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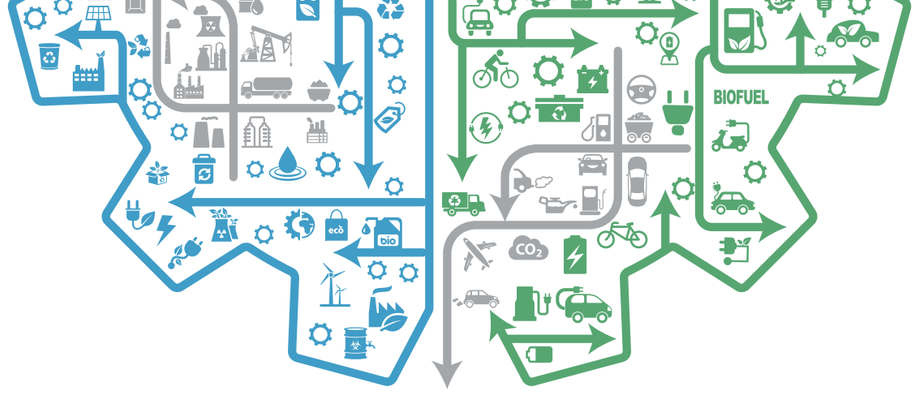
Energy System Deep Dive

The Electrification of Everything

October 2022



Introduction

The science of climate change is reverberating through economies, communities, and business, worldwide. The great leap forward over the last few years has been the translation of this challenge from environmental or moral arguments to an economic, and now commercial, discourse.

The reality is now clear: the progression of climate change, if unchecked, will slow economic growth and destroy jobs and communities; while the economics of addressing climate change, with an orderly and global transition, will generate economic growth, jobs, and incomes for people across the world.[1]

If coordinated and early action is taken towards Australia's decarbonisation, the economy stands to gain around $890 billion over the next 50 years.

This is in comparison to a future of no further or significant climate action, which could result in $3.4 trillion in economic losses, over the same period.

The commercial reality is now unfolding in the boardrooms of industry, in the entrepreneurial activity to address climate change we see around us, in the pivot of the financial system to the realities of climate risk and the opportunities of a new net zero economy, and in the expectations and demands of consumers and communities.

As business now leaps forward, our understanding of the task ahead is informed by our understanding of structural economic change and the dynamics which will play out in the greatest economic transition that will take place over the coming few decades. Because the **task at hand is no less than the recapitalisation of the production system of the economy.**

Critical to this great economic transition, is the recognition that economies are made up of critical systems, the most important of which, at this stage of the transition, is the energy system.

If our economy, in Australia and the world, is to arrest rising global emissions in the next few years, then the coming decade will be critical for the transition of the energy system.

A transition of the energy system will mean that production of goods and services in our economy will be different by 2050.

This transition will play out most significantly in four systems in the Australian economy: energy, agriculture, raw materials and manufacturing, and transport.

The road to 2050 and net zero, for Australia, will need to see two things take place:

1.**a great reallocation of capital** – some $70 billion in just the coming decade alone[2] – away from emissions-intensive activity and into the new low-emissions economic systems Australia needs to grow and create jobs; and

2.**additional investment of some $420 billion**, over above the $20 trillion in investment which would otherwise take place over this time period specific to the structural changes that will make our economy net-zero, such as the formation of new industries like hydrogen and the reengineering of Australia's energy and transport systems.

The energy system, which produces the most emissions in Australia, will undergo the deepest and earliest transition – of capital reallocation and new investment needed.

Over the next decade, Deloitte Access Economics estimates around **$25 billion (net present value) must be reallocated away from emissions-intensive to low-emissions assets** in the energy system. We are already seeing this manifest in the form of asset write off and impairments.[3]

On the flip side, when it comes to new investments, **around $100 billion in additional capital (over and above a baseline investment trajectory for the economy) must flow into low-emissions assets** for the Australian economy to be on the path to net-zero.

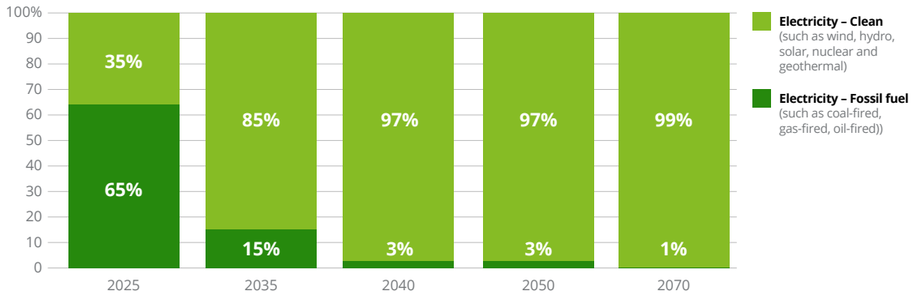
This is a transformation of the structure of the economy. An incremental approach to this will be to fail the objective of net zero by 2050. An economy by 2050 which has effectively decoupled emissions intensity from economic production will be an economy which is structurally different to that of today.

In terms of energy, the energy mix will be radically different.[4]

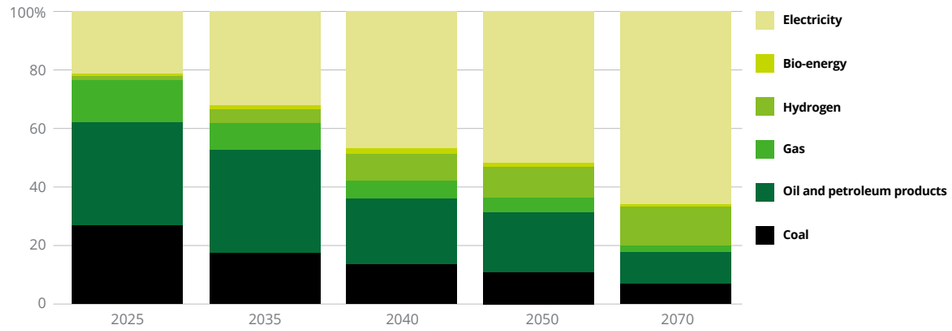
Electricity which makes up about 20% of the energy mix today may need to comprise over 60% of the energy mix by 2070. Moreover, clean energy sources for electricity will need to shift from around 35% to nearly 100% over the coming decades.

