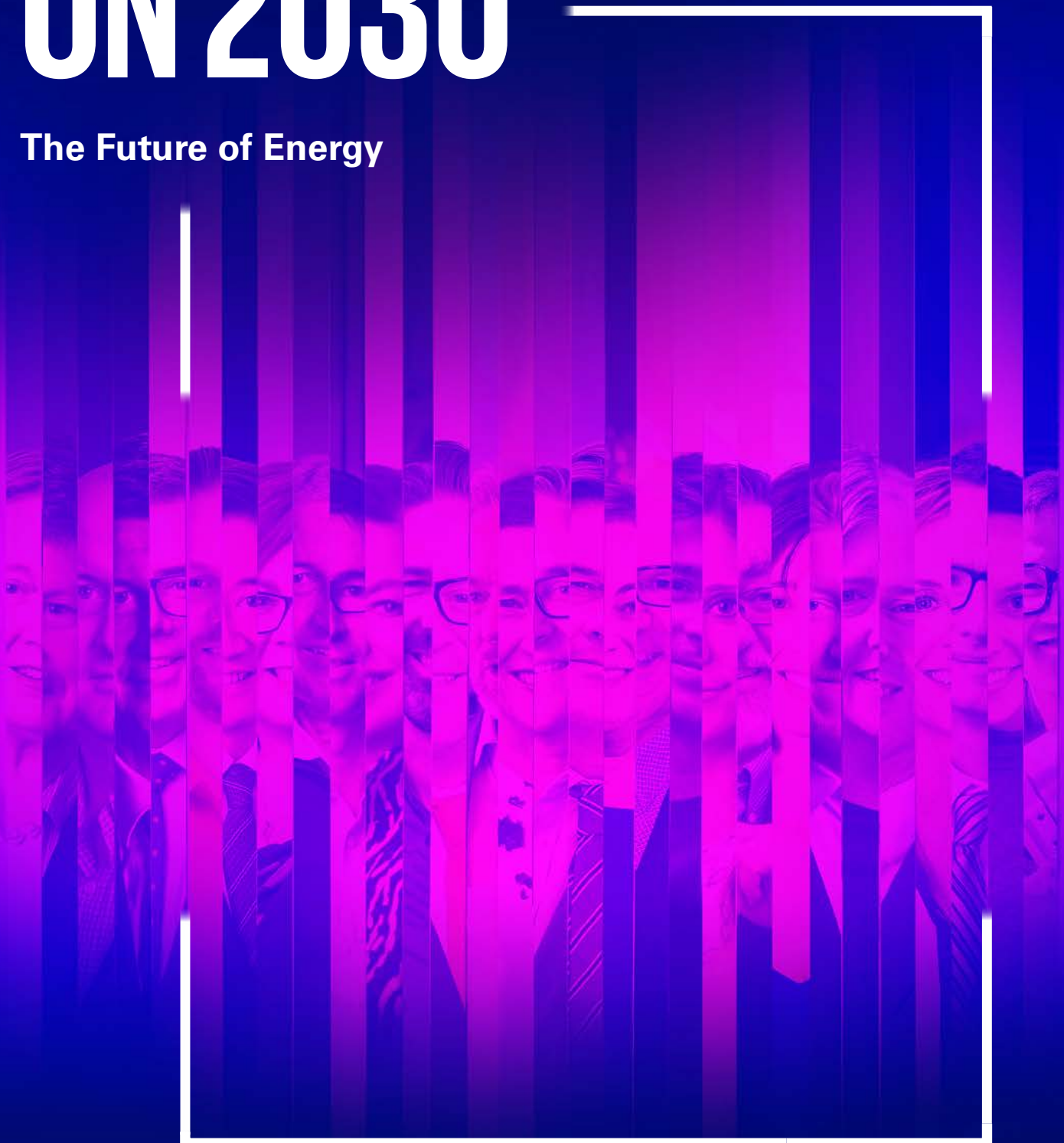
30 VOICES ON 2030

The Future of Energy



KPMG

KPMG.com/au/30voicesonenergy

30 Voices on 2030: The Future of Energy

The energy landscape is undergoing unprecedented change. To explore what the energy landscape could look like, KPMG asked 30 Voices to place themselves in 2030 and look back over the last ten years. The 30 Voices in this report cover every facet of the energy industry and beyond – from incumbents to challengers, big tech firms to investors, government ministers to academics and more. Taken together, the Voices create a valuable chorus of insight and expertise. Their predictions span six areas in which KPMG also envisages dramatic change – they are supported by a survey run by KPMG of over 240 energy and natural resource businesses across Australia which was carried out in mid-2021:

1.

THE ENERGY MIX OF 2030

69% of survey respondents agreed that most businesses and households in Australia will have shifted to use of solar and battery storage in 2030.

2.

ESG AND THE TRANSFORMATION AGENDA

59% of survey respondents agreed that in 2030 a law will have been passed requiring companies to meet specific ESG targets.

3.

DATA - THE FUEL BEHIND NEW ENERGY

74% of survey respondents agreed that most households will be actively monitoring and adapting their energy usage through the adoption of smart energy monitoring devices in 2030.

4.

PEOPLE AND TALENT – THE ENERGY BATTLE GROUND

65% of survey respondents agreed that to attract and retain talent in 2030, industry leaders in energy and natural resources will have strong plans to meet net zero emissions well before 2050.

5.

THE 2030 POLICY AGENDA AND GEOPOLITICAL LANDSCAPE

60% of survey respondents agreed that the shift towards raw materials needed for 'green' technology and low emission renewable energy fuels has pushed Australia to be a dominant member in terms of geopolitics.

6.

BEYOND NET ZERO – THE PUSH FOR THE GREENEST ENERGY

65% of survey respondents agreed that in 2030, the challenges of meeting net zero targets will mean all forms of carbon capture technology will be considered.

Many of the views expressed in this report may be personal and do not necessarily represent those of the Voices' organisations or that of KPMG.

Cassandra Hogan

NATIONAL INDUSTRY LEADER
ENERGY & NATURAL RESOURCES

KPMG AUSTRALIA

In the past year, the conversation on energy transition and decarbonisation has accelerated. The science has been clear for some time: the world will need to move to net zero emissions if we are to avoid severe climate damage. This goal has now been embraced by stakeholders across consumers, investors, communities and governments.

The insights from the 30 leaders we interviewed for our 30 Voices on 2030: The Future of Energy show the industry is undergoing a profound transformation. Supply of energy is shifting to renewables and lower emissions fuels. Consumers and industrial users are becoming more active participants in the energy market. They are choosing new technologies, products and data to meet their needs. At the same time, the grid is changing, becoming more distributed and reliant on a more diverse range of energy sources and storage. Sectors are converging, presenting new opportunities and challenges.

We know, too, that the decisions we make today will be critical in shaping the future of energy tomorrow. So, where will we be at the start of the new decade, in the year 2030?

Why 30 Voices on 2030: The Future of Energy?

We asked 30 leaders in the Australian energy sector and beyond (insiders, outsiders, disruptors and policy makers) to project themselves into the year 2030 and make bold predictions on what the energy future could look like for Australia.

These 'Voices' capture a range of views on the different energy transition pathways between now and 2030.

One point on which they all agree is the that industry will be fundamentally transformed – reshaped by changing stakeholder expectations, driven by technology, digitisation, regulation, evolving customer expectations and other innovative and disruptive forces. And in a world where ESG is front of mind for all stakeholders, how you grow over the next decade will truly matter.

KPMG Australia is also committed to playing a constructive part in the energy transition towards 2030. This year we released our first KPMG Impact Report aimed at enhancing the transparency and accountability of our firm, including the capture of our own environmental footprint and sustainability initiatives. We are also investing in capabilities that will assist our clients in navigating these choices.

I hope the insights and predictions of our 30 Voices will challenge your own thinking. We want to stimulate conversations about the actions needed to get us to the energy world we want to have in 2030 and beyond.

Whilst the exact pathway for energy to get us there is still unclear, I am confident the actions we take over the course of the next decade will be key to achieving a new and positive energy future.

Contents

Predictions for 2030

1. THE ENERGY MIX OF 2030

Renewables are now predominantly powering Australia.

Closure of coal-fired power plants is underway. Gas continues to be an option to provide firming capacity for intermittent renewables.

Hydrogen, green and blue, dominates the remaining decarbonisation journey.

2. ESG AND THE TRANSFORMATION AGENDA

ESG has been incorporated in core business strategy. Laggards will be starved from capital investments.

The entire energy value chain has been overhauled and reconfigured.

Electrification and low emissions transportation is transforming whole cities and industries.

3. DATA – THE FUEL BEHIND NEW ENERGY

The availability of data and artificial intelligence (AI) has increased demand flexibility and energy efficiency; protecting the consumer is paramount.

Cyber security is a priority investment focus to future proof the new energy system.

Digital verification and tracking of energy and emissions has become standard in global trade.

4. PEOPLE AND TALENT – THE ENERGY BATTLE GROUND

The energy industry is facing a talent crisis for contemporary energy and technology skills.

The data driven energy system is seeing a rise in demand for data management and AI skills; data is also driving more leadership decisions.

Increasing uncertainties around the pandemic and climate change mean operational resilience is crucial.

5. THE 2030 POLICY AGENDA AND GEOPOLITICAL LANDSCAPE

In an evolving geopolitical landscape, the race to decarbonise is amplifying uncertainties.

Net zero is a bipartisan issue; the urgency of acting to mitigate the impact of climate change has accelerated policy making.

Governments have reinforced policies to protect consumers and communities.

6. BEYOND NET ZERO – THE PUSH FOR THE GREENEST ENERGY

Technology focus is positioned around emissions reduction and clean energy.

"Green investment" is now known as simply "investment".

The decarbonisation action is now with hard-to-abate sectors.

Predictions for 2030

It's 2030. The energy industry landscape looks very different to what it did ten years ago. A tipping point has been reached during this decade. Many countries and companies are on the way to realising their net zero goals as the pace of change in the sector has been faster than at any other time in its history, and therefore fraught with challenges. The foundation of this new energy system has shifted from fossil fuels to clean electrification. While climate change concerns have forced stricter decarbonisation and ESG targets for both governments and companies, seeking to stay relevant to consumers has become a priority, meaning getting to net zero is now at the top of most corporate agendas.

For Australia the energy transition means major new opportunities. Big decisions made earlier in the decade have been key to energy market success by 2030. Governments and companies who foresaw the changes needed acted early, whereas laggards were left behind. They realised that managing fossil fuel assets and production costs were less important in a fast-electrifying world where renewable power is cheap and abundant. They quickly switched focus to offering differentiated low carbon energy services to the new energy consumer - such services are now a major source of value and growth.

What seemed like a major task in the early 2020s is today seen as a common purpose. The future is there to be shaped. The decisions and actions taken in the last decade have shifted the dial and helped to create an industry that is decarbonising for survival, more accessible and thriving today in 2030.

1. The Energy Mix of 2030

Renewables are now predominantly powering Australia.

Closure of coal-fired power plants is underway. Gas continues to be an option to provide firming capacity for intermittent renewables.

Hydrogen, green and blue, dominates the remaining decarbonisation journey.

By 2030, Australia has changed its energy mix and has the highest global per capita penetration of renewable power generation and storage. Diverse storage and balancing technologies (demand response, lithium batteries, hydrogen, pumped hydro) are being used to solve intermittency issues for solar and wind generation, as is natural gas, particularly as plans are now in place to progressively phase out coal-fired power generation plants.

Australia's head start in this energy transition was facilitated by its rich renewable resource base, but new policy initiatives also helped. Early in the decade it created multiple renewable energy zones (REZs) which are now generating vast amounts of cheap, reliable, and clean energy, attracting additional global energy investment. Today, Australia is a new player in offshore wind in the world market, with a continuous flow of projects under development.

The nation remains a major LNG exporter as its export markets undertake their own complex energy transition and increasingly switch fuel towards a gas and renewable mix. This trade has strengthened interconnectivity between Asia Pacific and the Australian east coast domestic market, but volatility of change remains a constant. The industry has focussed initially on reducing its scope 1 and 2 emissions. However, cost pressures and regulatory challenges in new gas developments and long-term demand uncertainty from pressure to reduce scope 3 emissions in export markets have substantially reduced new gas exploration. Hence the industry is increasingly focussed on zero emission sources of energy to service the next phase of the global energy transition, including the use of carbon capture and storage.

A new hydrogen economy has developed. Early pilot hydrogen projects are now proven, deployment incentives are now in place and Australia has a gigawatt scale production capacity. Existing gas infrastructure has been used for scaling hydrogen and facilitating cost competitiveness, and still servicing transitioning natural gas uses including where gas is a feedstock to other processes. Selective domestic gas networks have been converted to 10% hydrogen blend and there are hydrogen hubs expanding on Australia's east coast. Threshold choices are being made in different parts of the country to transition networks to zero emissions gas or fully electrify. Hydrogen is also starting to be used in hard to abate sectors such as industrial processing, the steel and aluminium industries and heavy vehicle haulage.

Growing hydrogen demand means more purpose-built hydrogen infrastructure to support both the domestic and export markets. Demand is also being sustained by widespread fiscal and regulatory incentives. By 2030, the distinctions of blue and green for hydrogen are all but gone, as it is largely produced using zero emission methods. Australia is now expected to become the dominant exporter of hydrogen to Asia over the next 20 years (2030-2050).

The acceleration of renewable power generation, and the demise of coal, has made synchronous condensers, grid forming batteries and hydrogen ready gas plants more important to maintain grid reliability and resilience. While this continues to provide some revenue to incumbent thermal power plants, the rapid decarbonisation and innovation of the energy system is providing cheaper lower carbon alternatives - the end of all high emission thermal power generation is now in sight.

The transition to new REZs, distributed energy resources and dynamic dual flow networks required significant investments. This needed to navigate consumer requirements for a reliable and affordable energy transition and financiers' requirements for investable markets. This level of investment saw the government interventions in energy projects during the early 2020s continue into the 2030s, particularly where new decarbonisation technologies are being deployed.

2. ESG and the Transformation Agenda

ESG has been incorporated in core business strategy. Laggards will be starved from capital investments.

The entire energy value chain has been overhauled and reconfigured.

Electrification and low emissions transportation is transforming whole cities and industries.

Maintaining a social license in this energy transition is a major focus of organisations. In 2030, Australian companies are required by law to report on ESG targets while businesses without tangible achievements in reducing their carbon footprint are being starved of new funding from investors and external markets. Business success now depends on ESG themes from 2021 - understanding and meeting the demands of consumers and investors and anticipating and implementing policy changes. Australia is not at net zero, but significant progress is being made.

The energy ecosystem has become more complex and distributed. There are more players than ever before, including new and adjacent industry entrants, and incumbents are transforming to stay competitive. Most energy and mining companies have moved into wind, solar and hydrogen while whole new sectors of consumer co-operatives, electric and hydrogen vehicle players and new building and storage companies are emerging. Being organisationally agile and adapting business models to seize new market opportunities is now crucial as the nature of investments, mergers, divestments, and service offerings has fundamentally changed.

The COVID-19 pandemic from earlier in the decade put considerable strain on global supply chains which has been exacerbated by the energy transition. The surge in demand for critical minerals and raw materials means that demand now outstrips supply. As the medium-term outlook for carbon intensive gas demand declines, the LNG export industry, supported by the Australian Government, is heavily investing in Carbon Capture and Storage technology. It is also actively developing industrial scale hydrogen export projects, leveraging its long-standing trading and supply chain relationships.

Reducing renewable energy industry waste has become important for all companies. The solar and battery industries have implemented domestic recycling schemes, like mobile phone recycling schemes of the last few decades. Water waste is also high on corporate agendas, as climate change continues to disrupt weather patterns. Even though water consumption in some renewable technologies like hydrogen is still low compared to other industry sectors like agriculture, rapid hydrogen industry growth has brought water usage, particularly in hot countries like Australia, into sharp focus.

By 2030, Australia has a stronger green mobility pathway driven by clearer policy and regulation mechanisms. Infrastructure has now mostly adapted to support Electric Vehicles (EV's) following discussions earlier in the decade with the Original Equipment Manufacturers (OEMs) to ensure a broader range of EV options. These include such measures as the cessation of all production and purchases of new internal combustion engine vehicles, standards ensuring minimal waste (such as EV batteries) and more consistent road pricing mechanisms to reduce the number of older vehicles in use.

The greening of Australia's public and heavier vehicle fleets has been a notable success. Most buses are now electric while large vehicle technology has improved the fleet. New infrastructure and the better range and power-to-weight benefits of heavier vehicles means that the transition to hydrogen fuel cells in haulage and mining fleets becoming electric and/or hydrogen powered is well underway.

3. Data – the Fuel Behind New Energy

The availability of data and artificial intelligence has increased demand flexibility and energy efficiency; protecting the consumer is paramount.

Cyber security is a priority investment focus to future proof the new energy system.

Digital verification and tracking of energy and emissions has become standard in global trade.

The hallmark of the new energy system is greater electrification and more distributed energy - generated via millions of solar panels and wind turbines all connected to the grid through inverters. The system is more intelligent and integrated and creates huge amounts of data. Energy usage is more efficient as it is better managed through automation - controlling millions of devices in customers' homes (with consent) - including household batteries, electric vehicle chargers, electric hot water systems, air conditioners and heaters.

Machine learning and other AI technologies are influencing energy consumption behaviours through greater grid flexibility. This means it is now fully optimised and operates with increased demand response, capacity, efficiency, and storage. Deriving further insights from this more integrated system, companies can better control costs while offering cheaper and more relevant services for their customers.

The changes in the market are also creating opportunities for new energy and technology industry players. The enhanced real-time visibility of the energy system, and the accessibility of information via online "platforms", has allowed new entrants to challenge incumbents in all business segments, blurring the boundaries between networks, retailers, and other service providers. In Australia, as elsewhere, the sheer volume of personal data, driven by smart devices, online platforms and IoT, has led to increased application of regulations such as Consumer Data Right (CDR) and General Data Protection Regulation (GDPR), giving consumers control of their own data and who they share it with.

Trust is now a key differentiator for energy companies - protecting customer data and privacy and ensuring they are receiving the fairest energy services and prices are all non-negotiable. Customers have higher expectations - not only around how sustainable their energy is but also its value and flexibility. Companies doing this well are employing AI to clean up and analyse massive amounts of data and utilising it to better understand and serve their customers. They are differentiating themselves through efficient and cost-effective energy services as well as greater personalisation of their services.

By 2030, cyber security has become a key focus area for de-risking and future proofing the energy system. Largely driven by geopolitical concerns around the activities of nation states, the transition to net zero and the growing digitisation of the energy system, investment in cyber security has risen dramatically. In 2030, cyber-attacks are very common in an energy system which has end-to-end connectivity, is more automated and has full cloud capabilities. There are considerable global tensions as cyber threats grow in scale and complexity. Networks have had to invest in redundancy to boost resilience.

This energy system is not only more complex but more transparent. The digital verification and the tracking of the source of energy and emissions is standard for domestic and international trade. There is strong demand for certified zero emissions products, with AI and blockchain technology helping to classify which products are sustainable and low carbon. As the digitisation of the energy supply chain expands, a growth industry is developing around the sourcing and tracking of commodities. Companies able to validate their energy as green and those who have created a transparent and integral supply chain compliant with ESG commitments are capturing a greater share of new energy demand.

