology development and decarbonisation.
- While there are existing relationships between NSW stakeholders based on their networks and partnerships, some initiatives are fragmented across NSW by individuals and organisations. These existing relationships should be leveraged and built upon to increase the collaboration and cooperation between NSW universities, local industries and investors. Coordination through a single hub and networks could optimise resource allocations and avoid duplicating efforts for NSW as a whole.
- The Net Zero Industry & Innovation Program is NSW Government's investment made into the innovation ecosystem to accelerate the commercialisation and adoption of clean technologies over 10 years. A bespoke Hub with dedicated resources could support other streams within the CTIP streams to ensure their investment priorities related to R&D, skills development and research infrastructure best meet NSW's decarbonisation challenges, pathways and opportunities.
- The Networks could facilitate demonstration projects in industries to increase uptake and attract private and public investment. This will also assist with building collaboration and facilitate strong communication with SMEs, including landowners and indigenous groups, and trusted sources of information.
- The Hub and Networks could assist in facilitating access to insurance, finance and investment opportunities as well as with de-risking large-scale capital investments, especially for smaller businesses.

The outcomes from the three workshops, the findings from the Decarbonisation Innovation Study and the recommendations for action from the KPMG/OCSE analysis together provide a rich set of identified initiatives and opportunities that can be used to support the detail of the work programs for the Hub and Networks.