Similarly, hydrogen, comprising just a fraction of energy mix today may need to reach around 15% by 2070, while gas could shift from just over 30% to around 10% of the energy mix by 2070.

Australia's electricity mix, to 2070



Australia's energy mix, to 2070



Consistent with this, new infrastructure – from energy generation, to energy transmission, to energy storage, will look nothing like it does today.

Indeed, the nature of energy markets will be different as localised and mobile energy sources become more prevalent leading to new thinking around regulations, competition, and pricing.

While the case is clear for turning ambition into action when it comes to an orderly energy transition, the specific next steps may be less so. The following deep dive looks to answer some of the key questions about electricity system transition in particular and presents a series hypotheses of how this could look in 2030 and beyond.

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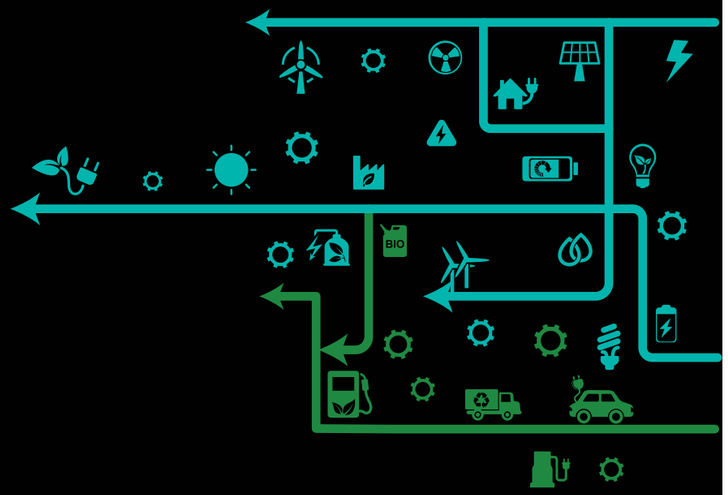
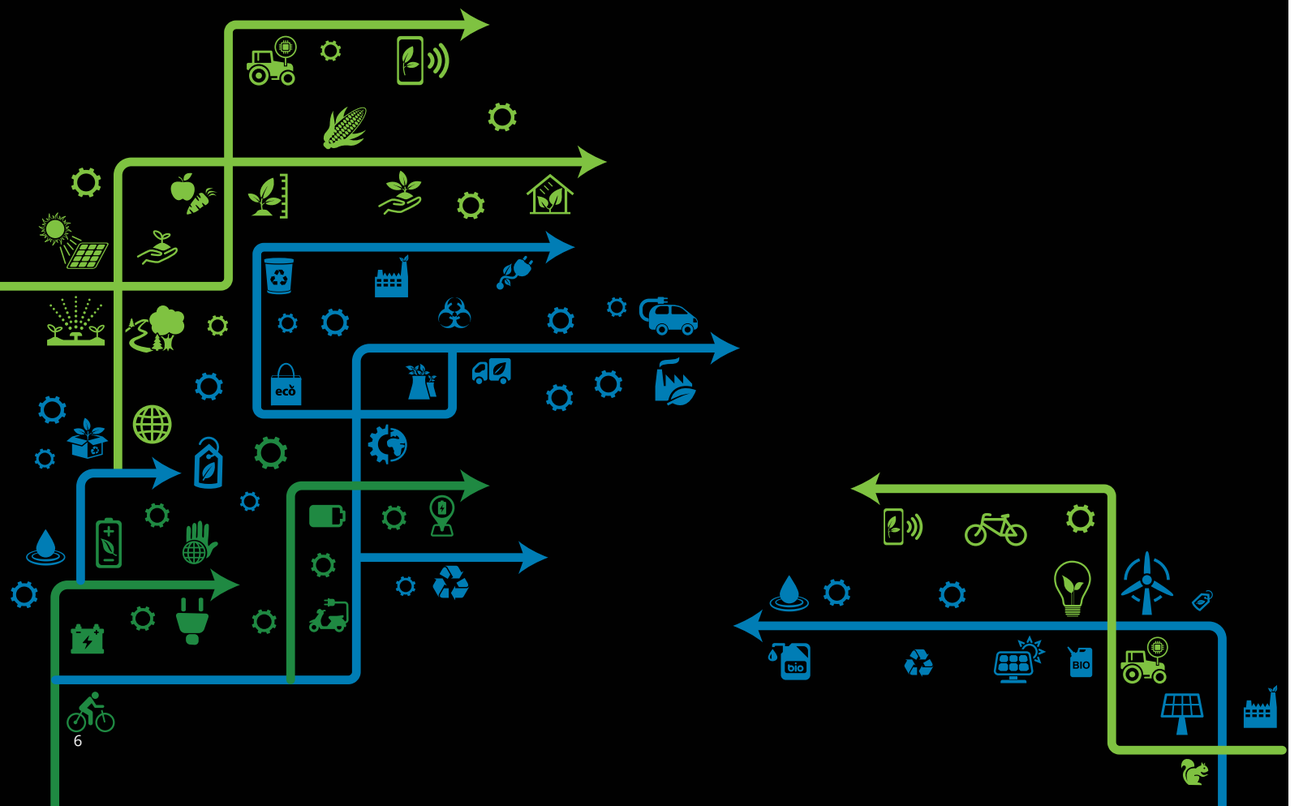