4. People and Talent – the Energy Battle Ground

The energy industry is facing a talent crisis for contemporary energy and technology skills.

The data driven energy system is seeing a rise in demand for data management and AI skills; data is also driving more leadership decisions.

Increasing uncertainties around the pandemic and climate change mean operational resilience is crucial.

During the decade leading up to 2030, the way in which organisations approached talent management had to change along with the energy system. As the application of AI proliferated and the sector became more automated, demand for both office and field workers declined. Successful organisations who protected and created jobs by cross and up-skilling employees so they could transition into other parts of their businesses were able to maintain their social license to operate.

This changing way of working is having longer term impacts. As hybrid and remote working became common practice, leaders have had to adapt their management style and make use of different techniques and channels to maintain engagement with their teams. It has also transformed cities and suburbs into quieter and busier places respectively. Commuter and air travel growth, particularly for business use, is on a lower trajectory, with the pandemic and net zero commitments reinforcing a growing social norm of video conferencing and staycations.

There is newfound collaboration between governments, industry, and academia, primarily based on the employment impact of the energy transition. In Australia, many companies have made widespread operational changes such as bringing offshore customer service jobs and select supply chains home, while many of the technical skills learnt in the traditional energy sector have been transferred or adapted to the decarbonised energy sector via targeted training initiatives with varying levels of success.

Energy companies have had to transform themselves into data management experts. The shortage of data and AI skills, already evident earlier in the decade, is increasing due to high demand across all industries. Leaders have invested to build data and AI skills into existing and new roles, while data driven insights underpin most C-suite decision making. This data heavy energy industry has created demand for data business partners or "translators" who liaise between leadership, operations, product, customer service and technology groups, changing mindsets and behaviours to create more data driven business outcomes. As leaders better understand the problems data can solve, risk management is also improving.

The war for contemporary infrastructure and technology talent is acute. Boomers with decades of engineering skills have retired. New role creation is centred around the massive expansion of the zero-emissions energy sector - infrastructure associated with renewable energy zones, new energy networks and the decommissioning and repurposing of existing infrastructure. Industry focus continues to develop in the areas of carbon capture and sequestration, hydrogen, energy storage and ancillary products and services. Organisations in these sectors are finding their commitment to net zero is enabling them to better attract and retain their workforces. Companies that failed to take talent management seriously have been left behind.

The digitalisation of the energy system is also supporting a more people centred approach. Companies are now fully understanding the enhanced value coming from diversity and are using a more diverse workforce to orchestrate alliances in the broader energy ecosystem. Technology is also improving Health Safety and Environmental initiatives (HSE) with automation, AR/VR and digital twin simulations enabling safer working environments through faster, more accessible and cost-effective training.

In 2030, the key to business survival and success in the energy world is organisational resilience. Climate change and the geopolitics of new energy are intensifying the unpredictable environment, adding another layer of tension to those already there including challenges following the global pandemic. HSE initiatives now routinely include mental health as supporting the workforce through the many uncertainties in 2030 is now a priority.

5. The 2030 Policy Agenda and Geopolitical Landscape

In an evolving geopolitical landscape, the race to decarbonise is amplifying uncertainties.

Net zero is a bipartisan issue; the urgency of acting to mitigate the impact of climate change has accelerated policy making.

Governments have reinforced policies to protect consumers and communities.

By 2030, the race to decarbonisation is reshaping the global power map. The geopolitics of energy is transforming as demand for the critical minerals needed for cleaner energy grows. However, countries are pursuing decarbonisation agendas at different speeds, resulting in a proliferation of ad hoc policies.

Australia, today, plays a key part in the energy transition as it has some of the world's largest resources of the commodities and critical minerals needed for this energy transition. Cobalt, nickel, lithium and rare earths all make up a bigger part of Australian exports today, along with its more traditional commodities like iron ore, copper, gold and metallurgical coal.

In this radically different geopolitical landscape defined by the rise in unilateralism, trade and investment policy have become political tools for pursuing national strategic interests, creating an era of global mistrust. Tensions are appearing all over the world as countries not only seek critical minerals to meet new renewable energy demand but are also imposing tariffs and regulations on fossil fuel imports and less sustainable goods. Australia has had to respond to these risks. Legal action regarding Scope 3 emissions and unsustainable consumer products is now common and is reinforcing policy and investment drivers for change. Increasingly, trade routes are being redefined and prioritised by their level of transparency and how green the products are in their supply chains.

The speed of change has seen the energy system becoming increasingly unreliable and unstable, requiring significant regulatory change and government intervention. In Australia, transitional mechanisms have also been put in place to ensure that its regions are supported and thriving in the transition. There is also a strong focus on ensuring this energy transition is democratic - that everyone benefits, and no community is left behind. Communities have been at the heart of the energy changes; today there are millions of Australian citizens who own and manage their own power generation and storage systems (including EVs). This energy transformation feels more inclusive, not only because the consumer is at the heart of it, but because energy is more readily available, cheaper, and more efficient.

Changing societal expectations have been crucial in the transition. Whilst consumers and communities have demanded clean, reliable, and cheap energy this also came with physical siting issues and complexities with community consultation. Governments retained strong regulatory oversight over energy prices and have introduced stricter protection measures for the more vulnerable. The transition has caused some assets to be stranded and new opportunities created.

In Australia, areas dependant on more traditional energy sector employment are being supported through the transition; higher investment in education, upskilling in low emissions technologies and repurposing of brownfield sites are all playing a significant part. Green initiatives such as energy rebates, no interest loans for high energy efficient properties, minimum rented property energy efficiency standards and retrofitting inefficient household energy systems are also creating a more inclusive transition.

6. Beyond Net Zero – the Push for the Greenest Energy

Technology focus is positioned around emissions reduction and clean energy.

"Green investment" is now known as simply "investment."

The decarbonisation action is now with hard-to-abate sectors.

By 2030, there has been an upsurge of carbon positive technologies with the focus firmly on an accelerated path to zero emissions. These new technologies are supporting the development and growth of sectors such as energy services, electric vehicles, hydrogen, big storage/batteries and carbon capture and sequestration.

The natural gas industry is changing fast as it services the energy transition in Asia, replacing coal, and develops alternative ways of exporting low emissions energy molecules. Industrial heating and processing, and domestic heating in the cooler regions are in the process of moving to zero emissions gas and electrification. All new gas plants are being built to be hydrogen ready. Governments have co-invested significantly with the private sector in the development of major energy hubs and precincts to both de-risk and decarbonise the energy system.

The surge in new energy technology is being supported by the investment community. By 2030, "green investment" has simply become "investment" as investors and shareholders prioritise ESG agendas. The consumer of 2030 has no time for companies that are not meeting net-zero objectives. Those industries not contributing to greater sustainability and the hard to abate sectors not cleaning up faster, are under immense consumer and investor pressure to do so; otherwise, they will have become uninvestable and uninsurable. They are already suffering from reputational damage and are losing the trust of both their customers and employees. Legal actions regarding the impacts of climate change are now common following several landmark cases in the early 2020's; governments and companies must now legally protect the younger generation from the impact of climate change and not expand fossil fuel use.

What was considered "energy activism" in 2020 is now, in 2030, mainstream due to the influence from climate legal cases. It is seen as fundamental to sustaining pressure on governments and organisations alike. The major shift towards more sustainable living being driven by aging millennials is often supported by activist organisations acting as the consumer voice.

For those organisations who have not achieved net-zero by 2030, realising it over the next decade will require greater downstream integration. Technology and innovation will continue to drive the different pathways that have emerged, electrifying and hydrogenising whole sectors - even those which are hard to decarbonise such as aviation, maritime, industrial processing, and heavy industries. For leading organisations, a new north star is emerging. They are already looking beyond being carbon neutral and aspiring to becoming carbon negative. They want to pay back their carbon debt and contribute to global action to combat climate change.

What seemed like a major task in the early 2020s is today seen as a common purpose.

"The journey of 'decentralisation, decarbonisation, and digitalisation' that the electricity network went through years ago has now transformed the gas system."

BEN WILSON

CHIEF EXECUTIVE OFFICER
AUSTRALIAN GAS INFRASTRUCTURE GROUP

Alan Yu

CHIEF EXECUTIVE OFFICER

LAVO

"For any sort of new energy ecosystem or hydrogen economy, we need both blue and green hydrogen.."

As we build the hydrogen ecosystem, both blue hydrogen and green hydrogen are playing important roles to reduce carbon. Traditionally, the most common form of hydrogen has been grey hydrogen, which is produced from fossil fuels, predominantly gas. Over the past decade, there has been growth in both blue hydrogen - produced from fossil fuels, however the carbon is captured - and green hydrogen - which uses renewable electricity like wind or solar to power the electrolysis. Blue hydrogen had traditionally been cheaper than green hydrogen but today in 2030, green has become much more cost competitive - not only due to cheaper renewable power used in the electrolysis, but also cost reductions in key components like the electrolysers and fuel cells.

Energy storage plays a critical role in making renewable energy more reliable and affordable. Green energy storage is not limited to only one solution and hydrogen storage has become very much part of the mix. While the most common form of renewable energy storage relies on lithium batteries, which support the intermittency of solar and wind power generation, they have limitations. Key to these limits are the lifespan and duration of the batteries, their performance degradation over time and end of life disposal. Hydrogen, however, can provide significant storage volume without compromising or deteriorating energy over time, increasing its cost competitiveness when combined with lithium batteries.

Emission-free mobility today combines both electric and hydrogen powered vehicles - both have important roles in this transition. While electric vehicles have dominated the evolution of the greener mobility market up to 2030, hydrogen is now catching up. It has several advantages - real potential for the hard-to-abate heavy transport sectors such as trucking and shipping where electric solutions are less viable - as well faster charge times.

Also, hydrogen powered bikes and cargo bikes[1] are playing a crucial role in developing emission free transportation. With trucks increasingly being banned from city centres all over the world, hydrogen cargo bikes are the future of the online delivery market. A cargo bike - used for much longer distance deliveries such as food or parcel delivery - it can even use its hydrogen fuel cell as a heater or a fridge to keep the food or items being delivered, warm or cold.

This new hydrogen economy has created its own energy ecosystem for Australia and accelerated its journey toward net zero. Australia is always well positioned to capitalise on the hydrogen economy as it has unique and rich resources - sunshine, wind, an abundance of land and minerals - enabling it to become a hydrogen superpower country. We are now exploring the opportunity to export hydrogen to the rest of the world. This progress needs to be facilitated by Australia implementing a federal, long term energy transition strategy encompassing very transparent emissions reduction targets - this is critical for the hydrogen sector as it provides investors with clear direction about the investment environment.

Companies could not achieve these stricter decarbonisation targets alone and partnerships have been key to their success - accelerating the decarbonisation journey and allowing the hydrogen economy to take off. The 2030 net zero target required all stakeholders in the energy value chain to work faster and more collaboratively and companies have not only started working with the big energy companies, but public and private companies are now working more closely together.

Our company, LAVO, had already incorporated ESG principles as part of our investment and product development mandate. Today, we are looking to take the ESG framework to the next level - a hydrogen circular economy.

We want a future where people develop energy assets not only looking at the carbon footprint, but also at areas like the availability of critical materials and water consumption.

New technologies such as the Internet of Things and artificial intelligence are also critical. LAVO is now developing new software and centralised control systems which can incorporate these digital technologies. Our integrated portal now allows us to both work with many more stakeholders while optimising our decision-making processes. Earlier this decade, the COVID-19 crisis became an opportunity to accelerate digital transformation; today the energy transition is another. Blue hydrogen, green hydrogen - regardless of the colour, the future is certainly becoming a lot brighter.

Alan Yu is the Co-founder and Chief Investment Officer of Providence Asset Group, an Australian leading ESG investment firm and the Chief Executive Officer of LAVO. Prior to founding the Providence Asset Group, Alan held executive roles at the Commonwealth Bank of Australia and the Westpac Group.

In 2018, Alan co-founded YOZO, an Australian Fintech small business lending company. And in the past 4 years, Alan has founded and invested in a series of clean tech companies, demonstrating his strong commitment towards sustainability and circular economy.

Alan has executed complex transactions across broad industry segments with specialised investment expertise in technology, innovation and renewable energy assets. He has proven experience in assisting companies with their growth strategies through capital raising, trade acquisitions and pre-IPO processes.

1 A cargo bike is designed for carrying heavy or bulky loads, or several passengers, including children. They can come in either two-wheeled, three-wheeled, or four-wheeled form, with or without e-assistance or powered by hydrogen fuel cells.

Alba Ruiz Leon

MANAGING DIRECTOR

CORNWALL INSIGHT

"Regulation is still playing catch up with the energy transition."

WHAT IS THE ENERGY MIX IN 2030 IN AUSTRALIA, AND HOW DOES THIS COMPARE TO WHAT WAS ANTICIPATED NINE YEARS AGO?

Back in 2021, the energy transition saw renewables taking over from gas and coal-fired power plants. However, there was still a need to build out the network - and by that, I mean connecting the renewable energy sources now distributed across the country to where the demand is located. Today in 2030, we have made good progress in some areas like pumped hydro schemes, battery storage, grid performing inverters which have stabilised and firmed up supply improving system strength and network security. But the energy network still lacks sufficient capacity in certain areas. We need to create more integrated renewable energy zones to replace fossil fuel power plants. Hydrogen has also made progress, and its development continues to attract significant interest from both industry and government.

HOW HAS THE AUSTRALIAN ENERGY SECTOR TRANSITIONED TOWARDS NET-ZERO CARBON EMISSIONS WHILE MAINTAINING SYSTEM STRENGTH, RELIABILITY, AND FLEXIBILITY?

Australia accelerated its energy transition by creating a more coordinated environment. This has facilitated partnerships between governments, regulators and energy providers and incentivised new entrants, which has led to a more diverse range of energy resource schemes and help foster a healthy and competitive energy market.

As a result, each eastern coast state and territory in Australia has achieved their 2030 renewable target of around 50% renewables energy generation or more.

It has not been an easy journey. We started an energy transition without the right policies and regulatory framework in place. The federal government needed to be more involved much earlier and align with the state targets and progress. The lack of coordinated government policies has undermined the confidence of some private sector investors during the early 2020s. As a result, we have seen some investment drifting away from Australia due to the lack of early federal direction, and the market complexities of adding renewables to the grid.

Paradoxically, Australia underwent the renewable energy transition faster than most other countries. However, the system and the policies that govern it were still trying to catch up during early 2020. During these early days, whilst in the midst of the energy transition, we saw system strength issues, networks upgrades and battery storage be rushed up, synchronous condensers installed to mitigate system strength and inertia shortfall, negative pricing, marginal loss factors (MLF) worsening up, etc. Of course, the rush of decommissioning old and obsolete power stations, mostly in Victoria (VIC), New South Wales (NSW) and Queensland (QLD), had to accelerate this change and uptake of quick solutions within just a decade.

WHAT ROLE HAS THE CONSUMER PLAYED IN THIS ENERGY TRANSITION?

The consumer wants cheaper and greener energy. Over the past few decades, this has driven significant uptake in rooftop PV and the rise of distributed battery use. This preference towards renewables has also led to many businesses signing power purchase agreements for renewable assets, which has supported the green transition at a grid level.

Distributed energy resources (DER) integration is part of the new age solution. We need to raise consumer awareness of what is necessary to make the power market work more efficiently, reliably and cheaply. This includes reducing the cost of consumer participation in the wider market, simplifying the complexity of compliance, and making it easier for them to participate more actively in day-to-day market operations. For example, back in 2021, several trials were already underway by some utilities to capture the vast potential of distributed consumer solar resources through a 'Virtual Power Plant'. These trials showed that utilities could manage minimum demand conditions by increasing supply nearly 5 MW by using such aggregated DER[1].

WHAT HAVE BEEN THE BIGGEST DEVELOPMENTS IN ENERGY SECTOR FROM A DATA PERSPECTIVE OVER THE PAST DECADE TO 2030?

Large corporations use the energy market data and insights to assess risks and opportunities better and distinguish where to invest. For example, these days, you would not commit to a large-scale project without using 30 years good Power Curve Forecast Model for the life of the plant where you can quickly identify both; total revenue over the life cycle and return of investment. Cornwall Insight Australia has these tools and we use them to do project due diligence for our clients.

Data gathering has also helped smaller DER resources into the virtual power plants as it allows them to participate in the central dispatch process directly. This has been an important step towards integrating small scale and behind meter resources, which in aggregate is the largest "generator" in the market.

Not to forget that data has also benefited consumers to become more self-aware; they now know when it's more cost-effective to run their appliances, and so they can now manage their energy use more efficiently. Like investors, they just needed the right tools and environment to unlock the potential of renewable energy.

Alba Ruiz Leon holds the responsibility of Cornwall Insight's Australian business, supporting the company's growth in Australia since January 2020. Alba has over 15 years of energy market experience, including more than 12 years of practical exposure in the APAC region.

Alba's recent experience includes projects such as constructing and operating the largest Australian solar farm 2018-19, Limondale 349 MWp in NSW, liaising with the EPC and O&M groups as well as other suppliers. Other career milestones include managing the operations, maintenance and production teams for ACCIONA oversighting the largest wind farm in the southern hemisphere, at the time, as well as support building and operating other large wind farms in NSW and SA.

1 DER – generally defined as distributed energy resources, which comes from small-scale units of local generation, typically rooftop solar or small wind turbines connected to the grid at the distribution level.

Alexandra Clunies-Ross

PORTFOLIO MANAGER

ARTESIAN

"Capital targets green energy... not fossil fuels."

Over the last decade, there has been a major shift in capital allocation from fossil fuels to green energy, whether it's renewables, energy efficiency or energy storage – all investments now have a green element to them. The first point to note is that in 2030 we are no longer calling investments "green", we just call them "investments". There are no large-scale investors in pure fossil fuels or in companies who are not moving into carbon neutrality.

Not only are such investments larger, but we are seeing the importance of investing in green research and technology at an early stage, which is enabling this global transition to net zero emissions. So, now in 2030, climate technology is one of the largest investment trends for venture capital, private equity and research.

A major innovation in the energy market over this period has been in energy storage to improve grid stability by increasing the energy density and reducing cost of batteries. This has enabled greater renewable energy use and has facilitated a more distributed and decentralised power system, as more households moved to solar and wind powered generation. We have had numerous storage developments including lithium-ion batteries, solid-state batteries and hydrogen to store excess renewable energy.

The energy supply chain has been redrawn. Instead of manufacturing energy the way we once did - producing fossil fuels and then transporting them to the centres of demand - we now generate renewable energy on site, store it on site, and often use it on site, for example to charge our electric vehicles or to create steel. These more modular solutions for energy are a real innovation and are proving to be a game changer for heavy industry: for example, generating hydrogen on site, rather than transporting it from another location, is much cheaper.

This transformation has been facilitated by clean technology start-ups. Some have been scaling their technologies and are taking the place of the incumbents that have stood still over the last decade. Others have formed partnerships with the incumbents who wanted to change and generate new business lines. The rest have simply been acquired by incumbents.