What is the scale of the change required? Our Electricity System



Acronyms	
AEMO	Australian Energy Market Operator. Manages the electricity and gas systems and markets across Australia
AEMO ISP	Australian Energy Market Operator Integrated System Plan. A roadmap for the maintenance, development and expansion of the National Electricity Market based on projected needs
NEM	National Electricity Market, operating in all Australian States and Territories except Western Australia and the Northern Territory
Step Change Scenario	Electricity system scenario. AEMO considered four scenarios for the pace of energy system transition to project different investment requirements and align on a basis for planning this investment going forward. The Step Change Scenario, deemed most likely, assumes renewable energy sources will generate 83% of NEM energy by 2030-31 and NEM generation will double by 2050[5]

Currently, our National Energy Market (NEM) delivers 180 TWh of electricity to industry and homes every year and ~72 percent of it is generated by burning fossil fuels.[6]

The federal government's recently legislated emissions reduction target of 43 percent by 2030 can only practicably be achieved by further decarbonisation of this electricity system.

The Australian Energy Market Operator (AEMO) estimates that fossil fuel generation must fall to below 20 percent within the next 5-7 years, while at the same time the amount of electricity the NEM generates must nearly double by 2050 to support the decarbonisation of other systems (320 TWh per year).[7]

It is possible that the demand for electricity might be even higher by 2050 due to the potential development of energy-intensive industries not included in the latest AEMO ISP, such as a robust green hydrogen and processed carbon neutral minerals export industry. In one modelling of this scenario, electricity could be as much of 40x today's capacity of the NEM by 2050.[8]

Threading the needle of decarbonising the electricity system while ramping up electricity supply is a problem that must be addressed today and will impact every participant in the current system.

What will this change look like?
Our Electricity System Today and Tomorrow

Now

Develop policy and regulation to support market transition. Facilitate investment in infrastructure and services through policy, regulation and incentives.

Future

Shifting focus away from preventing monopolistic profit taking to also enabling the inevitable energy transition across the energy value chain to be more orderly, more efficient and more equitable.

What next?

Generation

Penetration of renewable energy accelerates as coal retirements brought forward

- Build innovative revenue stacking with both customers with different needs and gird firming and stabilising services
- Manage risk of curtailment through combining with storage or onsite, or near-site, uses
- Build portfolios considering variable generation profiles to reduce hedging requirements

Transmission

Dynamic pricing enables new business models to emerge to deliver both value and grid stability

- Regulatory reform, or subordinated funding, to reduce risk profile for new transmission lines that will have increasing load from multiple projects building over several years
- Increasing use of HVDC for on-land projects
- Increasing interconnection capacity and links to build a more resilient system

Distribution

Demand response, vehicle-to-grid and virtual power plants become the glue that holds the systems together

- Distribution networks will become highly dynamic and interactive
- Control systems will manage millions of individual assets consuming or providing energy
- AI and Machine Learning will enable network optimisation

Retail

- Significant new entrants with no historical liabilities and strong brand presence
- Upselling opportunities expanding as the smart grid enables smart homes and smart transport

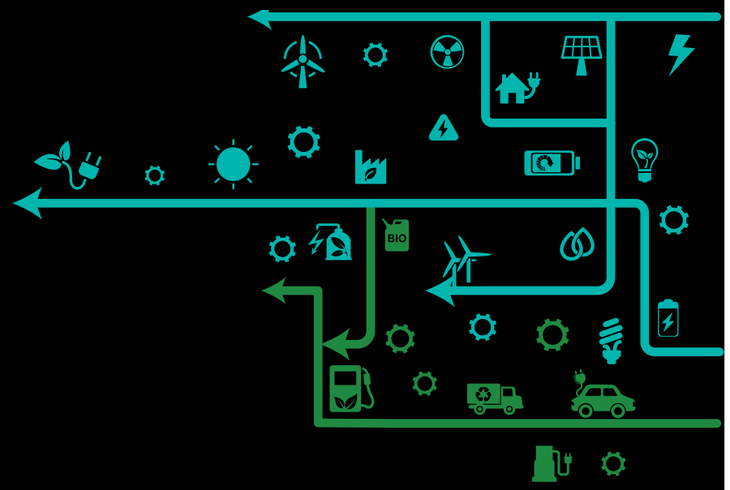
Consumption

Prosumers participate in the market via their standard energy agreements to drive down costs

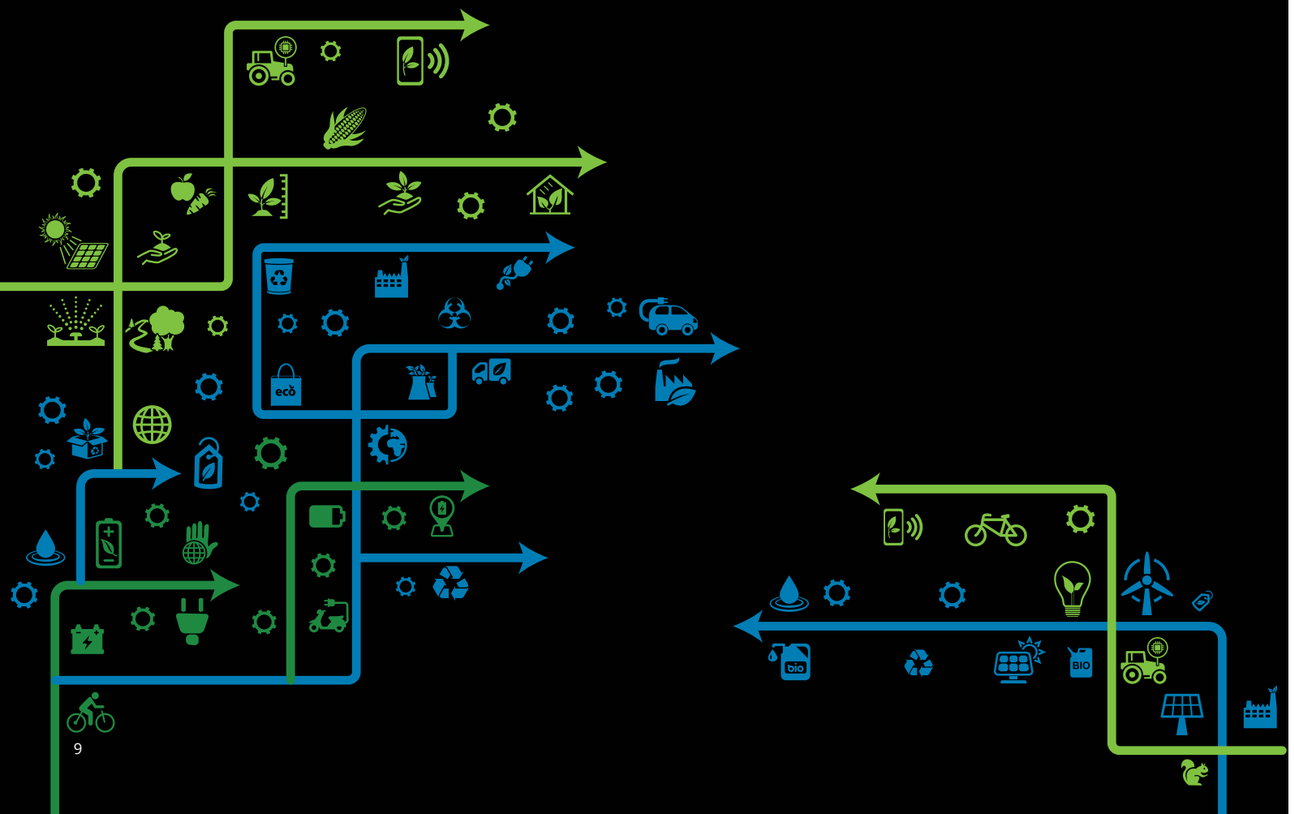
- All consumers are active market participants either directly or through their energy agreement
- Consumer data access will become the the most important asset
- Connected EVs and household appliances will optimise energy utilisation
- Community initiatives, both local and through common interests, will tilt power further towards the consumer

Large scale investment in infrastructure upgrades and capital works. Retail lending to support consumer investment in renewable infrastructure, EVs etc

Opportunities to look at new business models, to seek returns from data rather than electrons, to leapfrog customer offerings and disrupt the incumbents.



How will participants adapt? Incumbents, Disrupters and Enablers



The shift forecasted by AEMO is already starting to happen. Our electricity mix is shifting away from centrally dispatched and simultaneously generated forms of energy like coal and gas and towards a mix of traditional fossil fuels and variable renewables like wind and solar.

Accordingly, the businesses involved in energy generation and retailing are becoming more diversified and the boundaries between actors are blurring as executives realise that business models based on vertical integration and generous regulatory tariff settings are no longer relevant.

Ambition to transition combined with the disruption this causes paves the way for new entrants

This change in the fundamental economics of the sector has paved the way for new entrants into the electricity market who are less resistant to the transition – be they incumbents from sectors adjacent to electricity generation and retailing or completely new entities with radically different business models, lower capex costs, and innovative new technologies.

Australia is an attractive, if volatile, environment for these new players to test new technology and market solutions as we are mostly privatised, mostly deregulated and potentially both lucrative and high risk due to our extreme peak load requirements.

Accepted risk profiles for investment in the sector will adapt

These new players and new waves of investment will also see old market dynamics of privatisation, vertical integration and concerns over 'gold- plating' or over-investing in electricity networks give way to new ways of doing businesses and new efforts to build customer loyalty.

The addition of new players in the market will quicken the pace of decarbonisation while injecting the competitive vigour needed to keep prices competitive for consumers. But it also means the market's existing regulatory frameworks will struggle to keep up.

Regulatory frameworks will struggle to keep pace with market dynamics

Although effective regulation will be critical to facilitate innovation and support an efficient transition, the speed of innovation and the range of economic, consumer protection and technical challenges this creates is likely to mean regulatory frameworks cannot always be relied upon to provide a clear transition pathway.

If we consider that the whole system must be fundamentally redesigned in 5-7 years, market participants won't have the time to wait for certainty before making investments – they'll make decisions in anticipation of where the market and the regulations might land. This challenges the cultural norms of the energy sector and its leaders.

This is where the benefit of attracting new and different players with different investor risk tolerance into the market may be attractive and essential. Industry, investors, governments, and regulators need to be willing to abandon traditional concerns and test and trial, 'failing fast and failing cheap' strategies to create value for their shareholders.

A key to navigating this successfully will be to build optionality into company strategy to allow for a variety of transition pathways and a variety of transition speeds. Deloitte works with many companies in the electricity sector and across large energy consumers in building out these options and making sure that the company can proceed with 'no-regrets' investment decisions despite this uncertainty.

What are renewable energy zones and will they help?

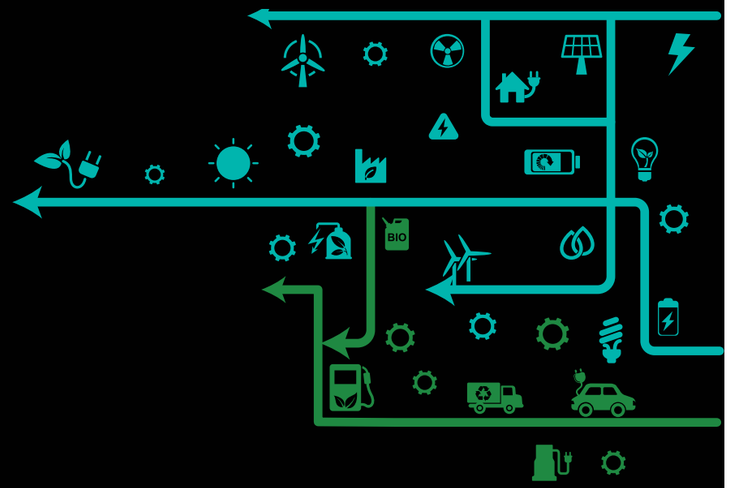
The opportunity to build out concentrated areas of diversified renewable energy and storage in regions that have high solar and wind resources is coming to fruition in the form of Renewable Energy Zones (REZs).