As a result, new business models are emerging. I would highlight those around hardware-as-a-service and decentralised energy software-as-a-service; they are enabling the sharing of different types of energy technologies to reduce wastage and improve efficiency. Today in city centres there is widespread sharing in the electric vehicle ecosystem. So underneath large buildings, instead of parking your own car, you might share an electric car and the means to charge it; and it's the same with electric bikes, whose usage has continued to grow through 2030. We are seeing the sharing of large-scale battery systems, which has created an energy system not controlled by one utility or retailer, but rather by the individual or the community.

Today, people are also better at embracing new energy technologies. Back in 2020, due to COVID-19, we saw mass adoption of many new healthcare tools and technologies; now we are seeing something similar in energy, as consumers better understand the impact of climate change. As households have become connected to their own energy supply, they understand how much energy they are using, when they need to charge their battery and when it's most efficient to deploy that energy. Part of that understanding comes from a better breakdown of energy bills to show them where the energy is coming from and how much of it is renewable or from having their own energy system through solar on their roof and batteries. Consumers have been more willing to adapt to and adopt the "new" to ensure

Alexandra Clunies-Ross is part of the Investment team at Artesian, the most active early-stage venture capital fund in Australia, which now manages +$400m. Alexandra leads Artesian's ClimateTech VC investment activities and is a Portfolio Manager for Artesian's Clean Energy Seed Fund. Alexandra is a startup Board member and a member of the expert panel for the Cleantech Group, which releases an annual list of 50 climate startups to watch. Prior to her work at Artesian, Alexandra was part of SkyNews' digital team. Alexandra has a Bachelor of Commerce from USyd and a Master of Business Law from UNSW.

that they're doing their part - they have more trust in technology. Now, we not only have a greener and, in most cases, a cheaper, energy system - but one which is decentralised and digitised as well.

All of this means that companies have had to rebalance their focus to address stakeholder management as consumers better understand their own energy needs. The private sector has moved towards sustainability because their main stakeholder - the individual - has demanded it. Companies with less green credentials have been left behind.

In fact, I would say that over the last nine years, it has been millennials who have really driven this shift. So, if a company has not thought about the importance of sustainability, then they're at risk, not only due to policy and regulatory changes but because people will not buy their product. Many companies are now increasing pressure on themselves and bringing their carbon neutral targets forward in response to the demands from these stakeholders. In summary, we still have a long way to go to limit global warming, but technology has enabled greater use of renewable energy through cost reduction and new innovations.

Angus Taylor

MINISTER FOR ENERGY AND EMISSIONS REDUCTION

AUSTRALIAN GOVERNMENT

"Australia has led the way in showing the world that a growing economy can decarbonise..."

WHAT DOES THE AUSTRALIAN ENERGY LANDSCAPE LOOK LIKE IN 2030?

Australia's energy and natural resources sectors have evolved and reduced emissions much faster than we expected a decade ago. The extraordinary uptake of renewables, particularly household solar, towards the end of the 2010s, has been matched by huge growth in the 2020s of a range of new low emissions energy technologies. Energy sources, like hydrogen, are becoming more competitive with existing technologies - driving down emissions and producing affordable, reliable energy. Both blue hydrogen (produced from sequestered natural gas) and green hydrogen (made from electrolysis using renewable energy) are allowing us to reduce emissions in hard to abate sectors. As a platform technology, hydrogen's impact is widespread across multiple industries and sectors of the economy. Hydrogen is now feeding into many sectors - transportation, industry, power generation and agriculture - and using hydrogen vehicles is rapidly increasing in these industries. Australia's success in these sectors has all been driven by a focus on the customer.

WHAT HAS BEEN THE IMPACT OF THE ENERGY TRANSITION ON AUSTRALIA'S REGIONS AND CITIES?

Australia's regions are thriving. Traditionally export focused areas like Gladstone, the Hunter, Latrobe Valleys, the Whyalla, the Pilbara, the Northern Territory and northern Tasmania have all continued to strengthen their export positions by expanding into new opportunities like producing hydrogen and low emissions metals. Australia is continuing to supply customer countries like Japan, Korea, Singapore and Vietnam with reliable and affordable energy, resources and minerals products.
The Australian agricultural sector has been a notable green energy success story. Nitrogen fertiliser supports the food industry - it feeds millions of people every day - and much of it is now produced from clean hydrogen, supporting the reduction of agricultural emissions. The energy transition has also resulted in significant changes in land management in many regions. Soil is an extraordinary carbon sink and making it a better one - through healthier soil - is important. The lessons learnt in better soil management and the reduction of agricultural emissions means that today, Australian farmers are not only more productive, but the soil is more effective at storing carbon, and Australia's soils are, generally, much healthier.

Hydrogen has long been a priority low emissions technology for Australia - producing clean hydrogen under $2 per kilogram (kg) has been a stretch goal under its Low Emissions Technology Statement since the start of the decade. Battery powered electric vehicles play a big role in cities, but hydrogen is the fuel being used for long range transport and in trucks and other heavy vehicles. Growing hydrogen consumption in heavy industry - the mining industry, for example, has been an early adopter of hydrogen fuel, as it was of greater automation - along with a fall in the cost of hydrogen production and ongoing technology improvements means the $2/kg goal is much nearer today in 2030. Hydrogen has contributed to making heavier industries in Australia both cleaner and more energy efficient.

In Australia's cities and suburbs, household solar was already moving at breakneck pace in previous decades and has continued to gain ground. Huge amounts of household solar have been added to the grid and additional storage from household batteries and electric vehicles, and improved regulation and digital technology, have provided for a more balanced power network. In 2030, the energy network is a combination of grid scale generation and storage, along with this more distributed power generation. For them to work in harmony, recognition of the role of dispatchability in the electricity grid and the shift to a capacity mechanism was needed. Reforms in the early 2020's made a big difference and achieved balance between intermittency and dispatchability, making the network not only more sustainable but more reliable too.

Prior to entering politics in 2013 when he was elected as the Liberal Federal Member for Hume in New South Wales, The Hon. Angus Taylor MP was a Director at Port Jackson Partners and a partner at McKinsey & Co.

Minister Taylor was promoted to Assistant Minister to the Prime Minister with special responsibility for Cities and Digital Transformation and reappointed to the frontbench after the 2016 Federal election and became Minister for Law Enforcement and Cyber Security.

Minister Taylor was promoted to Cabinet as the Minister for Energy in August 2018 and reappointed as the Minister for Energy and Emissions Reduction in May 2019.

With a passion for cutting edge technology, Minister Taylor authored an essay The Promise of Digital Government which was published by the Menzies Research Centre in 2016.

Minister Taylor has a Bachelor of Economics (First Class Honours and University Medal) and a Bachelor of Laws (Honours) from the University of Sydney. He also has a Master of Philosophy in Economics from Oxford, where he studied as a Rhodes Scholar. His thesis was in the field of competition policy.

IS AUSTRALIA THRIVING IN THE INTERNATIONAL ENERGY INDUSTRY COMMUNITY IN 2030?

Australia is leading the way in the energy transition because it knows how to do it - it has been a world leader for centuries in industries like agriculture and mining. The developing and developed world needs new energy technologies to fully decarbonise. What Australia is showing the rest of the world is that you do not have to make trade-offs between economic growth and making industry greener and more sustainable - you need to find the right technologies to scale. Australia today plays a unique global role in the development and export of new energy technologies, moving them towards being commercial, and making products and services the world needs to reduce emissions without substantially raising costs. Many new energy technologies, such as hydrogen, stored carbon, carbon capture and storage, support Australia's economy today - it has led the way in showing that a growing economy can decarbonise.

Audrey Zibelman

VICE PRESIDENT

X, THE MOONSHOT FACTORY

Audrey Zibelman leads X's moonshot for the electric grid. Her team is developing new computational tools to enable the rapid and cost effective decarbonisation of the electrical grid.

Audrey has spent over three decades leading organisations (having previously worked at the Australian Energy Market Operator, PJM, Xcel Energy, founder and CEO of Viridity Energy and was the Chair of the New York Public Service Commission) with the goal of making power cleaner, more affordable and more reliable. She is an international expert in power system transformation, regulation, markets and operations. She's also been a utility executive, regulator, system operator and entrepreneur.

When she's not working, she's hiking the hills of San Francisco, playing tennis with her husband Bruce, or spending time with their children and grandchildren.

"In this energy transition, the innovation has been in consumer services as opposed to investment in supply..."

WHAT HAVE BEEN THE BIGGEST TRANSFORMATIONS TO THE ENERGY SYSTEM OVER THE PAST DECADE?

The biggest change has been in the use of technology at more affordable costs to make the whole energy system much more efficient, which has enabled a more cost-effective decarbonisation of the grid. A decade ago, the grid was dominated by large scale resources and demand was static - the most efficient utilities were meeting large volumes of predictable industrial demand. As we retired older units and replaced them with wind and solar generation, and more and more batteries, electric vehicles and other forms of longer duration storage come online, the system not only became more distributed but also less predictable.

When we realised that we could use technology to better harness resources like electric vehicles (EVs), batteries and internet-connected appliances to optimise the grid, it opened the door for industry innovators. They have since been able to seize the opportunity to create greater system automation, allowing more precise decision making and widespread efficiencies.

Today the grid operates with large-scale power systems and billions of devices, like EV's or HVAC, which connect to it through inverters. Using technologies like the cloud, artificial intelligence and machine learning, we have been able to put more automation in, building system efficiency and predictability. Now, we are not only paying less for our renewable energy resources supplying our

electricity, but utility service providers – through the consensual management of devices such as charging EVs during the night, when wind is available, and demand is low – can manage that demand much more efficiently. As a result, innovation has been more services focused – supporting consumers to maximise demand patterns for the best cost and efficiency gains - rather than supply side focused. This network autonomy, automation, and ability to remotely manage devices means the energy system has become more intelligent.

This intelligence gives us more confidence to solve further inefficiencies right at the system edge. Without it, any decarbonisation of the grid would never have worked as well as it does today.

WHAT DOES THE 2030 ENERGY MARKET LOOK LIKE FROM THE PERSPECTIVE OF ENERGY INCUMBENTS AND OTHER SERVICE PROVIDERS?

We imagine a world and are now advancing one where, IT, AI and machine learning have transformed the operating environment such that all players have access to the full system operating information in real-time.

We are still seeing experimentation in how to make this market perform best. We have not yet resolved whether the network and gentailers are best placed to move into other services, building on their incumbent position operating the system, or a whole range of aggregators have effectively provided the full range of energy services.

This market won't automatically emerge. Markets are ineffective at this kind of transformation because of all the uncertainties and the difficult risk/ reward trade-offs. In a future world where it is understood how this new operating environment works, companies can start layering services on top of existing offerings, rather than moving straight to new markets.

In 2030, like in 2021, the market still has incumbent utilities with access to customers and other assets in a strong place, but the survivors have reinvented themselves into true service companies, building on strong customer information and existing relationships. These companies drove greater efficiency in the grid and had the advantage of implementing storage at scale. Up to now, this has worked as the best business model from the consumer perspective, but this is in the process of changing. For example, with customer information becoming more ubiquitous, we are seeing consumer retailers or other new entrants challenging for market share.

HOW IMPORTANT HAS TECHNOLOGY BEEN IN DEVELOPING THE NEW ENERGY SYSTEM IN 2030?

Technology has been fundamental to market development during this energy transition. It has transformed our ability to forecast demand changes and predict system disruptions. Even in the last decade, we were at the point where power systems could be virtualised and we were creating digital twins. Since then, the power of simulation technology has allowed us to better anticipate events and resolve them - creating a single source of truth for decision making.

As our natural resources like wind and solar are dependent on the weather, and became our dominant source of power generation, climate change and cloud cover became central to managing its complexity, technology has allowed us to not only run the system more efficiently but forecast its behaviour more accurately. It's been a massive game changer – we're able to understand the nature of the issue, have innovators help solve it, while being very comfortable that we are making strategic operational decisions.

As energy technology becomes more fast paced and interoperable, Australian policy makers have had to take a new interest in product standards. This allows new energy products and services to plug and play more easily, allowing more rapid innovation, driving down costs for the consumer.

WHAT CULTURAL CHANGES DO YOU THINK ENERGY MARKET PARTICIPANTS NEED TO EMPLOY TO BE ABLE TO DEAL WITH THIS PERIOD OF RAPID CHANGE?

In the past, policy and compensation incentives have constructed the energy industry to be one with a lot of long-lived technologies, generally meaning it does not prioritise the implementation of new technology or new design considerations well and is often dealing with legacy system issues. By 2030, energy companies and utilities have developed a better willingness and ability to take on greater technology risk. They have alleviated some of this risk by developing deeper technology partnerships and collaborations - so they do no longer need to go it alone. We've seen the success of this approach in other sectors, particularly the airline and financial services industries.

Energy regulators too, have become more comfortable with risk and allowed for more R&D experimentation. This is a period of great change in our energy system, and it means that a lot of things will not work out the way people might anticipate; allowing time for learning and sharing and not penalising companies for failures is important.

But perhaps the biggest change has been with policy makers. In 2030 energy and climate policy is no longer a cultural or tribal signifier, so it has become less political with everyone rowing in the same direction for a decarbonised, efficient, reliable, and cost-effective energy system. This has allowed policy to focus much more on problem solving for the issues thrown up by the rapid energy transformation which is now proceeding at pace.

Ben Wilson

CHIEF EXECUTIVE OFFICER

AUSTRALIAN GAS INFRASTRUCTURE GROUP

Ben Wilson is Chief Executive Officer of Australian Gas Infrastructure Group (AGIG), which comprises Dampier Bunbury Pipeline, Multinet Gas, and Australian Gas Networks. With a growing portfolio of operations, AGIG is one of Australia's largest energy infrastructure businesses. AGIG has over two million customers across every Australian mainland state and the Northern Territory. AGIG operates Australia's largest renewable gas production facility, Hydrogen Park South Australia, blending green hydrogen into part of the gas distribution network in Adelaide.

Ben is the Chair of Energy Networks Australia, former Chair of the ENA Gas Committee from 2015-2020, and a Member of the Ministerial Advisory Panel for the Federal Government's Technology Investment Roadmap.

Ben has a Bachelors Degree in Natural Science from Cambridge University in the UK.

"In 2030, the gas system operates more like power – decentralised, decarbonised, and digitalised."

LOOKING BACK AS WE ARE NOW IN 2030, HOW HAS THE AUSTRALIA GAS INDUSTRY AND NETWORK CHANGED?

The natural gas industry in Australia has undergone a major transition, with three major changes.

Firstly, it has experienced a decarbonisation journey which is still underway. Today all our gas networks and pipelines are delivering a mixture of natural gas and renewable gases, such as hydrogen and biogas. The traditional natural gas industry is mostly producing gas with carbon capture and sequestration (a journey which started with capturing associated CO2 at the Gorgon LNG project[1]), or producing blue hydrogen with CO2 by-product captured and stored.

Secondly it has gone from being a system which was primarily centralised to one which is more distributed. We are now seeing distinct pockets of the network which produce methane, hydrogen, and biogas blends.

Finally, the industry has had to revaluate its customer proposition and become smarter. As cheaper, more renewable energy choices grew, it had to consider a range of factors - the price proposition? the customer service proposition? the environmental proposition?

The journey of "decentralisation, decarbonisation, and digitalisation" that the electricity network went through years ago has now transformed the gas system.

WHAT ARE THE FEATURES OF THIS MORE DISTRIBUTED MODEL FOR NATURAL GAS?

The transition has required significant operational changes. Previously, the gas and power systems in Australia were not directly linked but now the two systems are much more intertwined through the growth of distributed electrolysers[2]

which produce hydrogen. They sit in the middle of the gas and electricity networks, connecting and playing off each other.

So, if the renewable supply is in surplus these electrolysers soak up the excess demand on the grid by producing hydrogen which can then be stored as energy in the network, and then used like utility scale batteries, providing system strength and peaking support for the grid during times of variable demand. If renewable supply is interrupted (when it gets cloudy or it is less windy) then the electrolysers can quickly be turned off, providing valuable interruptible demand.

AS THESE SYSTEMS BECOME MORE CONNECTED, DO YOU THINK WE NEEDED A MORE COMPREHENSIVE "ENERGY" VISION AS OPPOSED JUST A "GAS VISION" AND AN "ELECTRICITY VISION"?

There is a well-known saying that the future is already here, it is just unevenly distributed. Gas companies have had to think more about being a system operator like a power company. This is much more complex; running a real-time dynamic gas transmission and distribution system.

Previously, storage solutions for the gas and power systems were not able to support more renewable energy delivery at a larger scale. Now in 2030, we have more of a cohesive vision with this linkage between the gas and the electricity grids as the gas grid acts as a storage and a firming agent for the power grid - a giant battery.

Transportation has also facilitated the drive to a more integrated energy vision. Back in 2021, transportation was largely independent from both the electricity and the gas grid. Today, most new vehicles being sold are either battery electric vehicles (EVs) or fuel cell EVs running off hydrogen. These battery EVs are also supporting storage in the grid.

SO, THE GAS NETWORK HAS BECOME DECARBONISED AND DECENTRALISED – HOW HAS ITS DIGITISATION TRANSPIRED?

Artificial intelligence (AI) and machine learning have optimised network operations. Back in 2021, the electricity market knew much more about its customer energy behaviours than gas companies did due to the growth of smart meters. This has now changed, and we are seeing smart meter use in the gas industry. The only thing the individual consumer is lacking is smart meter choice, as Australia is still a small market.

Digitisation has however come at some cost. Back in 2021 we thought that everything smart was good, that there were certain things you couldn't get to, such as cost reduction or better customer service, without being smart. Back then, the natural gas network wasn't so smart, it was more mechanical[3].

But this also meant it was difficult to hack; it might have been a dumb network, but it was a safer network. Today we are more aware of the pros and cons of being smart including some of the risks like cyber threats.

WHAT ABOUT COSTS – HAS HYDROGEN BEEN ABLE TO COMPETE IN THE LOW CARBON ENERGY MARKET?

Today the price of hydrogen is similar to the price of wholesale gas; it has decreased due to the creation of larger and larger solar and wind projects dedicated towards producing hydrogen. Australia has commenced hydrogen exports to Asia and reservation policies are being introduced to ensure that there is sufficient domestic supply of hydrogen and renewable electricity. Hydrogen electrolysers and storage are sized to take advantage of cheaper electricity costs, so its production is more cost effective.

Also, we have seen the capital costs of the electrolysers which produce the hydrogen come down. Electrolyser gigafactories were already being built a decade ago, in places like the UK and Italy[4]. Back then, we were on the upward slope of decarbonisation - today we've finally reached the plateau.

1 Chevron's Gorgon LNG project in Western Australia was one of the first natural gas (LNG) projects to capture carbon at scale. Carbon Capture and Sequestration (CCS) is expected to reduce greenhouse gas emission from the Gorgon Project by approximately 40%, or more than 100 million tonnes over the life of the injection project.

2 An electrolyser is a device which splits water into hydrogen and oxygen using electrical energy, providing a practical way to generate a zero-carbon energy source.

3 Gas networks in 2021 were mainly operated mainly by mechanical regulators which responded to changes in pressure.

4 In 2021, ITM Power announced the construction of the largest electrolyser manufacturing facility in the world, in the UK, to provide an integrated hydrogen energy solution to use renewable energy that would otherwise be wasted. In 2019, the company Enapter opened a serial fabrication facility for modular hydrogen electrolysers in Italy, reducing manufacturing costs by 20% and increases production capacity eightfold for more affordable hydrogen generation.