Grouping large scale renewable generation together enables both efficient higher-capacity transmission line construction and a less variable supply profile through the combination of solar and wind generation.

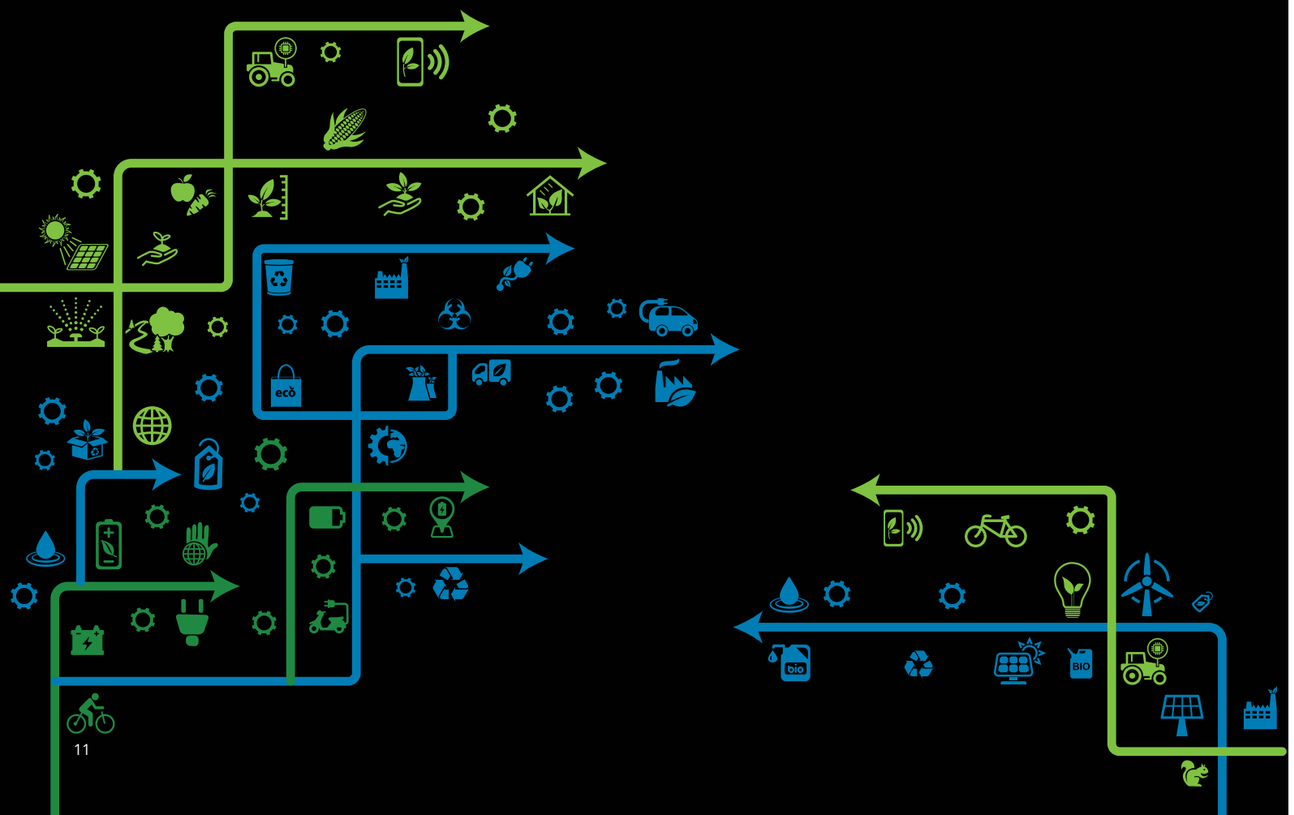
The clarity of REZ planning also provides an opportunity for high emitting industry to co-locate, and in doing so coordinate their industrial electrification.

As coal-fired generators are withdrawn from the system, the replacement by large-scale renewables in REZs presents the most economically efficient way to provide secure energy across the grid. This reality is reflected in AEMO's roadmap with much of the new renewable capacity forecasted is planned for construction within one of the REZs.

There are currently 41 different REZs existing or planned for construction over the next two decades,[9] almost all of which are still subject to significant review and design and/or are still pending investment. To be successful the construction of REZs will require significant ecosystem collaboration across government, business and community.



What are the key shifts and trends? Decarbonisation, Decentralisation and Digitisation



Decarbonisation of the electricity system requires it to be decentralised and digitised. Every participant has a role to play in facilitating this change and is affected by it, see below key questions to consider as your business navigates this transition.

Decarbonisation

14 GW[10] of coal-fired generation capacity is expected to be withdrawn by 2030. This amounts to over half of total NEM coal consumption (23GW) – a large gap that will have to be filled by low-emissions sources of power.

Based on current technology costs and forecasts, a least cost pathway to replace coal would be utility scale renewables, supported by large-scale storage (batteries) and assisted by the growing role and increasingly interconnected dynamic potential of Distributed Energy Sources (DER), like at-home solar panels.

While this technology exists the scale of the roll out required is remarkable. In AEMO's Step Change Scenario an additional 125 GW of solar and wind farm capacity is required by 2050.[11] To contextualise this, our single year record for construction of solar and wind farms is 3 GW. So that means, on average, we need to build around 150% of our best-ever year in wind and solar farm construction and we need to be doing that for the next several decades.[12]

As outlined, our overall total generation capacity will need to double. We will also need to get all the new clean electricity to where it needs to be – to the electric cars, to the heat pumps, to the businesses – so our transmission grid will need to grow from 40,000km today to 50,000km by 2050 according to AEMO.[13] That means we need to expand our transmission grid by roughly 1% per year to 2050. Our average over the last decade has been about 0.5% per year, so our pace needs to double.

This is a significant transition agenda for Australia. But also a huge opportunity to drive investment in physical infrastructure and build out new low carbon industry.

Key Questions

- Have you clearly modelled the financial impacts on your business of rapid decarbonisation of the grid as increasing demand is occurring?
- What are the options you have to invest in the future whilst maintaining optionality on the speed of transition?
- How would you build your business for the future energy market? How can you adapt to disrupt yourself to head in that direction – before others do?
- What is the capacity of the current supply chain to meet your strategy now and in the future? What will the impact of any constraints on skills, equipment, and/or materials be on execution of your roadmap?
- How can you engage across the lifecycle of innovation and development to guide participants and investors, new and existing, on regulatory enablers and constraints?

Decentralisation

By 2050, AEMO predicts 65% of detached houses in the NEM will have solar photovoltaic (PV)[14] panels, with most systems complemented by battery energy storage. If we can get the market's operations right and coordinate the efficient running and export of this DER – this could meet nearly one fifth of the NEM's total underlying demand.

Supplementing electricity demand with decentralised solutions like rooftop solar PV reduces overall demand for electricity in the wholesale market, playing a significant role in driving down wholesale prices during hours of generation and reducing the overall capex spend of operators by reducing the need to invest in network capacity infrastructure.

The benefits of enhanced decentralisation will be further secured once household battery technology becomes more economic and is effectively managed to deliver both demand response solutions and virtual power plant capabilities.

Although significant advancements have been made in the distribution of DER, its growth has continued to create challenges for managing the power system that won't be resolved until either the market's regulatory and operational toolkit (including effective and widespread deployment of vehicle to grid transmission, virtual power plants and similar enabling technology) evolves to be smarter and more dynamic.

Developing a clear view of the end state of a dynamic and decarbonised electricity grid will enable those with medium term investment horizons to establish market leading propositions that will benefit their shareholders.

Key Questions

- Do you understand the energy market end state and how to integrate this into your risk and opportunity considerations?
- Have you fully understood the speed of likely change and how that may impact the value of existing assets and the extent of liabilities?
- Are you looking globally at best practice energy market investment and how can you attract global investors into the local market?
- What further changes to regulatory frameworks are required to continue to support innovation through trials and regulatory 'sandboxes'?
- What role can you play in getting all parties to the table to better coordinate development and change?

Digitisation

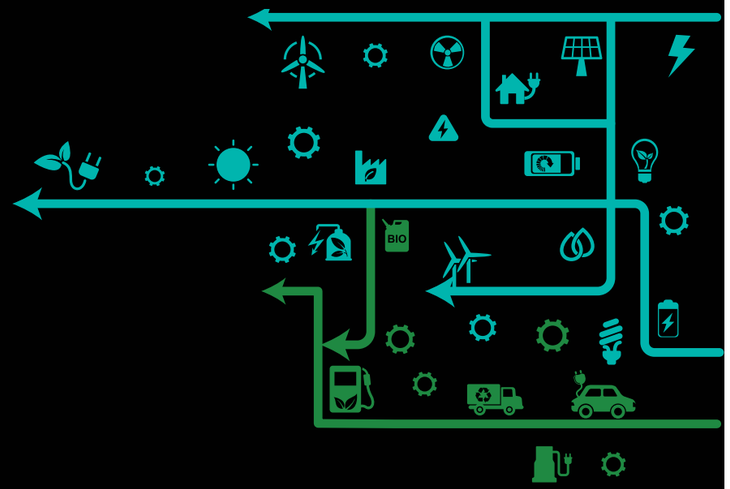
The wealth of data able to be collected by market participants is likely to prove more valuable than the electrons they sell. The efficient harvesting and use of data will be key to managing the complexities of a more decentralised energy system. Data analytics can assist energy asset managers to track weather patterns to determine supply patterns and to effectively and profitably manage demand systems to match this available supply. A company that can effectively balance its books for electrons using enhanced data analytics and machine learning can deliver enhanced returns for its investors.

Data can also be leveraged to offer value-enhancing dynamic grid stabilisation services, not just to balance capacity, but also to actively balance voltage and frequency regulation in a decentralised electricity network with multiple, rapidly changing sources of power generation.