Brian Janous

GENERAL MANAGER OF ENERGY & RENEWABLES

MICROSOFT

Brian Janous is responsible for leading the development and execution of Microsoft's global data centre energy strategy. His responsibilities include oversight of energy policy, procurement, renewable energy, distributed generation, and overall environmental impact to ensure that Microsoft's cloud infrastructure is reliable and sustainable.

Brian joined Microsoft in 2011 after 12 years in the energy industry where he worked as a Sr. Consultant at Brubaker & Associates, assisting Fortune 500 companies with energy procurement, policy and sustainability matters. Brian has also served on the board of the American Wind Energy Association (now the American Clean Power Association), and presently serves on the board of the Institute for Energy Studies at Western Washington University.

"The more intelligence we can build into the energy system, the more resilient it becomes."

BACK IN 2020, MICROSOFT, MADE A PLEDGE TO BECOME CARBON NEGATIVE BY 2030 - HAVE YOU MET THAT TARGET AND WHAT HAPPENED FOR YOU TO ACHIEVE IT?

We not only met the target, but we met it faster than we thought, and more importantly, helped others along the way to achieve similar goals. We made a commitment by setting a bold vision - clarifying it and making it both measurable and close enough to force immediate action. And to ensure impact beyond our own operations, we launched the Microsoft Cloud for Sustainability that was designed to help companies measure, understand and take charge of their carbon emissions, set sustainability goals and take measurable action. Microsoft's other leaders and I all accepted personal responsibility for meeting the zero-carbon goal; we knew that we could still be around in 2030 to see if it had worked, to witness the achievement, and here we are.

In the years leading to 2020, there was a massive shift in the business world regarding zero carbon commitments. Before then, few companies had given much attention to the subject, but it soon became a core priority, and this resulted in a tidal wave of companies making similar commitments. These pledges continued to outpace regulations - as governments were focused on 2040 or 2050, we were making commitments that were a decade or two ahead.

Our company's pledge triggered a wave of people within Microsoft who leaned in on the issue. We extended the scope to include not only electricity and direct emissions, but our entire supply chain - from software design to procuring components for our data centres. We met the target initially by leveraging what we already had, largely low-cost wind and solar, and accelerating what we knew worked. We executed almost six Gigawatts of net new renewables in only the first year. We also established a billion-dollar Climate Innovation Fund which has continued to grow over the last decade. In this case, what helped was that the renewable energy market is far more distributed - so you can be a smaller company and still bring innovation. Today, innovation scales faster and is easier to do than when the market was dominated by fossil fuels.

Going forward, we know we will run into challenges - particularly with intermittency issues from all the zero carbon resources we're putting on the grid. These resources must be more balanced and better integrated - this requires new software, more intelligent grid operations, greater volumes of storage and new technologies. Fortunately, we invested early in start-up companies to develop some of these

technologies we knew would be crucial for the success of this next stage of energy transition.

WHAT KINDS OF INNOVATIONS HAVE YOU DEVELOPED AS PART OF YOUR NET ZERO MISSION?

We needed to become more intelligent in terms of how we operate. Through new hardware, technology and software we've accomplished, for example, longer duration storage. In 2020, we didn't have a battery that could run cost effectively for 150 hours; it was probably more like two to four hours. To help to balance grid operations for longer durations when we lacked wind and solar generation, we have developed better batteries.

We have also created a smarter grid. A decade ago, there was a lot of talk about smart grids, but really there was nothing smart about them. We couldn't see what was happening on the grid, what was being dispatched, what resources were available. Today, with the creation of deep models of grid operations, we're able to better measure energy supply and demand across the grid, not just when it dispatches, but also where it should be best located for the fewest emissions. It means we can better orchestrate and optimise across our entire operation.

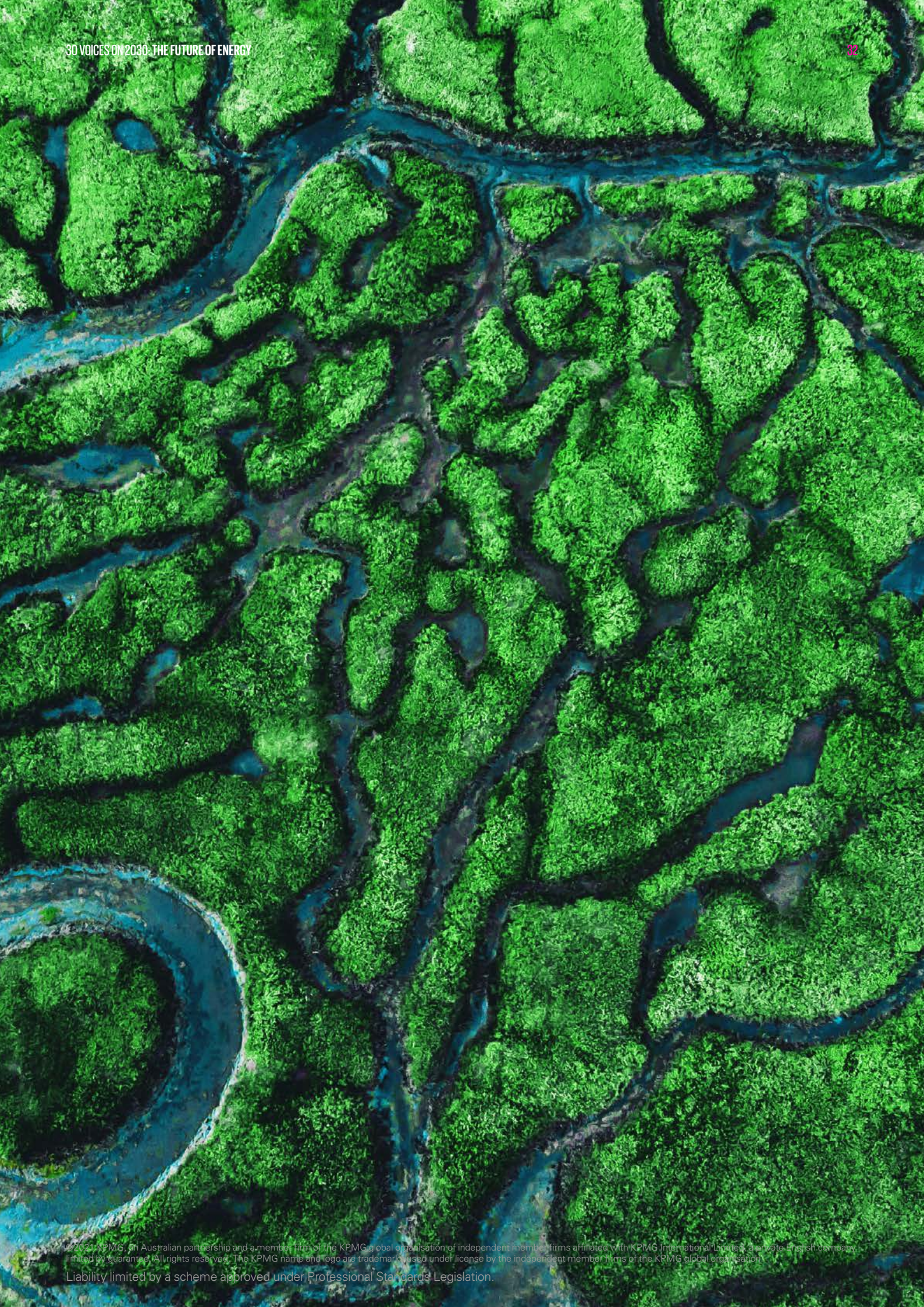
WITH ENERGY DEMAND GROWING FROM CLOUD SERVICES, WHAT STEPS HAVE MICROSOFT TAKEN TO ENSURE A RELIABLE ENERGY SUPPLY WHILE REDUCING EMISSIONS FROM SUCH SERVICES?

There used to be a real fear that the cloud would just gobble up all the world's electricity. It hasn't happened, primarily because we've been able to leverage the infrastructure which supplies the data much more efficiently. Previously, workloads deployed in the cloud were migrating from far less efficient environments - enterprise data centres and servers - which weren't optimised or running on clean energy. As our zero-carbon commitment was not only for electricity, but also for things like cement and steel that go into the construction of a data centre, we have been able to achieve more productive and less carbon intense data centres. It means that - despite global power demand continuing to increase - generally, overall data centre power demand has not.

IN WHAT WAYS ARE 'BIG TECH' COMPANIES LIKE MICROSOFT SUPPORTING THIS NEW ENERGY SYSTEM IN 2030?

We're about enabling the success of all companies and individuals, and we think about electricity, the cloud, artificial intelligence and quantum computing in the same way. They are utilities and we want to create a level playing field around them that allows others to come in, innovate and drive efficiencies - be it in transportation, food production or medicine. No one goes to the doctor and thinks I'm thankful for Microsoft, but we are working with the backbone of these different industry systems - which are often very complex - so they become intelligent. It means they operate more productively; with precision, and their optimisation can facilitate, in medicine, for example, a much better decision making and diagnoses process.

The great thing about more intelligent systems is that they are also more resilient. If you orchestrate everything well together it also becomes safer and more secure - even if individual devices fail, the whole system does not as it isn't dependent on just one device. So, in a power grid, for example, now that we understand the systems better, we can prevent cyber-attacks, as we can isolate different parts of the grid. If you are concerned about a particular power plant staying online, then you just don't have a resilient system.



"In 2030, we are leading the energy transition by driving different thinking and innovation, and by listening to what our customers need and want from us."

JOANNE FOX

ENERGY EXECUTIVE, PEOPLE & CULTURE

AGL

Chris McGrath

CHIEF EXECUTIVE OFFICER

5B AUSTRALIA

"The solar tipping point - we just had to turn up the dial..."

In 2030, we are celebrating the incredible success of solar energy. Its growth has surprised everyone. Solar PV[1] is not only the lowest cost form of new electricity generation but is now, by far, the cheapest energy source. It has transformed the energy sector through its massive uptake.

Solar's success has been driven by the obvious opportunity. Back in 2021 we already knew that we had the technology required to do what we needed to do - we just had to get it out there at scale. There was no shortage of land, of solar irradiance, of sand to refine into silicon for the solar arrays.

All that was needed was pure industrialisation to further deploy and integrate solar into our energy system. The role of energy storage in solar generation has also been significant and is integrated into almost every solar system you see.

The tipping point for this mass uptake of solar was cost. The solar sector quickly evolved from being a project by project, custom engineered, power station type industry to mass industrialisation through factories dotted around the world and located in places that are most efficient for them to scale and produce ultra-low-cost outcomes.

One such place is Australia. Here, solar has helped to tip the energy balance and today green energy is the driving force behind the economy. The country has gone from being a net exporter of dirty fossil fuels and a net importer of oil for transportation to sustaining its own energy supply. Australia also exports many minerals needed for renewable energy, supporting net zero goals all over the world.

Where we have seen mass uptake of solar, it has been facilitated by digitisation. You can now buy solar farms online in the way people used to buy books. Digital has facilitated how solar projects are financed and approved and how councils, government and utilities interact with those projects. Previously it was a slow, bespoke exercise to buy and procure solar power - it would take months, if not years of buying cycles. Technology did not have to drive the transformation that's occurred; it was simply a matter of turning up the dial to maximum and mobilising the industry behind the task at hand. Today, the ability to buy and deploy solar power - and the whole ecosystem and platforms to support this - have been built around technology.

The geopolitics of the solar industry has also changed - and this was largely supply chain driven. Back in 2021, 90% of the world's solar modules came from China. Now, there is a more balanced and integrated supply chain as opposed to one that's overly saturated in certain locations. Greater levels of automation have meant that solar production is no longer concentrated in those countries with lower cost labour.

The only remaining constraint for the solar industry is how to best maximise this infinite amount of low cost, clean power for use further downstream. We have seen an almost complete transformation of transportation to electric over the last ten years. The grid is now almost 100 percent clean electricity. Even big industries like aluminium smelting and steel production are using green electricity and increasing hydrogen production to support this trend.

However, renewable energy use in certain sectors is still a challenge. The aviation industry, for example, has seen some traction with different pathways to electro-fuels made from clean electricity or hydrogen, meaning battery-based aviation is more prevalent. But it does not quite solve for everything: while deployment has been cracked, the downstream integration side of the equation remains a challenge - that's the next frontier.

Chris McGrath's strong focus on developing cutting-edge technology that reduces the cost of renewable energy led to the start-up of 5B which has since grown to a global organisation, based on award-winning technology. 5B has reinvented the solar supply chain to simplify how projects are delivered, with fewer materials, lightning-fast deployment and streamlined logistics.

After graduating with 1st class honours in Renewable Energy Engineering, Chris designed and installed a micro-hydropower system for a remote Vanuatu village, founded 'Solar Fields' and worked at Infigen Energy as Development Manager, before co-founding 5B.

Chris is an avid explorer of the natural world, a tech diver, a rock climber and enjoys a good adventure with great friends.

1 Solar PV or Photovoltaics is the direct conversion of light primarily from sunshine into electric power using semiconducting materials such as silicon.

Chris Reed

MANAGING DIRECTOR

NEOMETALS

"Using Lithium, we have stored enough energy in a small space to transform mobility."

The element lithium is essentially a portable energy enabler - once you've got a portable store of electricity, you can then use energy much more efficiently. Lithium is the lightest, most reactive element in the periodic table - it was lithium batteries which enabled mobile phones to become irreplaceable - it enabled the energy they stored to be placed in a compact space and now it is doing the same for mobility. At the start of last decade, we saw every major car company commence investing in Electric Vehicles (EVs) and today, the internal combustion engine represents the minority in new fleets. This fleet transformation accelerated as battery ranges improved - a typical range is now supported by around 75 kilowatt hours of storage capacity per car, capable of running an average household for a couple of days.

Lithium is enabling an energy revolution. You combine that battery power with renewable energy, and you become your own generator; you've decentralised the power grid so you can harvest sunlight during the day, store it, and use it for mobility when you need to. A key development this decade in this area has been around households selling excess decentralised power on peak days to the utility generator which can be credited or given back to the household during the night.

In Australia, our primary energy mix is working well in terms of supporting current EV adoption and EV architecture. We can charge off our own domestic infrastructure with no problems for the grid operators or energy traders.

Europe's push towards climate change mitigation can be seen as a lead indicator domestically. Widespread EV adoption and climate commitments have been slower in Australia. However, changes in the market, particularly as they relate to technology raw materials, are being felt strongly. Raw material demand and prices have gone up and reset the dial in our industry. It has changed from scrimping and saving - trying to maximise recoveries - to investing in more environmentally sustainable processes, acids, neutralising tailings and capturing emissions. We've responded to what the market wants, which is a much more carbon and environmentally conscious minerals processing industry.

Previously, internal combustion engine vehicles had a far smaller carbon footprint than electric cars during the production phase due to the materials and minerals used to create the chemicals for EV batteries. OEM's were attempting to retrofit a lot of their existing vehicle platforms but the battery packs were hard to access at end of life and recycle. Cars are now designed to be much easier to recycle and batteries more easily replaced. The big EV car companies are, for example, using the batteries as part of the strengthening mechanism for the frame of the car and because the battery is utilised in this way, it also means that EV's are safer to drive in terms of impact. The industry had to take some pain because we needed to get batteries into cars - they needed to last longer. Ultimately there was a massive net benefit; we've been able to lower the pay-off from seven years down to two years on a carbon balance in EV's versus internal combustion.

New regulations have tightened the requirements on what is mandatory recycling in many jurisdictions. There is more electronic waste recycling, more carbon efficient recycling, carbon labelling, regulated recoveries and minimum use of recycled content. Stakeholders want to see more transparency on sustainability of companies and their supply chains. Over the last decade, we have had to fundamentally change how we've approached processing minerals and looking at it more holistically. What are our tailings like? What are the least green processes? What and where are we emitting - we realised that you really can't manage what you can't measure.

It was a big challenge though - the battery minerals supply chain is very large and long - from mining lithium, nickel or cobalt in Australia or China to chemicals production in Europe or North America or Asia. Neometals has been able to develop a recycling process which basically enables you to regenerate those materials because they've already been mined and used once. We can't sell a product into the supply chain today unless we know the carbon footprint, because the car makers must also declare it, as must the battery cell makers. The provenance of everything in that car is verified in a digital certificate right back to the point of origin testifying and attesting to its ethical, environmental and sustainability credentials. This is also forcing minimum amounts of recycled product in the cars.

Innovation in the operating and the safety systems, utilising things like Bluetooth, wireless and satellite, has made us all super connected and safer. Services provided by NRMA, RAV etc. just aren't required for anything more than flat tires now. The ability to not have to own a car but to summon a car on demand is also fantastic.

Now, in 2030, we are recycling 100% of the world's batteries to generate - 10% of what is needed to make new batteries and it's improving all the time. By 2040 or 2050 we should be close to self-sufficiency. Our industry today is much more mature about working collaboratively so everyone gets the value they want. Consumers not only get a cost benefit - better value for money - but also a sustainable benefit too.

Chris Reed started in the mining industry in 1990 and co-founded Reed Resources in 2001 (now Neometals Ltd). Chris holds a Bachelor of Commerce from the University of Notre Dame and a Graduate Certificate in Mineral Economics from WA School of Mines. He is a Member of the AusIMM and immediate past Vice-President of the Association of Mining & Exploration Companies.

Dan Adams

COFOUNDER AND CO-CEO

AMBER ELECTRIC

"Consumers have embraced renewables - they can reduce their electricity bills while supporting the energy transition."

Dan Adams is the Cofounder and Co-CEO of Amber Electric. Dan is focused on shifting Australia to 100% renewable energy in a way that creates value for customers. Prior to Amber, Dan worked for Tesla where he developed the South Australian Virtual Power Plant and the Boston Consulting Group where he advised electricity companies on the future of energy. Dan was also the Victorian Young Australian of the Year for his work founding the Make Poverty History concert in Australia.

HOW HAS THE CONSUMER AFFECTED THE PUSH FOR GREEN ENERGY OVER THE PAST DECADE TO 2030?

The consumer has played a critical role in driving the energy transition towards renewables. As they became more concerned about the environment and climate change, they sought out more sustainable solutions and this has been accelerated by the falling cost of distributed energy technology including solar, batteries and electric vehicles. Today, consumers are also more circumspect regarding the decisions they make, for example, about what kinds of energy retailers they deal with or the type of smart devices they purchase for their homes. This is particularly true regarding the younger generation.

In Australia, government policy continues to play catch up with the consumer regarding the energy transition. In the early 2020's, when we reached a point of cost advantage for renewables against more traditional fuels like coal and gas, a rush of new businesses appeared to be focusing on securing more value for the consumer. While some state government policies that came about in the early 2020's

were fundamental in the uptake of large-scale renewables, it has been this better value of renewable energy - cheaper power prices - which has facilitated the conversion of consumers to greener energy.

WHAT ARE THE DIFFERENT CONSIDERATIONS CONSUMERS HAVE ABOUT THEIR ENERGY PROVIDER TODAY IN 2030?

Through Amber Electric we pioneered a different electricity retail model in Australia. We give consumers direct access to real-time wholesale electricity prices, which incentivises them to use cheaper renewable power when it's available. The traditional retail power model was not doing this - consumers were always paying the same price, whether cheaper renewables were available or not. They trust us to empower them to take advantage of the cheapest market prices.

In today's market, companies like Amber have enabled consumers to be the driving force in the renewable transition via millions of smart connected devices. We have enabled our customers to move a major part of their energy consumption to periods of the day when power generation is primarily renewable and therefore cheaper; this has facilitated the closure of most coal fired power stations. The coordination, orchestration, and automation of all these devices searches out the most value for customers and supports the transition to renewables. There are a wide range of smart devices out there, so we also integrate with other technology companies to create a seamless experience for customers. By becoming a trusted partner and helping customers navigate this complex world of renewable energy, we help users participate in and progress the energy transition while reducing their own electricity bills simultaneously - it's a win-win.

WHAT IMPACT HAS TECHNOLOGY AND DATA HAD ON THE ENERGY SECTOR OF 2030?

The green transition is primarily enabled by technology. It is not only about investment in large scale batteries, for example, but is also being driven by software and more intelligent use of existing devices in the home. Giving consumers the tools and technologies to shift their usage to those periods of the day when cheaper renewables are available has been an effective way of both integrating renewables into the grid while making the market much more flexible and resilient. Flexibility has always been valuable in the electricity market. Previously it was flexibility in terms of large scale dispatchable coal and gas generators, but today it's to do with the control and automation of millions of devices in customers' homes - household batteries, electric vehicle chargers, electric hot water systems, air conditioners and heaters.

The consumer is still in control - we just provide them with the tools to help them use their devices more intelligently. We allow customers to tell us the constraints of how they want their devices used; we then automate and optimise within those boundaries. For example, we will enable a customer to plug in their electric vehicle at 8:00pm and tell the Amber App "I'd like my electric vehicle charged by 8:00am tomorrow morning". The app will automatically charge the car at 2:00am when, say, cheaper wind power is available, rather than at 8:00pm when power is perhaps being generated by more expensive natural gas power stations. Of course, the consumer can also override the algorithm and still charge their car whenever they like.

IF YOU WERE A START-UP FOUNDER IN 2030, WHERE DO YOU SEE THE GREATEST OPPORTUNITY OVER THE NEXT 10 YEARS - TO 2040 AND BEYOND?

Ten years ago, the energy start-up landscape in Australia was nascent but it has evolved as new investors have come into the market. More capital is available that has allowed new start-ups to scale. Australia has been leading the renewable transition globally, particularly in distributed energy through rooftop solar and household batteries. It is the ideal test market to develop the technologies of the new energy future, like hydrogen, which can then be exported all around the world. This, combined with the growing availability of capital, has accelerated the start-up ecosystem in Australia. This innovation foundation continues to support other opportunities, for example, in transferring our energy technology overseas. Amber and other smart device companies have been using Australia as a technology training ground, improving technology, and then licensing and selling that technology overseas.

The other big opportunity is in the automation of smart devices in the home. This is helping to integrate renewables into the grid and new business models are being developed to enable it. Up to now, energy business models were built around utilities trying to match their retail book with more flexible supply. In the new world, the focus is all about the consumer – how can we help customers use the flexibility of devices in their home to best access renewable power when it's available. To be honest if a business hasn't already realised that it's probably too late.

Innes Willox

CHIEF EXECUTIVE OFFICER

AUSTRALIA INDUSTRY GROUP (AI GROUP)

"The business conversation is fundamentally different to a decade ago - it's not whether we go there but how we get there..."

AS AN ORGANISATION THAT REPRESENTS ENERGY USERS – WHERE DO YOU SEE THE MAJOR INDUSTRY CHANGES OVER THE LAST DECADE?

For the past twenty years, energy businesses generally have known they needed to change but it was complicated by a lack of investment certainty in the sector. Over the past decade, a growing government focus on climate change issues has pushed clean energy development, energy technology and reducing emissions to the forefront of policy making.

Today, investment in the energy transition sectors is growing - supported by clear government guidelines and regulations. The sheer pace of change in energy technology development has also been striking. There are more electric vehicles, increased energy storage and the advancement of hydrogen solutions - and all have driven a huge reduction in heavy industry emissions in industries like agriculture, transportation and construction.

Accompanying this shift in government and business focus has been an attitude change in society, not just around sustainability, but also in the view of energy technology. Because storage capability and capacity are now at the levels required to support further technological change, it can support stronger demand for energy technology - everyone wants and can now have the "Tesla" experience. So, while we're not yet at net zero in 2030, we're far closer to it than we were a decade ago.

WHAT DOES THIS ENERGY LANDSCAPE LOOK LIKE FOR INDUSTRY AND BUSINESSES IN 2030?

The individual energy user and smaller businesses have driven the biggest changes in the energy system so far; the transformation in heavy industry has yet to come - but we should see this over this next decade to 2040. Most households and smaller businesses are now at the point where the scale of renewable power generation and battery technology is enabling energy consumption to be

more of an individual choice. Their power generation is cheaper; there are more choices of types of renewable generation and technologies, such as batteries, and inverters are allowing them to better manage and customise what they need or don't need. So rather than talking about people going off grid, we now talk about more people being on grid.

For heavier energy consumers like steel, aluminium or car manufacturers, the pace of change has been slower. Despite their journey towards, for example, greener steel or aluminium and advances in production processes, these sectors are still reliant on traditional energy supplies, particularly natural gas. One of the biggest issues they've had to deal with to date is improving their energy efficiency and trying to overturn long held processes and practices. These industries have also been targeted by many countries who followed the European Union, introducing carbon border adjustment tariffs, which has put them under more pressure to adapt their energy management to become greener faster.

If the pace of change is now picking up in these hard to abate sectors. It is not only due to stricter regulations; their customers are demanding more sustainable practices too. It means that, in heavier industries, energy consumption conversations have shifted from the back to the front-office; today it's at the top of all business agendas including at the Board and C suite level. It also means that any new business needs to be net zero from the start.

WHAT IS THE PRIMARY CONCERN FOR BUSINESSES GOING FORWARD IN 2030 – IN TERMS OF THE FUTURE ENERGY SYSTEM?

It has always been a challenge for industry and policy makers to move simultaneously in the same direction over any issue, and the energy transition is no different. The challenge for business is to make sure that in considering those differences - and the speed and trajectory with which they are being considered by different nations and states - conversations remain harmonious and further tensions are not created. The worst of the climate wars are hopefully behind us; the major political parties are on board and, while there are elements that could go faster or things that could be done differently politically, the conversation is today a fundamentally different one to what it was a decade ago. After a lot of work, there's much better collaboration on the overall goals of the new energy system.

Going forward, the energy focus of the business world is switching from achieving net zero to becoming fully carbon neutral or carbon positive - going beyond achieving net zero carbon emissions and towards deeper environmental benefits from energy efficiencies and/or emission reductions. Even if we are still some way off this target - for example, economies like China are still stretching net zero targets out to 2060 - much of the international community is, at least, fast tracking net zero goals. There is optimism we will eventually get to a carbon positive situation - even if it is only around 2070. The discussion now is not whether we go there, it's how we get there, and that is a much better place to be.

Innes Willox was appointed Chief Executive of the Australian Industry Group in May 2012. He joined Ai Group in 2008. Prior to joining Ai Group he worked as a diplomat, journalist and in the private sector in Australia, Asia and the United States. He is also Deputy Chair of Australian Super and Chairman of the Migration Council of Australia.

Jason Chang

CO-FOUNDER AND CHIEF EXECUTIVE OFFICER

EMR CAPITAL

Jason Chang is the Co-Founder and Chief Executive Officer of EMR Capital, a global mining private equity firm with more than US$5bn of assets under management. EMR Capital currently owns and operates mines globally including mines in Australia, USA, UK, Spain and Zambia.

Prior to EMR Capital, Jason was Partner in Charge of KPMG Australia's Asia Practice which focusses on investment and trade between Australia and Asian economies in the energy and natural resources sector.

Jason was President of the Australia China Business Council's Victorian Branch from 2008 to 2015.

Jason graduated with a Masters of Law and Bachelor of Laws / Economics from Monash University, Australia, and is admitted as a Barrister and Solicitor of the Supreme Court of Victoria, Australia.

> "Demand for the minerals required for the future is just massive - and the world has underinvested in them so far..."

WHAT ROLE HAS MINING PLAYED IN THE TRANSITION TOWARDS NET ZERO?

Mining has played a pivotal role in this transition as the new energy system is based on certain critical minerals and metals such as copper, cobalt, nickel, lithium, as well as zinc and a few others. Also, with a very clear motivation from governments to decarbonise the energy system, and momentum from net zero targets signed by many countries and companies, the mining industry is now underpinned by a new wave of demand and investment. Finally, the sector itself, as a big consumer of energy, has made immense strides in decarbonising and becoming more energy efficient.

WHAT ARE SOME OF THE CHALLENGES THE MINING SECTOR HAS EXPERIENCED OVER THE LAST DECADE?

Successfully exploring for and producing these critical minerals has become more challenging. As the mining sector played more of a central role in our energy system, and supply chains have become longer and more complex, supply and demand patterns for key commodities are now more volatile. We are already seeing big supply constraints - demand for copper, for example, has more than doubled over the past decade, and now it's even more scarce. As the global car fleet switches to electric, demand for cobalt has also rapidly increased. Though global demand is increasing, ore grades are decreasing, meaning these commodities are harder to extract, increasing their cost of exploration and production. How we mine better, faster, and more efficiently is arguably a bigger challenge in 2030.

The mining sector remains underinvested, and the rate of investment needs to be accelerated. Today more than 50% of the new vehicle fleet is electric - but a lot of investment was needed in the mining sector to get us here. Where there has been a rise in investment over the last decade, a large portion has been driven by private capital. The appetite from investors for the opportunities in mining during this energy transition has been large. It was replicated to a certain extent in the public sector too, but it has been private capital which has driven the change.

Geopolitics is another big concern as there are ongoing tensions and heightened security risks everywhere. So, it's a question of how we can work better with the countries and corporations we are doing business with. We wouldn't invest or operate in a country, for example, or a location where we weren't confident there was appropriate regulation, policy or rule of law. It will always be an issue - it's very difficult to find copper resources in a mature country with good infrastructure, so the questions will always be - how do we do this better? How do we collaborate better? How do we work with different governments so we can get access to resources in places which perhaps investors are not that familiar with? Newer markets provide a lot of opportunities and we still need to work better with them to meet the supply needs of this energy transition.

WHAT HAS THE MINING SECTOR DONE OVER THE PAST DECADE TO MITIGATE SOME OF THESE CHALLENGES?

Capital flows best to those companies demonstrating strong ESG principles and best practice behaviours. Mining regulations have tightened but mining companies themselves were already putting in place stronger ESG procedures and mines are being run with sustainability and community in mind. For example, track and trace processes are now common, showing where and how minerals are sourced. In our former gold and silver operation in Indonesia, 70% of the employees were from local villages; working and supporting such communities has always been a key mantra of the mining sector, but it is now part of global regulation. In one of our mining operations in regional Queensland, that statistic is replicated where more than 70% of the workforce live in the adjacent town. Today in 2030, most mining companies have outstanding ESG credentials.

Focus and direction from leadership has also facilitated putting ESG at the centre of mining operations today - a successful operation is based on trust and strong ESG principles. Engaging with communities, for example, requires a big team of people, good policies and good execution, but leadership is what makes it work. The results then speak for themselves, we see successful communities, mine workers and their families all flourishing and prospering alongside the mining operators and investors, through establishment of better infrastructure, new schools, training, better medical care, or even just the availability of clean water.

We have also seen more vertical integration between sectors dominant in this new energy transition - this has increased competition and lowered costs. Earlier this decade, electric car companies were already moving into mining to secure supplies for their operations. Mining companies have also formed partnerships with technology companies to secure better access to the technologies driving their operations. As demand for minerals and metals has increased, these technology partnerships have supported higher valuations in mining; as not only was the sector underinvested, but it was also undervalued. Governments and businesses have also learnt lessons from the COVID-19 crisis where the mining sector has played an important role. It taught us not to outsource everything - meaning there has been a lot of focus over the past ten years on developing new mines, new processing and mining technology and establishing new raw material supply chains for domestic use as well as for exports.

Public and private sector collaboration is making the energy transition easier in mining. There has been a lot of collaboration across government and businesses, and across different regions and newer supply chains. Initially, this all meant that business slowed down - a lot can go wrong as supply chains are very precarious and it takes a long time to go from a greenfield site to a producing copper mine - seven to ten years minimum. Stricter regulations around permitting were also a delaying factor and it pushed costs up. Now that mining plays a more critical role in the global energy system and we needed to ensure a stable supply of these critical minerals, a lot of patience, effort and working together has created a sector where operations are working more cost effectively and efficiently.

Australia, today, is becoming a superpower as it has some of the world's largest resources of the commodities and critical minerals needed for this energy transition. Cobalt, nickel, and lithium all make up a bigger part of Australian exports today, along with its more traditional commodities like iron ore, copper, gold and metallurgical coal - growing global demand for minerals and mining is very good news indeed for Australia.

"In 2030 energy and climate policy is no longer a cultural or tribal signifier, so it has become less political with everyone rowing in the same direction for a decarbonised, efficient, reliable, and cost-effective energy system."

AUDREY ZIBELMAN
VICE PRESIDENT
X, THE MOONSHOT FACTORY

Jemma Green

CO-FOUNDER AND EXECUTIVE CHAIRMAN

Powerledger

After completing a business degree majoring in finance at Murdoch University, Perth, Dr. Jemma Green moved to London where she worked in banking including at J.P. Morgan, where she oversaw a geographically dispersed team of 25 to implement software development for deal and risk capture in exotic and hybrid equity derivatives.

Jemma was also involved with setting up J.P. Morgan's Global Environmental Risk office which was launched in 2007. Jemma has also completed two post-grad diplomas and a Masters at Cambridge University in sustainability and completed a PhD in electricity market disruption at Curtin University. Since co-founding the Powerledger venture, Jemma has overseen the development of numerous software projects that integrate blockchain technology in software for distributed energy markets.

> "Blockchain technology is building the trust needed in this new energy world."

WHAT ARE THE KEY TECHNOLOGIES THAT HAVE TRANSFORMED THE ENERGY LANDSCAPE OVER THE PAST DECADE AND WHAT DO YOU THINK HAVE BEEN SOME OF THE KEY DRIVERS?

Our company Powerledger was built on a clean energy vision. We have developed an energy and flexibility trading platform that allows households, organisations, and the grid itself, to trade with each other. In 2030, we are much closer to having predominantly clean energy in a system that works for everyone, with many people having access to electricity generated in large part via local, low-cost, stable and clean energy sources. This electricity is delivered through the main grid, meaning the market is now both distributed and decentralised.

As the market has changed, the role of technology has become increasingly important. New technologies were needed to better enable renewable energy trading, renewable asset financing and more efficient carbon and renewable energy certificate and credit markets. New technologies also allowed individual consumers and organisations to participate in wider market supply for energy, ancillary and network services, as well as on the demand side.

From my perspective, the major driver has been the emergence of two-sided energy markets and the need for efficient and transparent markets and operating systems, supported by technologies that seamlessly connect buyers and sellers and authenticates and settles transactions. The Powerledger system uses blockchain technology to certify the origin and source of renewable energy. As an example, households can choose their own energy mix from a variety of sources such as solar farms, wind, biogas and P2P with their neighbours – they can choose the certified source and origin of the energy purchased. Trust will be of increased importance in this new energy world - people want to know they are getting the specific things they are purchasing and supporting.

WHAT HAVE BEEN THE KEY STEPS OF THE POWER MARKET EVOLUTION TO 2030?

It is key to understand that the energy transition was not just a matter of swapping coal or gas for solar and battery systems. Energy is not like cocoa beans. The system has moved from centralised planning and centralised pricing to this decentralised hyper local market signalling, which balances local energy supply and demand and reduces the need for more costly upgrades to the grid.

Looking back, the first part of the energy transition was around energy self-supply from solar and then batteries and the move to microgrids. Here in Australia, everything changed in 2025 with the rollout of two-sided markets and adoption of new regulations. By 2030 we have a fully-fledged two-sided market where households are paid variable rates for their energy based on the value they provide to the grid or the wholesale electricity market.

So in 2030, we have a more flexible, independent, and more automated energy system which consists of many microgrids and local energy markets within the grids. This has meant less autonomy for the big utilities as any household or business can connect to and trade directly with wholesale electricity markets and be paid for it.

WHAT DOES THE UTILITY OR RETAILER OF 2030 LOOK LIKE?

New players have entered the energy market - cities, new utilities and corporates like shopping centres, supermarkets, and hardware stores. Incumbents still exist but they are seeing immense competition from new commercial and business models from the big technology companies which typically have a large customer base. At the beginning of this decade, they were already offering things like credit cards, insurance and other services, so it was a natural next step for big tech to become power retailers.

Existing market incumbents had three choices as they lost market share and their margins were squeezed - they could fight, flight or innovate. Some fought against regulatory changes. Back in 2021, the grid was not set up to deal with the large influx of power coming into it from rooftop solar. At that time, the Australian Electricity Regulator was even recommending bringing in charges for this excess electricity to help the grid cope. Utilities started their flight from the market by divesting or separating old energy assets from new and demerging.

The rest chose innovation – and there are broadly two types: cannibalistic and non-cannibalistic. Cannibalistic innovation is where you cannibalise your own market share, because if you don't, someone else will. So, if I am a retailer, I offer customers solar panels and batteries before someone else does, even if it means I sell that customer less electricity, and I make margin on the sale of the solar and battery system, which offsets or supplements the loss of income from selling them electricity. Non-cannibalistic means targeting new markets, so, for example, setting up in parts of Australia where you didn't operate before, like regional areas. Those who have chosen innovation are succeeding.

HOW HAS THE ENERGY CONSUMER CHANGED?

Under the old model, the customer was more of a passive recipient of energy, just buying what the utilities sold. Over the past decade customers have been engaged in the subject of energy in a more personal way, to identify what matters to them with the goal of better targeting products and services.

It has been interesting for me to see renewable energy households and communities emerging and becoming more active market participants. They now think, "shall I connect my energy system to a platform that allows me to access many market opportunities?" Customers may have different energy suppliers for their electric vehicles (EVs) and for their houses, so they think, "shall I charge my EV tonight as there's a high price event coming and that can pay for my dinner at a "restaurant?" Consumers may invest in a large battery system to allow them to play energy markets like investing in the stock market. They watch the price of electricity like they watch the price of Bitcoin, with settlements happening in real-time. Consumers make choices like this about energy all the time today.

This has however, generated a greater need for managing customer privacy. There are exceptionally large volumes of data being generated and it needs to be protected. What we are seeing is a whole new electrical world of energy emerging - a root and branch market change - and it needs to be managed seamlessly, securely and efficiently. This will be a key focus area as the industry continues its evolution.

Joanne Fox

EXECUTIVE, PEOPLE & CULTURE

AGL ENERGY

Joanne Fox joined AGL in June 2019, following a successful career at Santos.

With more than 25 years' experience, Joanne has a strong and diverse background leading the Human Resources function in large ASX100 companies in the oil and gas, FMCG and pharmaceutical industries. Joanne brings extensive experience in capability and culture development, succession management, talent development and organisational design.

Joanne holds a Graduate Certificate in Energy & Resources from University College of London, a Masters of Business Administration from the University of South Australia and is a Graduate of the Australian Institute of Company Directors.