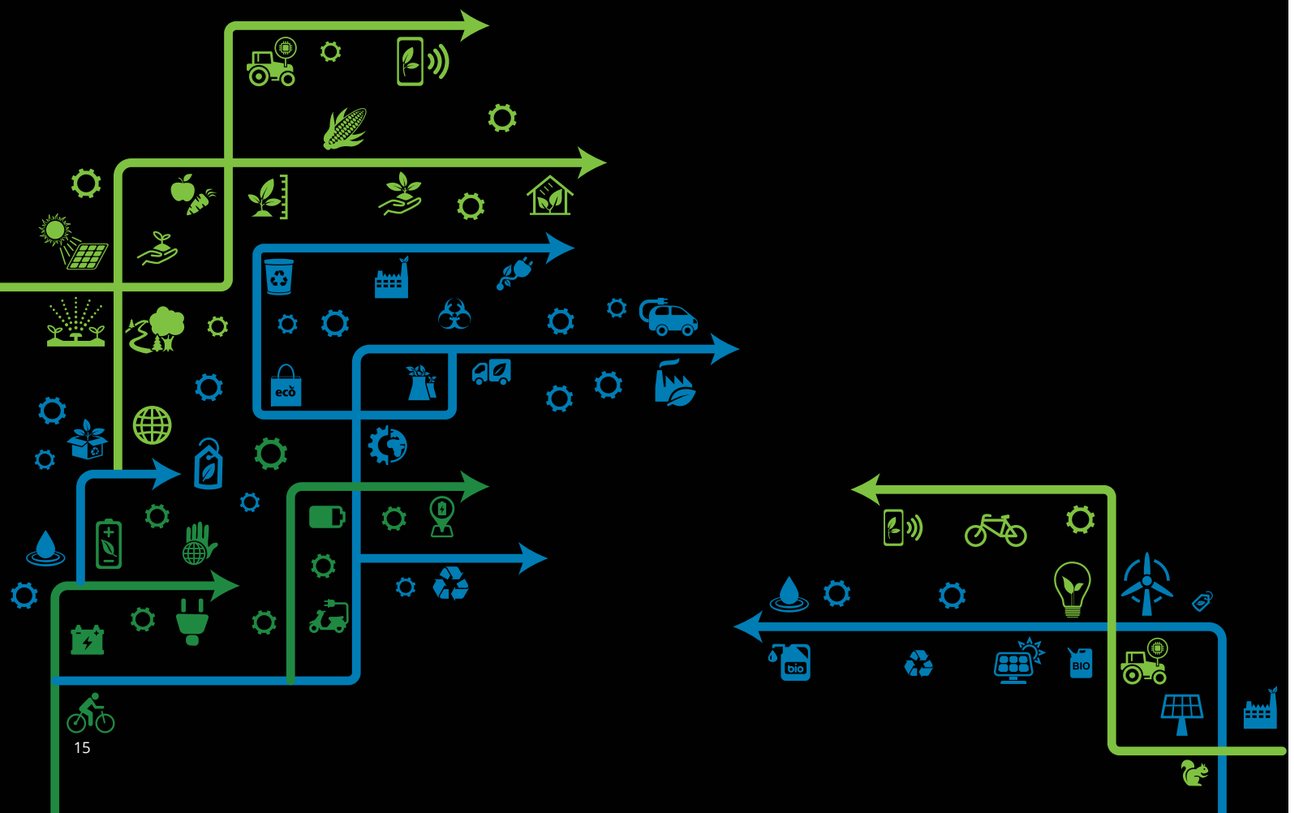
The ability to easily offer variable pricing will also reduce stress on the grid by changing consumers behaviour. For example, communicating to consumers, or activating pre-agreed arrangements, that it is cheaper to charge an electric vehicle, or even run the washing machine, at off-peak rather than at peak will result in a better matched supply-demand profile.

Key Questions

- What is the right balance between data collection to drive network efficiency and value, and implications for user and customer privacy?
- What usage data can you access, how can this be leveraged and what is its value?
- How do you recognise the value of collected data early and build this in to strategic decision making to drive long term value?
- What lessons from other sectors, such as telecommunications, could be harnessed to create different business models or value streams?
- How can you value stack offerings to create value where others cannot?