"Our transformation started with the understanding that our customers and people deserve the best."

In 2030, we are leading the energy transition by driving different thinking and innovation, and by listening to what our customers need and want from us. We engage people at work by understanding what is important – whether it be meaning and purpose, flexibility, or the opportunity to be with like-minded people working towards a common cause. We have changed our ways of working, taking advantage of new opportunities and having a highly inclusive working environment. We have evolved our approach to talent development, training and leadership, and place equal focus on the mental and physical health of our employees.

Some of these changes came about because of the COVID-19 pandemic of 2020-21, but it is also the result of the pace and agility required to lead the accelerated energy transition. It has required different skillsets and approaches to relationship building.

The COVID-19 crisis meant we had to deal with an increase in hybrid working; its legacy is that most of our people are now working far more flexibly to suit their lifestyles. We always believed that the office was an important place for connecting people, building trust and culture. Post-COVID-19, less time in the office meant we were more focused on making sure that when people were not working face-to-face, there was planning and time for both networking, knowledge capture and information sharing.

The pandemic meant we had to look closely at the employee experience lifecycle. We transformed our approaches to onboarding, developing and mentoring people with connection hubs in regional centres and throughout the cities in which we operate. We brought work back to Australia by thinking differently about how we build mastery level capabilities using international, online learning communities and built global capabilities.

This increased the depth of the pool of candidates with specialist skills in Australia and significantly improved our ability to innovate and perform. Working differently means our people have much more control over when and where they work, and our leaders are skilled at knowing how to get the best out of people who work in distributed teams.

COVID-19 also changed our focus on health and wellbeing, in particular, mental health. It has now been mainstreamed as part of the safety conversation and the mental health resources we have available to our people are sophisticated and supported by a growing demand for them.

The pace of change in the energy transition has also driven our transformation as an organisation. We have a greater focus on Research & Development (R&D) and a keen focus to improve stakeholder engagement. Our R&D is progressing as we bring people together who can provide clarity of what is required while managing relationships collaboratively. With thinking from many different disciplines, we have been able to achieve or exceed our commercial goals and at a rapid pace.

Our approach to ESG issues has changed significantly. Over this decade there has been an expectation from boards, the public, and our customers and employees to give more prominence to ESG and stakeholder engagement. This is a key topic for our people who challenge the business to be agile and open to change, knowing that when they speak up and offer these views they will be listened to and supported.

We have also built the digital capabilities of the workforce - which have supported our wider use of artificial intelligence and data visualisation tools. Our digital know-how mentoring program is bearing fruit and is democratised to the point that our digital and data specialists come from all walks of life, applying divergent thinking from engineering and customer experience to ethical leadership. Our workplace is a safe and thriving space for people who think and work differently as they achieve amazing results together. These new skill sets and different capabilities are also facilitating better networking and results across our organisation.

Over the past decade we have also been able to transform core organisational processes using different mindsets and technology. In doing so, there is clear communication on what is required and how it will be delivered. We recognise that the pandemic as caused people to think long and hard about what they want out of work and life. Our approach has been to enable our employees to choose from a wide range of benefits which are tailored to their own unique life. As part of this, we connect earlier with people who are off-ramping for the next stage in their life. This has delivered big benefits in attraction, retention and knowledge transfer, which allows many to stay working productively for longer.

Our customers know we have embraced change and as result we have become a key place for customers to get all their essential needs meet. We are focused on providing choice and flexibility, enabling our customers to get the best deals and remain connected. They know when they choose us they will receive genuine and quality interactions, a wide range of choice and flexibility and all to be found through seamless digital experiences.

Our leaders have become more effective because they take the time to really know and understand our people - they are skilled talent developers and connect our people with meaning and purpose.

Training has changed due to the wider use of tools like augmented and virtual reality. The days of everybody attending a training course simultaneously and in person are over! Learning has become more democratised and decentralised from onboarding right through to leadership development. We no longer design our own bespoke leadership programs because we do not need to - we are more equipped to capture and use all the great work that is already out there.

Our organisation looks different today. The old set up of big corporate offices has morphed into smaller hubs - connecting people both outside the company with technology leaders and stakeholders, and internally through hubs where our people and projects come together.

This new, more flexible organisation with smaller working hubs has built on our employees' sense of purpose and connection, ensuring as a business we are offering the personalised experiences we know our customers want. This understanding started with us taking care of our own people and coming together with the right mindset - only then did the better people experience and the customer experience really come together.

John C. Mankins

DIRECTOR

SOLAR SPACE TECHNOLOGIES

"Space power – the sweet spot between technology, efficiency, performance, and money."

Space energy - or specifically solar power from space - has become a major consideration in 2030. There are three main drivers making space energy work today. The low cost of launch, mass production of hardware and the urgent need to find more solutions to climate change. An excellent place to produce space based solar power is in middle Earth orbit - high enough so that the spacecraft is in the sun all the time, but not so high that the cost of transmission becomes prohibitive.

The success of space energy, up to now, has depended on the lessons learnt from space exploration earlier in this decade. Back in 2021, we already had clear examples of solutions that were cost effective, achievable and utilised simpler technologies. The use of reusable launch systems meant the cost of getting into orbit was already 90% cheaper than it was in previous decades. Affordable satellite networks were also being launched, offering low-cost internet access in remote locations at costs below fiber-based solutions. Today, we have modular hardware launched on new, largely reusable boosters as well as reliable and cost-effective communications in space.

John C. Mankins is President of Artemis Innovation Management Solutions LLC and of Mankins Space Technology, Inc. and a Director of Solar Space Technologies. He is Vice President of the Moon Village Association, and is a Dean and Professor at the on-line Kepler Space Institute.

While at NASA and JPL, Mankins held numerous positions, including as Chief Technologist for Human Exploration and Development of Space at NASA HQ, where he received the NASA Exceptional Technology Achievement Medal.

He holds a B.S. (HMC), an M.S. (UCLA) and an MBA (Claremont Graduate University). He is a member of the AAAS and the IAA.

Mankins is known for writing the definitions of the Technology Readiness Levels and as the world's leading expert in the field of "Space Solar Power".

Over the past decade, solar power has been a primary focus of space development and is the main reason we are now able to deliver terrestrial energy from space. It has proven highly complementary with traditional ground-based renewables. It has not only become cost competitive, but it also mitigates the intermittency of renewable energy on Earth as it has a dispatchable baseload, meaning the energy from space solar power stations can be delivered when you want and where you want it. This means that today you can have that power fed into the local grid near Sydney and tomorrow you can feed into the local grid in Singapore. There is no other renewable energy option flexible enough to do that. Also, even if it is locally overcast or raining, space solar power can still be delivered as clouds are almost transparent to the microwaves used to wirelessly transmit power back to Earth.

Space energy is not all simplicity and flexibility, however. We have seen the development of other new and complementary technologies including alternatives to magnetic-confinement tokamak fusion and marginal improvements in solar arrays. There have also been improvements in battery technologies used for energy storage, especially cost reductions. It is, however, taking a lot of time to industrialise these technologies to make them cost competitive and robust at large scale.

Space energy is unfortunately generating a lot of geopolitical tension. There was a first mover advantage in getting an orbital slot and spectrum[1] allocated for wireless power transmission for your system, so one satellite could power various cities from one slot. Also, there are only so many geostationary slots, so you've got to get an orbital slot and you've got to get spectrum allocated so that your system won't interfere with others (as there are a multitude of spectrum users). Tensions have also grown concerning who owns space solar systems and who is selling power to whom.

As space energy gets cheaper, another source of geopolitical tension is on the horizon: cislunar space, i.e. activity on and near Earth's Moon. In this case, tensions are less likely to be about energy production for use on Earth but more about how to generate power for activities on the Moon and in space generally. For example, how to you do big data processing in space - for instance, block chain computing - or how do you support mining on the Moon? Also, you need to access cheap transportation throughout cislunar space, and for all of it you need vast amounts of cheap energy. So, I think, the next "Great Game," or source of great power tensions, will be centred on cislunar space and its resources. No one can do anything unless you can refuel, communicate and manufacture - and that all comes down to affordable and abundant energy.

1 The entire electromagnetic spectrum around the earth orbits is used to observe and allow a variety of things. Radio waves and microwaves – the longest wavelengths and lowest energies of light – are used by astronomers to look inside dense interstellar clouds and track the motion of cold, dark gas. The spectrum is also being harnessed for other uses and increasingly being looked at for energy production.

Justine Jarvinen

CHIEF EXECUTIVE OFFICER
UNSW ENERGY INSTITUTE

"The energy transition has brought a tsunami of data – it's like standing in front of a fire hydrant and trying to drink."

Justine Jarvinen (JJ) is CEO of the UNSW Energy Institute. She has a breadth of experience across the entire energy value chain and has worked in operational, investment analyst, strategy and advisory roles in Australia and the UK.

JJ is Chairman of energy technology company Wattwatchers, non-executive director of ASX-listed Milton Corporation, and non-executive director of Climate-KIC Australia. She is a graduate of the Australian Institute of Company Directors, holds a Bachelor of Engineering (Chemical) with First Class Honours, and is a Fellow of the Financial Services Institute of Australia.

WHAT IS THE MIX OF ENERGY IN THE MARKET TODAY IN 2030 – HOW FAR ARE WE TOWARD ACHIEVING NET ZERO?

As Australia's energy transition continues to unfold, we have finally noticed that the future of the energy sector is underpinned by electricity - electrical machines and power electronics. Over the past decade, we have been electrifying everything from vehicles and residences, to ports, airports, and commercial facilities. There are areas where Australia has been ahead of the rest of the world in the energy transition, such as rooftop solar and battery uptake, but in others, such as electric vehicle uptake, we have lagged. As we head into 2030 and get nearer to the net zero target, we're now panicking and asking if we can really meet it.

Over the last decade progress was made in some of the newer net zero energy technologies. To deal with the intermittency of renewables, we now rely on storage, not only traditional batteries but longer duration storage, including flow batteries, hydrogen, hydro and pumped hydro. We are now also considering technologies like nuclear - produced by smaller, cheaper modular reactors - and are seeing moves toward fossil-fuel independent vehicles, including solar-electric cars and fuel cell vehicles. For commercial transport, like trucks, where it's been much harder to use battery electric vehicles, we're trying to cost effectively produce hydrogen for use in fuel cells - including from biomass, solar PV electrolysis and electrolysis using seawater instead of fresh water.

As the energy transition progresses and is dominated by technology, there is increasing evidence of the technology "haves" and "have nots". Globally, millions of people still have no access to electricity and the COVID-19 pandemic of the early 2020's put a big dent in the ability to get to universal access. Some of that was eased by local solutions such as rooftop solar and home batteries, but there is still a big divergence in energy cost and availability depending on where you live. Meanwhile in Australia, it's more a challenge of fuel poverty (that is, affordability) than access. We are also aware of the need to protect vulnerable consumers from companies who are installing and managing their new renewable power systems - making sure that they still get quality products and a competitive deal in what is, sometimes, a monopoly market sitting on your rooftop.

WHAT ROLE IS DATA PLAYING IN CHANGING THE LANDSCAPE FOR BOTH THE CONSUMER AND THE SUPPLIERS OF ENERGY?

In the early 2020's, as our energy systems became more electrified, we saw exponential amounts of data being generated. This data is being created by smart meters, and by devices being installed by consumers and businesses: rooftop solar inverters, household and community battery inverters, EVs, and systems that monitor and help to optimise these devices with each other and with

the grid. It's also being generated by grid-scale inverters that connect solar and wind farms and so-called "big batteries" to the grid. The speed of response of inverter-connected devices is less than a micro-second or even in tens of nanoseconds. Over the past decade, they have been the tipping point on the grid, and we now have a system dominated by inverter connected smart devices all producing a tsunami of data.

The energy transition was unprecedented. First, the system buffers we relied on were disappearing. The buffer of gas storage in pipelines and gas reservoirs that supported and complemented electricity systems was dwindling, as gas fired power became relatively expensive and consumers switched to electric appliances. Coal-fired electricity was also rapidly retired from the grid.

Then timescales were compressing, and the pace of data flow was dramatically increasing. It was coming in at such speed and scale, it was like standing in front of a fire hydrant and trying to get a drink. We went from getting a few cumulative readings of a household electricity meter in a year to more than a hundred thousands real-time energy-related readings per day.

Finally, we realised that increasingly we were just flying blind. As we know with data, it's not quantity but the quality that is important and it has taken time for electricity network companies and other energy services companies to extract the insights from data. Only then could they offer better services and value for their customers.

The volume of data in this new energy landscape has resulted in other considerations. The first is that consumers needed to make sure they were in control of their own data and who had access to it, which presented new business models for companies to provide new data related services to consumers. The second is that data - for optimising consumption, for exporting energy to the grid, for billing - needs to be granular, real-time and not behind proprietary walls.

HOW HAVE THESE CHANGES AFFECTED HOW ENERGY MARKETS ARE REGULATED TODAY?

The nature of this new energy market needed new regulations and standards. Today, in Australia, the job of the electricity system operator, to monitor and balance supply and demand, is incredibly complex with so many households and businesses and renewable energy sites connected to the grid. So, we developed technology and regulations to allow control of the export of power from sites. This means that the output of someone's rooftop solar PV and battery can, when necessary, be directed by the government to stop grid congestion and avoid emergencies such as major blackouts. This needed open, yet secure, cyber connections and robust physical connections to the grid.

We have also seen a campaign to ensure that standards continue to evolve. For example, back in the early 2020s, most inverters had passed the Australian standards, but they were proving to be substandard just because of the new demands being placed upon them as a result of being installed on an increasingly complex grid.

Standards have also had to evolve in the consumer space. Companies have bundled other services with energy deals, such as the charging of electric vehicles. Also, new "virtual power plant" operators traded differently, some trading for price, grid stability, or green energy consumption. New retail tariff designs were needed and the regulators had to determine what prices would apply within community microgrids, in peer-to-peer supply or locally generated supply.

These new market issues - new technologies, more industry convergence, evolving standards, complex prices, and the availability and reliability of renewable generation (all operating in an energy system needing open, yet secure connections) - has been extremely complicated for the regulator to manage. To be honest, they are still trying to find a path through.

Lily D'Ambrosio

MINISTER FOR ENERGY, ENVIRONMENT AND CLIMATE CHANGE

VICTORIAN GOVERNMENT

The Hon. Lily D'Ambrosio MP is a member of the Australian Labor Party and has represented the electorate of Mill Park in the Victorian Legislative Assembly since 2002. In 2016 she became Minister for Energy, Environment and Climate Change and Minister for Suburban Development, and on the return of the Andrews Labor Government she was appointed Minister for Energy, Environment and Climate Change and Minister for Solar Homes.

Minister D'Ambrosio is a leader in action on climate change, renewable energy and energy efficiency in Australia. She is a leading advocate for a modernised Australian energy system that facilitates a smooth transition into a clean, reliable and affordable energy future.

> "The new energy system has improved our way of life – we are healthier, prosperous and more community focused.."

AS YOU LOOK BACK FROM 2030, WHAT STANDS OUT ABOUT THE ENERGY TRANSITION?

The key change in the last ten years is that the energy transition has become democraticised. Communities have been at the heart of this energy system transition and we, in government, have made sure that no one was left behind.

As the impacts of climate change became more pronounced, we knew that communities and governments had to step up. Today, in the state of Victoria, we have millions of citizens of all levels of income and household circumstances who own and manage their own power generation systems and range of smart and efficient devices.

The system is now different in three main respects. First, it's more decarbonised. Here in Victoria, over 50% of our electricity comes from renewable energy sources like solar and wind. We are also well on the way to solving the next energy challenge - decarbonising the natural gas system. Second, with more distributed power generation from renewables, energy is cheaper and more efficient. We've seen retail power prices and power bills decline. Finally, we have been careful to make sure that consumers are protected. For example, energy companies need to inform their customers whether they're on the best energy plan, how much the customer could save by switching and all default plans need to offer competitive prices.

HOW HAVE YOU BEEN ABLE TO PROTECT THE MORE VULNERABLE ENERGY CONSUMER?

We've always been focused on making sure that the transition did not leave communities behind. We put in place tangible programs to support more vulnerable energy users. For example, our Solar Homes program, which meant people could get solar no matter their circumstances. The program meant that solar panel installation could be done with rebates from the state for half the price of a new solar PV system, while consumers could pay the other half through a no-interest loan scheme. As a result, we've seen more than a million homes in Victoria installing solar panels on their roofs. This has been particularly important for the most vulnerable consumers, who have become both beneficiaries of, and contributors to, the decarbonisation of the energy system.

We've also made huge strides in improving energy efficiency in existing housing stock. Back in 2020, we announced a $797 million household energy package. As part of this, we upgraded and replaced older heating systems for 250,000 vulnerable householders, with a $1,000 rebate for low-income households to replace old heaters with modern split-system. This meant houses were cooler in the summer and warmer during the winter - and helped up use all the solar power being produced by households. We also upgraded 35,000 social housing properties and established requirements for landlords to keep rental properties at a minimum energy efficiency standard. We continued improving the energy standard of new builds, which has made the 2030 housing stock more comfortable and energy efficient than anything we built before.

HOW HAS THE ENERGY TRANSITION SUPPORTED THE ECONOMY IN THE STATE OF VICTORIA?

Energy investments like these have been transformative - they have created thousands of local jobs. At the start of this decade, we believed that our 50% renewable electricity target would create 24,000 jobs - but we've exceeded that by some measure. But this has not just been about creating new renewable megawatts or decarbonising the gas system - it has also led to a range of new supply chain opportunities. Energy industry skills and capabilities have existed in Victoria for many decades, but with a more targeted focus on local content, we have transformed our energy supply chain to better support solar, onshore and offshore wind industries and the power electronics industries.

Today, Victoria is a training hub for new energy technology investments across the Asia Pacific region. We have invested in more TAFE courses specialising in new energy technologies. As such, we have been able to grow an entire ecosystem of new energy technology skills here in Victoria.

Offshore wind has been a game changer. Victoria already had good resources for onshore wind generation across the state. But over the last decade, wind farms have been developed offshore, putting us amongst the top five offshore wind generators in the world.

Victoria has also led the development of a new hydrogen industry. We had the largest distributed gas network in the whole of Australia and were risking a huge stranded asset as it became underutilized. Several pilot projects led the way, which blended renewable hydrogen with gas in the existing network - one particularly successful one has been the Wodonga or Hydrogen Park Murray Valley project, which received early funding from Australian Renewable Energy Agency. We are continuing to increase the mix of green hydrogen throughout gas infrastructure today.

DO YOU REMAIN OPTIMISTIC FOR THE FUTURE OF ENERGY IN AUSTRALIA?

The impacts of climate change sent a clear message to all world leaders and state governments - they needed to pick up the game. Today, in 2030, Australia is no longer an energy transition laggard. We are now renewable energy leaders - particularly in solar, offshore wind and hydrogen. The urgency of responding to climate change has become shared across all Australian governments - which was what we always needed to solve a problem that impacted all of us.

In Victoria, the transition has to adapt our existing skills for a different energy system. Today, we have terrific workforce capabilities, whether it is in plumbing, power electronics, solar, hydrogen or offshore wind.