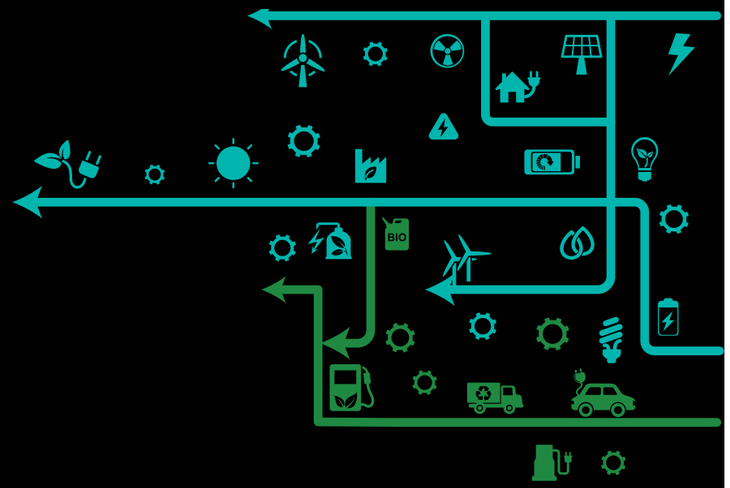


2030 vision

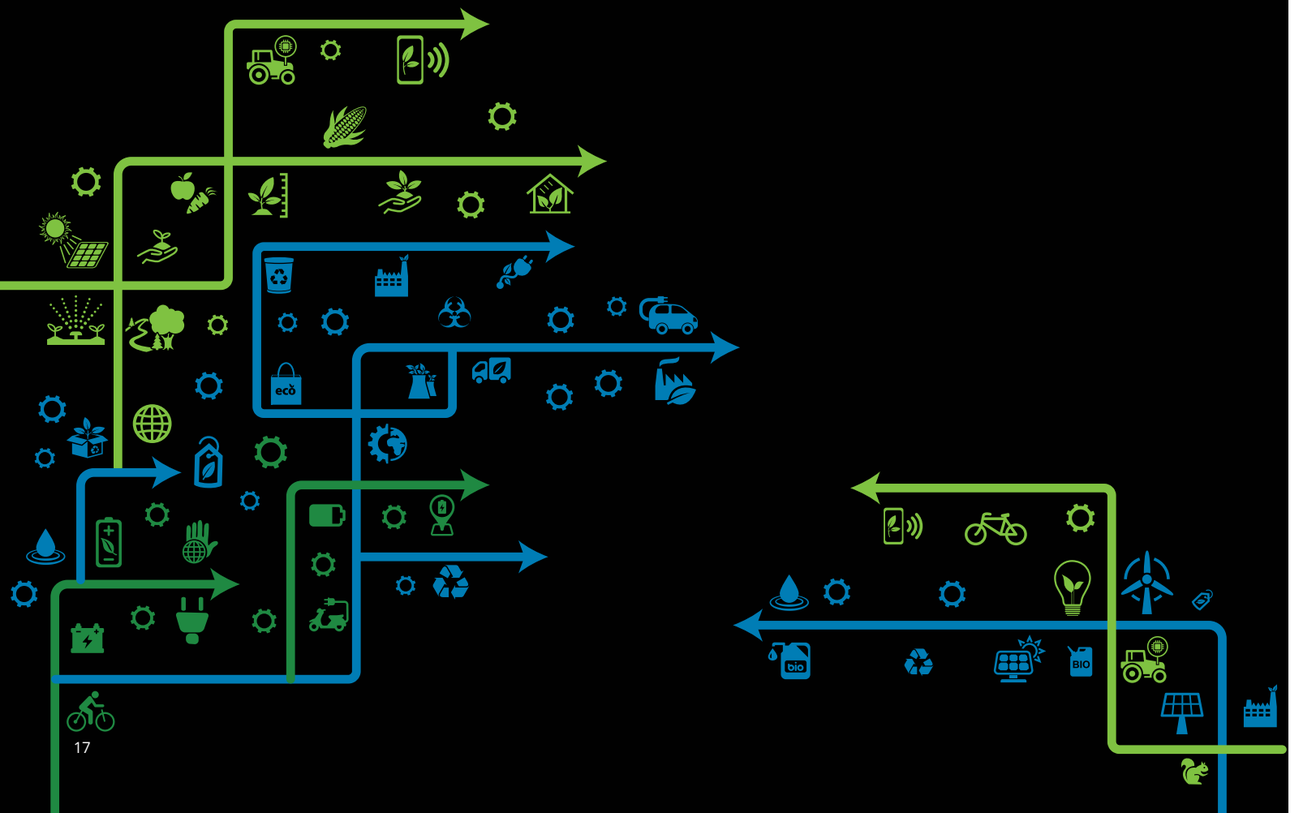


2030 VISION

Decarbonised	Decentralised	Digitised	Democratised
Coal's share of generation mix will decline by more than half (21%), with 14 GW coal-filed generation withdrawn by 2030, fully retired by 2043	Network infrastructure outside of the retailers jurisdiction increases, 20% of underlying capacity served by Distributed Energy Sources (DER)	Unbundling of the four essential system services: generation, transmission, distribution and retailing. Greater transparency and management of capacity, usage and pricing through increased digitisation	12% of household daily consumption stored in batteries, rising to 38% by 2050
Utility-scale solar achieves significant cost reductions (around 50% over the period), and triples its capacity by 2030 (much of this in fully operational REZs)	Micogrids replace the need for diesel generators at off-grid and edge-of grid facilities	Large and small customers actively participating in a market that supports the integration and coordination of customer DER, including via third parties such as aggregators	Growth in vehicle-to-grid services, 12% of road transport in electric vehicles
Gas phase out increases as State Governments incentivise householders to switch for both new houses and replacement systems	Consumer-owned solar PV capacity rising from 30% to 50%	Owners of storage facilities, particularly utility scale batteries and pumped hydro facilities, could take advantage of multiple revenue streams outside the traditional energy and frequency control ancillary service (FCAS) markets available today	640GWh in dispatchable storage by 2050, including new technologies like vehicle-to-grid, improved batteries and pumped hydro



Endnotes



1. Deloitte Access Economics analysis for the Business Council of Australia, Achieving a Net Zero Economy, 2021, pg 9
2. Deloitte Access Economics analysis for National Australia Bank, All Systems Go – Transforming Australia's economy to grow, 2022, pg 2
3. In 2018 the Grattan Institute (Down to the Wire, pg 4) estimated an excess of AU$10b in over investment in current state owned transmission and distribution networks suggesting these should be written down to support reduction in consumer electricity bills and a recognition of the changing system needs. Over the last three years, major generation players have reported in excess of $AU6b in write-downs and impairments resulting from deterioration in longer-term wholesale energy market forecasts driven by the evolving commercial and regulatory environment (see: AGL, ASX & Media Release – Asset impairment and recognition of onerous contracts, 2021; and Fowler, Louise, Origin Energy to write off losses from $2.2b sale, 10-02-22, afr.com)
4. Deloitte Access Economics analysis for the Business Council of Australia, Achieving a Net Zero Economy, 2021, pg 33
5. AEMO, Integrated Systems Plan, 2022, pg 7
6. AEMO, NEM Fuel Mix – Mix Summary – 12 Months, accessed 7 October 2022
7. AEMO, Integrated Systems Plan, 2022, pg 9
8. Net Zero Australia, Net Zero Australia interim results – public version, 2022, pg 32
9. AEMO, Integrated Systems Plan, 2022, pg 44
10. Only 8.4 GW announced, AEMO, Integrated Systems Plan, 2022, pg 9
11. AEMO, Integrated Systems Plan, 2022, pg 38
12. Clean Energy Australia, Fact Sheet, 2022, pg 2
13. AEMO, Integrated Systems Plan, 2022, pg 8
14. AEMO, Integrated Systems Plan, 2022, pg 8

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About Deloitte Climate & Sustainability

Deloitte Climate & Sustainability is a team of 250 dedicated experts supporting our clients in business, government and our communities to take practical action to decarbonise, become climate resilient and invest in the economic opportunity of Australia's transition to a net-zero economy. Deloitte has been a leader in identifying a coordinated climate transition as an enormous economic opportunity for Australia. Our recent The Turning Point report estimated this opportunity at $890b over 50 years. To support business seize that opportunity, we helped establish the Climate Leader's Coalition and provided the economic modelling for the Business Council of Australia's Net Zero 2050 commitment.

Our track record of helping our clients tackle climate transformation and our data-driven research, modelling assets and technology capabilities underpin our practical guidance to the c-suite and management teams.

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