We are building something here that benefits all our communities and delivers prosperity. It's not just about economic wealth either; it's about valuing every member of our community, no matter where they live. By investing both carefully and ambitiously, we have communities today who can both participate in and benefit from this new energy system. We've come a long way, but there is still a lot of hard work to do.

"Today, I think there is more of a mindset that we are all in this together, all our actions have an impact, and we need to collaborate more to drive real change."

LYNNE GALLAGHER

CHIEF EXECUTIVE OFFICER

ENERGY CONSUMERS AUSTRALIA

Lynne Gallagher

CHIEF EXECUTIVE OFFICER

ENERGY CONSUMERS AUSTRALIA

"Consumers up-ended the energy system, driven by expectations of a better energy future..."

Lynne Gallagher is an economist/econometrician by qualification and has substantial experience in economic modelling and policy reform processes, including working with the Council of Australian Governments, and in strategic issues management in the corporate sector. Her career has seen her spend 15 years in a technical environment, followed by 12 years in practice and as an adviser. Prior to her appointment as ECA's Director of Research, Lynne was Executive Director, Industry Development at Energy Networks Australia. Lynne brings to ECA strong insights, a strategic focus and a consumer advocacy perspective which has been honed from her work with network businesses, retailers and regulators.

LOOKING BACK AS WE ARE NOW IN 2030, WHAT CAN YOU TELL US ABOUT CONSUMER DRIVEN CHANGE IN THE ENERGY SECTOR OVER THE LAST TEN YEARS?

By 2030, the energy system has been transformed by consumers from the bottom-up. What started with the extraordinary consumer investment in rooftop solar was followed by a surge in demand for storage, electric vehicles and smart devices, all of which were increasingly embedded in services.

Companies that won the decade in this new environment understood Australian household and small business consumers in all their diversity and shaped their services accordingly. This was a paradigm shift from the winning business models of earlier decades which were all about understanding how to leverage scale and efficiencies in a centralised supply chain to compete on price for a homogeneous commodity.

The energy services market in 2030 is very difficult to distinguish from markets for other services, be that transport, telecommunications, and online retailing or real estate searches, because they are shaped by consumers needs for comfort, control and convenience.

WHAT DOES THE CONSUMER OF 2030 EXPECT FROM THEIR ENERGY SERVICE PROVIDER?

Consumers in 2030 trust their energy service provider to be their agent. They look for service providers who can maximise the value of technology that might be physically situated in their home or business. This means they are rewarded as part of the wider distributed energy system and their technology is managed in a way that doesn't just meet their own needs for home comfort or business profitability, but also creates value for everyone.

What we came to understand in the early 2020's was that while many of us were able to use rooftop solar to dramatically cut energy bills and clean up our own energy supply, many people - including people on low incomes and renters, and those without a roof - were being left behind by the energy transition.

ARE CONSUMERS NOW SEEN AS 'PARTNERS IN CHANGE' IN THE 2030 LANDSCAPE – AND IF SO, WHY?

Consumers are seen as 'partners in change' because the whole weight of the market and the place where value is created has shifted 'behind the meter' into the home and small business premises.

The more progressive and forward-looking parts of the energy sector started to make this big switch in thinking in the early part of the decade, realising that not only does business success hinge on securing the consent of consumers to make a change to the way essential energy services are structured and priced, but that you can take people with you. People are willing

to try new things, or wear cost or even inconvenience if they are persuaded there is a bigger payoff for them and the community.

WHAT JOURNEY HAVE ENERGY SERVICE PROVIDERS GONE THROUGH TO MEET THEIR CUSTOMERS' EXPECTATIONS IN 2030?

The old expectation in the energy market was that if consumers wanted 'better' they should really have to work for it by being 'active'. Virtuous 'active' consumers were expected to shop around and switch in a complex market where loyalty wasn't necessarily rewarded, or by changing their energy behaviours even if they were deeply embedded in daily routines that were largely fixed by practices around work, commuting, school hours and other social obligations. This of course was part of a construct which validated, quite explicitly, consumers being penalised for being 'inactive' or 'passive'.

By 2030, energy service providers have realised that it is their job to do the 'active' part for consumers who may not have time or expertise to devote to following the market or optimising increasingly complex energy technologies and systems.

The journey wasn't without bumps in the road, with business models emerging which promised savings or a great customer experience but in time failed to deliver. Empowered regulators employing a new, more agile, data-driven model of consumer protection, quickly identified bad behaviour and acted to prevent consumer detriment and a general hit to confidence.

WHAT ROLE DID THESE NEW BUSINESS MODELS HAVE IN DRIVING OR AFFECTING THE ENERGY TRANSITION TO NET ZERO?

The Australian rooftop solar story is a testament to the power of a compelling product arriving at the right time. The business model for rooftop solar PV which made the clean choice also the affordable choice in the early part of the decade really provided the impetus for us to begin the journey to net zero. It showed us where 'demand pull' can take you.

And fortunately new, more sophisticated business models then emerged which helped solve the next set of challenges for consumers and the system: how to optimise and coordinate millions of connected devices; how to unlock discretionary energy use in the home and business to give the system the flexibility it needed to host high penetrations of intermittent renewables without compromising on home comforts or business profitability; how to leverage the mobile energy storage capability of electric vehicles while giving drivers the freedom to plug in and charge when they need to.

HAS THERE BEEN A SHIFT IN PURCHASING POWER TOWARDS THE CONSUMER AND WITH THAT OPPORTUNITY? HOW HAS THAT MANIFESTED ITSELF IN THE MARKET IN 2030?

A consumer's 'energy dollar' goes much further in 2030 because smarter energy management technology and services in the home and small business have given them the fine-tuned control over their energy use that they never had in the old centralised, analogue, energy world.

This new control, paired with a massive uplift in the energy performance of our housing stock, means consumers have been freed from the tyranny of leaky homes where comfort depended on running the air conditioner full-bore in summer and the heater full-bore in winter.

In 2020, Australia was one of the few OECD countries without obligations on energy companies to support energy efficiency. Over the past decade, we have seen all sorts of creative ways emerging to support consumers from banks offering lower rates on loans for properties with higher energy efficiency ratings, to no-interest loan schemes for more energy efficient appliances and home retrofits, through to gifting programs which allow employees and customers to donate funds to support low-income households retrofit housing for greater energy efficiency. This has a social impact - for example, supporting people living in the poorest homes - as it means that less of their discretionary income is being sucked into simply heating or cooling their houses.

DO YOU SEE ANY OTHER BIG DISRUPTIONS IN THE ENERGY MARKET IN 2030 FROM THE CONSUMER PERSPECTIVE?

There is a tendency to think about disruption in terms of the technology - 'the shiny kit' - as the game changer for the energy market. But in the same way that even the experts were surprised by the way the iPhone unlocked the sharing economy, I think we will be surprised by the new interactions and services that evolve around these new technologies.

It's easy to overlook how the household not just as a taker of energy services but as a producer and a market participant profoundly changes the way we think about what 'home' means. The daily routines and social practices we take for granted - how and when we make breakfast, when we shower, where we launder our clothes, when we gather as a family to watch a movie - have grown up around a particular model of electricity and gas enabled lighting, heating, and appliances that might very well be recast by different models of ownership, production and relationships. We have seen how energy services evolved in the past decade as the impact of the COVID-19 working from home experiment stuck, opened up energy services which leveraged the additional flexibility working from home provided to run certain appliances at times that previously were not practical.

Mark Mazurek

CHIEF EXECUTIVE OFFICER

LINFOX

As CEO Linfox Logistics Australia and New Zealand, Mark Mazurek is responsible for leading the largest privately-owned logistics company in Asia Pacific to achieve its vision to be the most trusted logistics partner in Australia and New Zealand. Mark leads the way with a focused business strategy designed to deliver industry-leading safety, wellbeing and industry compliance, outstanding customer service and smarter, environmentally sustainable supply chain solutions positioned for growth and prosperity.

Mark is passionate about promoting the logistics industry and paving the way for a more sustainable future through innovation and investment while attracting the best people into the sector regardless of age or gender.

"In trucking and logistics, equipment has to work 24/7 - in the early days of hydrogen it was all a bit of a challenge..."

WHAT ARE THE CHANGES OVER THE LAST TEN YEARS WHICH HAVE LED TO A MORE SUSTAINABLE TRANSPORTATION AND LOGISTICS SECTOR?

Linfox operates thousands of vehicles across Australia and New Zealand and we have millions of square metres of warehouse space in both countries. Our five-year "Leading the Way 2025" business strategy was created at the start of this decade and will continue beyond it, with our key strategic driver: 'Act Sustainable.' Our GreenFox sustainability program aims to get Linfox to a better environmental position by directing our focus to cleaner transport, mitigation of diesel emissions, waste management, water conservation and temperature control of our buildings, so we don't waste power or food products that are being transported. Previously, around 80% of our emissions came from our vehicles, with the other 20% coming mainly from power usage for temperature control in our warehouses. Over the last ten years, Linfox has achieved an enormous reduction in emissions.

DO YOU THINK THAT THE INDIVIDUAL CONSUMER HAS PLAYED A MAJOR ROLE IN THIS SUSTAINABILITY SHIFT OVER THE LAST 10 YEARS?

We have been on so many journeys with our customers over the years - they choose us because we have sustainability embedded into the organisation. We built our first carbon neutral warehouse in Willawong, Queensland in 2020, installing over 700 kilowatts of solar PVs on the roof supported by a large storage battery and a renewable electricity contract. It enables us to charge electric vehicles directly, and, as it is also near the railhead, it allows us to transport products by rail, which is much less energy intensive. It means that when the COVID-19 crisis happened, we could easily support and be supported by our customers. They appreciated the effort made by Linfox and our logistics partners - particularly around the extra food deliveries and COVID-19 vaccination storage. Our customers saw it was possible for an organisation like Linfox, not only to develop a fully carbon neutral facility, but also make it available for use in a real emergency.

IN 2030, WHAT ARE THE MAIN RENEWABLE SOURCES THAT YOU RELY ON? WHAT ARE THE CHALLENGES AND BENEFITS THEY PRESENT?

Hydrogen has been big for our company and we have worked hard to assimilate it into our operations - to make it "market ready". Previously, most of our emissions came from diesel usage but switching to hydrogen was a game-changer. This was achieved through a combination of the big OEM manufacturers providing companies like ours with more durable, efficient, and warrantied equipment, along with growing hydrogen infrastructure such as refuelling stations for trucks.

Hydrogen hasn't solved all our problems. Even today, if we're trying to get freight from Melbourne to Cairns it's a challenge despite using hydrogen vehicles, so instead we use Linfox's intermodal rail solution. Growth in rail freight in Australia has been facilitated by the federal government's decision to build a dedicated inland freight rail service that connected Melbourne to Brisbane in the last decade - it meant a lot of trucks could be redeployed.

Lithium batteries have also been very important for our business. In our warehouses, we operate equipment like forklifts and materials handling equipment that used to run using LPG, which must be handled with care. As lithium battery power improved, we switched. Lithium has allowed us not only to become carbon neutral but to run our warehouse operations more safely.

With energy prices dropping during the last decade, renewable electricity from the grid powered by solar, wind and green hydrogen played an important part of the clean electricity consumed in our warehouses.

WHAT ELSE HAS BEEN IMPORTANT FOR LINFOX IN MOVING TOWARD YOUR NET ZERO GOAL?

There have been several changes which have really allowed us to decarbonise and optimise our operations. For example, we made a huge investment in solar power. Back in 2021, we increased our solar generation by 50%; a year later we increased it by another 100%, meaning it accelerated the greening of the sites we were building and the sites we were leasing.

We also changed to smart LED lighting with tens of thousands of light installations in our warehouses, transport yards and offices. Even though we generate our own renewable power, we are also keen to save energy. Previously, older warehousing technology used halogen style lighting which is very inefficient. Between 2020 and 2022, we changed over 12 thousand individual bulbs across our network - a huge undertaking. Today, it means we are saving more than 7,000 megawatts-hour of electricity every year. This new lighting has the added advantage of being safer - older bulbs take a while to warm up, meaning often people were working in gloomier conditions. The newer lighting is instantaneous. It's also smarter, not through being automatic, but in being more intelligent, with motion and daylight harvesting sensors. It can, for example, differentiate between warehousing zones to create optimum lighting conditions for our workforce. In this way, it has reduced both our costs and energy consumption.

We have used higher productivity vehicles in locations where it made sense - larger vehicles with higher weight loads. As they have more brakes and axles, they drive with better stability and efficiency. It means they are not only more effective to drive, but that the road surface isn't damaged by their weight.

The change in regulations to allow more of this type of vehicle has meant we can now take more product longer distances in a much more energy efficient way.

Strong relationships with our suppliers have also been very important. We value our long-term relationships and we have worked with our partners to stay ahead of the curve in both sustainability and technology. For example, we were buying Euro 6 standard vehicles to reduce our carbon footprint long before they were mandated in Australia; we have worked with suppliers and governments to create special rules to allow our 80 tonne plus vehicles to travel safely through traffic signals; we have figured out ways to make our vehicles more productive, so they don't return empty from long trips. All this only comes by having the strong relationships and understanding with our partners and our customers, as well as the right systems in place.

Our biggest shift toward net zero, however, probably came about through our people - the fact that our GreenFox Champions care so much about sustainability. Today we have a much younger workforce; they expect and demand that organisations like ours do not damage the environment. Through a unique combination of our employees being very passionate about sustainability, along with the Linfox family investing to realise a more sustainable logistics business, we have created a real driving force toward net zero for our business.

Matthew Warren

ENERGY JOURNALIST AND MARKET COMMENTATOR

Matthew Warren is a leading commentator on climate and energy in Australia. Matthew has spent the past 25 years working inside Australia's energy and environmental policy debates and has worked for coal, renewables and major energy companies, running the Australian Energy Council and the Clean Energy Council. He is author of the Walkley nominated book Blackout, and is a regular contributor on energy and climate for the Australian Financial Review. He is a Principal at Boardroom Energy, a business advisory on energy and climate.

"So far this energy transition has been inefficient and unequal..."

WHAT ARE THE MAIN CHARACTERISTICS OF THE ENERGY LANDSCAPE TODAY IN 2030?

In Australia in 2030, we are producing less emissions in our energy use compared to a decade earlier. Investment continues in Renewable Energy Zones supported by a combination of firming technologies: more utility scale batteries and pumped hydro. Snowy 2.0 is finally on-line, but there is still inter-state haggling about who will pay for the expanded transmission to Tasmania's *Battery of the Nation* project.

More coal generators have closed, while there is more gas peaking capacity, to jump in around the renewables, along with some early adopters of expensive bulk hydrogen which is used to store and release the renewables oversupply.

It's become an increasingly inelegant and interventionist transformation. More utility scale batteries are needed to provide the blistering electricity grid ramp rates required every late afternoon, but each one requires significant co-funding from governments to cross the commercial line.

Transport and stationary energy are still significantly dependent on fossil fuels with conventional fuel vehicles, while natural gas and coal are still in widespread use. Globally, affluent low carbon markets like Europe and the US have resorted to industrial protectionism to help them protect domestic markets while transitioning to a lower carbon economy.

The retail electricity market has fragmented. There is more bundling of energy with other services. Energy consumption is data driven. Trading between consumers is automated, distributed batteries and solar generators are digitally aggregated.

Electric vehicle charging is becoming an integral part of this system. Chargers are located in daytime car parks and shopping centres, anywhere to maximise the free solar electricity in the middle of the day. EV owners are supposed to leave their cars attached to chargers to help feed electricity back in during the late afternoon, but many of them unplug their cars so they still have a full tank of electricity to drive home.

Most of the electricity market reforms introduced in the 1990's have been phased out. It has been a gradual, indirect process. The electricity market continues mainly as a dispatch mechanism. Investment is driven by each state government in coordination with the Australian Energy Central Planner (formerly AEMO).

The replacement of a market-based approach with central planning has made the grid less efficient, more expensive and more "gold plated". Some multi-billion dollar transmission lines considered "essential" a few years earlier are rarely used. Stranded assets grow in number. Power bills are capped (it's more politically palatable) and the cost of a decade of wasteful investment transferred onto public debt.

Carbon pricing has been reintroduced (somewhat reluctantly) as a strategic response to the global carbon trade wars between China, Europe and the US.

WHAT HAVE BEEN SOME OF THE KEY DEVELOPMENTS OVER THE PAST DECADE THAT HAVE GOT US TO THIS POINT IN 2030?

Australia hoped to create new economic growth by exploiting cheap renewable electricity and using this to expand its industrial base and export cheap hydrogen. Australia remains the world leader in integrating renewables with resulting lower electricity emissions.

While we are blessed with abundant supplies of solar and wind energy, this has not converted into cheap hydrogen exports and world leading investment in green steel, cement, manufacturing, electric car making or hydrogen exports. Australia is still a major exporter of natural gas and some high grade metallurgical and thermal coals. There are still no meaningful commercial hydrogen exports from Australia. The cost of transporting it is prohibitive.

Like other developed economies, the enduring political fault line in 2030 remains between affluent, technology-embracing climate-firsters and poorer, more economically vulnerable jobs-firsters. The former have switched to electric vehicles, the latter continue to drive combustion engine cars.

To mitigate this, successive governments have tried to find ways of getting solar panels on even more household rooftops, increasing the costs of providing network services to manage massive daytime spikes in distributed solar generation and accelerating the rate at which firm electricity is needed to keep the lights on as the sun sets. This requires more money to subside large batteries. It's a virtuous circle of government support.

Electric vehicles continue to take market share from ICEs, resulting in a national subsidy scheme to keep essential petrol stations operating.

A decade of promising green collar jobs and an employment boom has not materialised. Most new employment is in services. As the renewables mega-build slowed, the scale of employment in electricity supply actually fell, as renewables required fewer workers per megawatt hour than fossil fuels and each coal generator closed.

HOW ARE THE COMPETING VOICES AND BUSINESSES IN THE ENERGY SECTOR CO-EXISTING IN 2030?

Changing industry dynamics and new competitors have created an extremely difficult environment for incumbents. This has been particularly evident in the natural gas industry which is battling for its survival - the fight has become highly politicised and companies are being increasingly demonised. While they still play a critical role in the new energy market, like proving low cost, high temperature heat, efforts to reduce emissions through sequestration have proved stubbornly expensive and ineffective. Gas remains essential for key industrial consumers and remains highly export focussed, yet its oddly also a twilight industry, its demise dependent on the arrival of low-cost hydrogen. The hydrogen revolution has progressed, but has underwhelmed early euphoria. It's a sullen market: gas continuing to serve critical industries and export markets while waiting for its execution by a replacement that has soaked up billions in government assistance and is running late. No one seems happy.

Consumers want simplicity. Energy is increasingly bolted on to other services in a time-poor, choice rich world. Banks, telecoms and insurance companies, basically whoever has a commercial relationship with households, have offered new services bundled up with cheaper energy. Incumbents are buckling under the pressure as more nimble or well-resourced competitors cherry pick the market sweet spots, leaving them with the bits that are much less commercially attractive and have an increasingly uncertain future.

Mike Nicholls

PARTNER

MAIN SEQUENCE VENTURES

Mike Nicholls is a Partner at Main Sequence Ventures. An Entrepreneur, Inventor and Technologist, he has over thirty years of 30 business experience in Sales & Marketing, is the CEO & MD of four companies and has practical experience across a range of industries. Mike helps a lot of start-ups, researchers and entrepreneurs in the Australian start-up and research ecosystem and is the fund expert at helping start-ups generate their early customer leads and opportunities.

"Decarbonising energy is increasingly a matter of storage and solving the sunset to sunrise problem and moving as much of our load as possible to when renewables are generating."

WHAT DOES THE ENERGY MARKET LOOK LIKE IN 2030?

In 2030, we have solved the biggest challenge the energy market was experiencing back in 2021 - which was how we can store renewable energy, particularly solar to provide power at night, solving the Sunset to Sunrise problem.

The solution isn't just about bigger and better batteries. Batteries are great for shorter time frames and sudden response, but they are hard to scale. We need a breakthrough in new types of materials but physics, chemistry and materials are not like software, you can't just dial them up overnight and often the improvements are incremental not exponential; batteries are part of the solution but it's going to take more.

A key part of the solution has come from the widespread use of hydrogen. While hydrogen was still pretty niche in 2021 and was largely created using fossil fuels, we now see it being used across transportation, storage and as feedstocks for industrial purposes like steelmaking and aluminium smelting. However, it's still early days and much of the hydrogen available today is created by reforming gas (blue hydrogen). So while it's cleaner burning than coal, petrol or diesel, it still doesn't completely solve the emissions problem. We need to get to the point where hydrogen is being generated by renewable energy and being stored and then converted back to electricity by a fuel cell to drive electric motors rather than being burnt.

In Australian rural areas, for example, we have seen the switching over from diesel generators to green hydrogen generated from renewables for more economical electricity at night with zero emissions.

State and the federal government have also become more aware of the flexibility that large-scale pumped hydro can offer. The NSW Government has invested billions in pumped hydro plants - essentially a large-scale storage solution that can be released onto the grid during the evening to generate electricity when renewables are generating less.

Renewable intermittency issues have also been addressed through better energy efficiency, with consumers moving their consumption away from expensive times of the day to when renewables generation is at the peak. In 2021, the wholesale prices for electricity during the middle of a day was already dropping fast and, in some states such as South Australia, dropping down to zero or sometimes paying consumers to take electricity off the grid. New smart grid technologies and processes have enabled consumers to program appliances and machinery to automatically move their consumption to when renewables are generating the most power and the price is cheaper or even free.

Successes like this have led to the faster than predicted demise of coal power generation. In 2021, it was already becoming uneconomic to run coal power generation at certain times of the day. As renewable power generation and consumption has become more balanced and we got more storage during the evening, coal had no escape plan as it became uneconomic in the evening - and their remaining margins were eaten away.

With coal power plants, you can't just turn them on and off like a battery. You need to run them at full speed and if you bring them up and down, it makes them very unreliable. Gas fired generation, however, hasn't experienced quite the same issues. Gas power plants are much more flexible and can be spooled up and down. While renewable generation is still cheaper, natural gas has found an interim role in the 2030 energy system firming up the evening cycle.

WHAT ARE SOME OF THE NEW SUCCESSFUL TECHNOLOGIES BEHIND THIS 2030 ENERGY SYSTEM?

Solar has been the big success story, particularly in Australia. In 2021, there were 2.6 million solar panel installations on people's roofs and that trend has continued.

We have seen interesting new developments in solar energy technology. One I would highlight is the development of solar film, a flexible thin film that generates solar energy sandwiched between two sheet of glass and is installed in buildings. This film could lead to net zero carbon glass as it could generate enough electricity in its lifetime to offset the emissions created by its manufacture.

Solar's success is resulting in new challenges. Many households installed solar panels, for example, but hardly any installed batteries; they only considered the first step of the renewable energy journey - batteries were subeconomic so there were only about 200,000 installed in 2021. Many forecasters had predicted that the cost of these back up energy batteries would have halved in five years. But building and scaling them is harder, particularly as the availability and cost of the critical raw battery metals and materials is becoming a real challenge.

HOW HAS THE ENERGY MARKET STRUCTURE CHANGED AS A RESULT?

As we move to an almost decentralised, distributed generation and storage energy system, we are seeing many more start-up and new technology companies in the market. This has thrown up the classic innovation dilemma. The questions for the incumbent energy companies are, should we move wholesale into that distributed model, can we get control or ownership of the assets behind the meter, and if we can, what happens to our existing coal powered generators, as we are sacrificing some of the old revenue to bring in the new?

For the new entrants, the challenge is more about whether their innovation or technology quickly becomes the new face of generation and storage and gaining some control over these distributed generation and storage assets. For the old market players, there are tipping points; they are being slowly strangled by their old technology and business models and the capital markets. Some of them are already splitting out those old assets into separate companies and selling this to the market (there are a bunch of climate deniers who will buy this) squeezing as much as they can out of the assets before they are shut down, and trying to turn the mothership around as a greener energy business.

HOW HAVE YOU SEEN TECHNOLOGY SKILLS ADAPT TO THE SHIFT IN THE ENERGY LANDSCAPE?

At Main Sequence, we highlight that one of the key challenges for the future is how to enable that next big intelligence leap, by that we mean where advances in technology are happening faster than society's ability to adapt. How do we re-educate, adapt, exploit and protect people for a new world? In energy, I see two key success factors - research work focused on renewables and the fast implementation of the skills needed to commercialise and deploy the new technologies. Australia has always had a strong research background; we are amazing at developing new technologies but not so awesome at commercialising them. One of the big challenges we have is upskilling and training new talent to work in this new industry and that is proving just as difficult a problem to solve.

Patrick Hartley

LEADER, CSIRO HYDROGEN INDUSTRY MISSION

CSIRO ENERGY

"In 2030 we're at peak energy sector disruption – and that's a good thing..."

Back in 2021 most people were saying it would take until 2030 for the transformation of the energy sector to even get going, but I have seen huge progress. Take transportation, we did a roadmap for Australia's hydrogen industry back in 2018, and highlighted it as the sector with the best near-term opportunity for emissions reductions using hydrogen - now we have fuel cell heavy vehicles and of course, electric vehicles everywhere.

Natural gas networks, meanwhile, have been transformed by hydrogen much more than we expected given the technoeconomic modelling we did. That industry pushed way harder than we anticipated to get hydrogen into their pipelines - whole towns are now running on hydrogen. Natural gas is now used much more to support solar and wind plants and shore-up supply to meet peak demand. We are also seeing a lot of combined wind and solar projects which has really pushed up the capacity of renewable generation. So, while it might all be low hanging fruit, these higher renewable capacity factors and a clearer pathway for hydrogen are making a real difference.

Hydrogen is becoming the game changer. People ask, what's different for hydrogen this time around? I say, the abundant supply of very cheap renewable energy. In 2030, we are now getting close to $2/kg of hydrogen mark - even for green hydrogen - due to the ongoing reductions in renewable energy costs, and it will become cheaper still.

Hydrogen technologies are becoming more mature. While work still needs to be done on economies of scale, we are getting there. Brown hydrogen (produced from natural gas) was already widely used in heavy industries like refining fertilizer production, and now blue hydrogen (produced from decarbonised natural gas) and green hydrogen (produced using renewable energy or electrolysis from water) are displacing it. We are also on the way to zero emission shipping using hydrogen-based fuels. The 2020 IMO regulations cleaned up shipping fuel to drive emissions reductions; and there are now some ammonia and hydrogen powered ships in operation.

Where will the innovations come from for hydrogen next? It could be from a new use case, like the role it can play as a feedstock and in industries like steel. What is also positive is that more countries have hydrogen as a key part of their national energy strategies so that's become quite a stimulus.

Other energy innovations which can connect to hydrogen are also on the horizon. Using direct CO2 capture from the air is a good example. If that becomes more economic, then you've opened a whole new area of low emission fuels and chemicals development - such as methanol production. Such innovations are interesting in sectors where decarbonisation is harder, so they can play a role in industries like petrochemicals, making net zero methanol feedstock for chemicals used in products like adhesives, foams, and solvents, for instance.

To make energy innovation an even greater success we need more - more focus, more time, and better economics (reductions in renewable energy and hydrogen supply chain costs). The need for patient, tenacious investment in this transition is especially important, as it's too easy to get swept up in the hype and believe it can all be done today. But perhaps the most important success factor is scale, and by that I mean economies of scale.

Take hydrogen, for example. We need to be expanding the market faster, driving up demand to scale production to further drive down costs. While a lot of equipment and infrastructure needs only minor alterations, there have been issues with the scale of the hydrogen rollout as so many appliances - like household boilers - needed to be changed.

This energy transition also needs a different workforce. People who know how to couple batteries with hydrogen, power, natural gas or refuelling systems, people who are good at sector integration and collaboration. They might be engineers, but if they are, they are a different sort of engineer; maybe we can call them energy eco-system integrators?

The regulatory environment for this new energy system is also important - some regulations have needed to be removed, others are being adapted, or invented. We have had to adapt environmental protection approvals to be more contingent on greenhouse gas emission intensity in projects, for example. Also, regarding safety, new regulations have had to be put in place for hydrogen as it's a hugely different gas to what we would traditionally pump around our gas networks.

All this cleaner energy technology development means we are not only seeing the electricity grid reimagined but increasingly, whole industries like chemicals and materials reimagined - it's exciting. In 2030, the energy sector is at peak disruption, that is a good thing and I'm immensely proud of that.

Dr Patrick Hartley is the leader of CSIRO's Hydrogen Industry Mission. In this role, he is responsible for developing the strategy and partnerships for a major new national initiative which was launched in May 2021 which focusses on delivering RD&D to enable the scaleup of Australia's domestic and export hydrogen industries. In 2018, he co-led the development of CSIRO's National Hydrogen Roadmap, and worked with the Chief Scientist of Australia, Dr Alan Finkel, Leader, CSIRO Hydrogen Industry Mission on delivering the briefing paper 'Hydrogen for Australia's Future' which was presented to the Council of Australian Government's (COAG) Energy council. This laid the foundations for the development of Australia's National Hydrogen Strategy, which was subsequently delivered and adopted by all of Australia's federal state and territory governments in November 2019.

"It's a very challenging geopolitical landscape. Leaders today need to understand that, as businesses are being transformed, they remain as engaged with their investors and consumers as they are with governments."

TOM RIDSDILL-SMITH
SENIOR VICE PRESIDENT CLIMATE
WOODSIDE ENERGY

Robert J. Johnston

MD ENERGY, CLIMATE & RESOURCES AND EXECUTIVE ADVISOR

EURASIA GROUP

"The green transition has led to new geopolitical tensions..."

The geopolitical energy landscape in 2030 is markedly different from previous decades. The biggest change has been that while the Middle East is still a major oil and gas producer (due to its low cost and low carbon intensity production), the dynamic between the United States (USA), the European Union (EU), China, Russia, and Japan is now less about securing oil and more about electricity grid security and access to those critical minerals needed to support low carbon energy.

The shift to a greener energy landscape is resulting in new tensions in countries producing materials like lithium and cobalt, which are needed for cathodes and anodes in battery production as well as platinum group metals and rare earth elements used in electrolysers for hydrogen production. The Democratic Republic of Congo, Bolivia, Australia, Indonesia and Canada produce the resources but most are still refined and processed in China, which now dominates the geopolitics of energy rather than Petro-States like Saudi Arabia, Russia or Venezuela, predominant in the 20th century.

China, has continued to grow throughout the decade, has progressed from being one of the largest emitters of greenhouse gasses to mass electrification through the rapid scaling of renewable and zero-emissions technology.

Tensions have also surfaced where states have imposed carbon border adjustment mechanisms that essentially tax fossil fuel imports. The EU and other mature economies[1] have advanced their green taxonomy and broader sustainability principles, particularly across the financial sector, while their consumers are increasingly green aware.

This is having a knock-on effect on climate politics in other large economies, but not in the way we originally predicted. The EU's more confrontational approach in terms of carbon border mechanisms and placing tariffs on states without appropriate climate policies has motivated countries like Russia and China to increase the stringency of their own greenhouse gas regulations.

The pace of the green transition in most countries has, however, been uneven. It has been hard to match job creation in renewable energy sectors with workers dislocated from fossil fuel industries like upstream oil and gas production or production of internal combustion automotives. Also, while the COVID-19 crisis in 2020/21 set conditions for governments to create green stimulus packages, the impact was temporary, with people quickly getting back to global travel and commuting. The bigger change has been where governments injected liquidity and stimulus into key green sectors such as hydrogen or large battery plants in Europe and China.

The transition has been much more challenging for countries in the developing world. Major oil and gas producers in parts of the Middle East, North Africa, West Africa, Central Asia, and Latin America, are now searching for new engines of growth to replace stranded oil reserves and infrastructure. Countries that have not had a successful transition to a post-petroleum economy are at risk of becoming failed states in the face of economic crises, corruption, and weak political institutions.

Additional geopolitical concerns have also emerged in 2030 around so-called 'geo-technologies' which support grid resilience and grid security. Critical infrastructure and integration of electrical grids into broader cloud-based IT systems has created new vulnerabilities and these are being

Robert ("RJ") Johnston returned in 2018 to lead the firm's energy and natural resources practice after serving as Eurasia Group's chief executive officer for five years. Prior to joining Eurasia Group, RJ served as managing director of equity research at Medley Global Advisors, serving as the lead analyst for global energy equities. RJ, in addition, was a research director at UBS Warburg Energy and previously directed internal research teams at Enron Global Markets.

RJ holds a doctorate in international relations from American University, a master's degree in political science from McMaster University, and a bachelor's degree in political studies from Bishop's University.

exposed by hostile actors, whether they are nation states, criminals, or terrorist groups. While distributed generation, local small-scale micro grids and renewables appear more resilient, they are also creating new openings for attacks at a more local level.

Data has become an important feature of the green energy landscape and a growth industry has developed around tracing the source of a commodity. For example, it's important to show that a fossil fuel like natural gas was processed with no flaring, or that a raw material has been mined at a site with responsible tailings management and been produced using green power. There has been rapid growth in data to verify company ESG claims, which they need to maintain their market share and access to capital.

Digital verification is increasingly necessary in consumer and industrial transactions to ensure people get the clean product they think they're paying for.

It's a very challenging geopolitical landscape. Leaders today need to understand that, as businesses are being transformed, they remain as engaged with their investors and consumers as they are with governments. These new energy supply chains need particular attention - not only on their efficiencies or on their new products and services but also on their wider ESG footprint; climate impact, human rights, gender and racial diversity and similar considerations. It is important to be aware of the impact of the energy transformation in its entirety.

1 For example countries such as Australia, Canada, China, France, Germany, India, Italy, Japan, Republic of Korea, the United Kingdom, the United States, as well as the European Union.

Sally-Ann Williams

CHIEF EXECUTIVE OFFICER
CICADA INNOVATIONS

As the CEO of Cicada Innovations Sally-Ann Williams leads Australia's pioneering deep tech incubator building companies solving the world's most pressing problems through science and engineering. Cicada Innovations has nurtured hundreds of visionary deep tech innovators to validate, commercialise and scale high impact technologies globally across MedTech, HealthTech, AgTech, FoodTech, Clean Energy, AI, Manufacturing 4.0 and more.

Prior to joining Cicada Innovations she spent over 12 years at Google as an Executive Program Manager on the engineering team leading work on R&D collaborations with universities, startup and entrepreneurship engagement and pioneering work on CS & STEM education including building world first collaborations delivering national transformation.

"Energy industry innovation is growing; it could have a huge economic impact."

In an innovation focused company like Cicada, we actively support technology ventured in many sectors like MedTech, agrifood tech, SpaceTech, quantum and more. Today in 2030, we are increasingly supporting EnergyTech, a focus which only started to emerge as a critical industry around a decade ago. Investor engagement in the energy sector is now massive and make no mistake, they're investing for the economic return they will get from their investments coming to market as well as the impact.

We know that science has been moving into the green energy space for a long time. But we needed business drivers and commitments from boards and from C-suite executives to invest and put their money where their mouth is. The C-suite needed to understand this transition is not only about environmental and social governance (ESG) and a licence to operate, but also about business continuity - their long-term survival as a company.

Over the past decade, there has been a lot that has emerged from a green energy technology perspective which I think is exciting. Instead of being on the fringe - something that only a few people did with solar panels on the roof - we are seeing the widespread take up of solar and wind power. We're also seeing batteries with a much longer and more efficient lifespan. And our technical know-how has improved across newer energy sources like wave power and geothermal technologies, and energy storage solutions like hydrogen.

I am really excited by the terminology being used in the energy technology space today, which reflects this massive change. Take the concept of collective energy, applied in such ways as through the operation of a shared community micro grid. Through concepts like this we are seeing a lot more novel ideas both around energy systems, including the reinvention of how the micro grid may operate with new distributed, democratised, and shared energy generation and storage. There has been a lot of focus on how communities can be supplied with renewables while also being self-sustaining and allowing better energy sharing.

Another term I like is elastic - we are thinking about energy in a more elastic, or flexible, way. For example, asking ourselves what the role of artificial intelligence in energy is, and how it can help us: not only as consumers, but in terms of influencing our behaviour and harnessing the flexibility of the system to optimise the whole grid, with better storage, availability and capacity for everyone.

This mindset of more collective and elastic energy systems is transforming the way we live. What is emerging, particularly in countries building new cities and new towns, are different designs and builds for energy infrastructure, roads, buildings, public lighting, transportation and public infrastructure. It is all low carbon, flexible and more energy efficient. We are now thinking about energy in a fundamentally different way.

None of this has happened easily. It needed visionary leadership, and governments have played a big role in that - though not every government! We also needed to have a greater understanding of

how to develop a greener energy system with more awareness of the economics and costs of scaling it. This is imperative as the impact flows back to companies investing in research and development (R&D) for new sources of renewable energies and technologies.

I think we still need to think more about resilience, reliability, and efficiencies in the energy system. Guiding people to make informed choices is important, whether it's about advancing independent energy, creating more awareness of energy resilience (the impact greater demand has on the grid) or a better understanding of high energy consumption in industry and supply chains. There will be so many things we haven't thought of yet that can be deployed, which might not only give us more flexibility but can build this resilience and reliability.

We shouldn't shy away from difficult tasks; we need to continue to lean into them because new technologies can provide greener energy solutions and prosperity for people and for the planet. It's not an 'either or', it's more of a 'yes and' opportunity. Take artificial intelligence and machine learning - that's a whole lot of jobs and skills opportunities right there. The impact of having policies that are visionary and transformative, that meet sustainability goals and delivers reliable energy, can flow through to these jobs and opportunities - from pure research through to technology commercialisation and deployment.

In Australia, we unfortunately have been playing catch up in R&D associated with energy technology. So we would be crazy not to run after it faster - it's the next economic boom. While we are known for exporting our minerals, there is no reason we can't be global exporters of green energy - renewables, technologies, new energy systems and engineers. It's a huge driver of long term, sustainable, high value job creation. You just need to show people a clearer pathway and better articulate the associated benefits. That's not only where the magic of innovation happens; it's also where the magic of business profitability happens.

Stephanie Unwin

CHIEF EXECUTIVE OFFICER

HORIZON POWER

As Chief Executive Officer of Horizon Power, Stephanie Unwin leads a 500 strong team of energy professionals to deliver power to some of Western Australia's most remote and regional communities. Under her leadership Horizon Power is transforming the WA regional energy landscape in an increasingly decentralised delivery model.

Stephanie is passionate about collaboration, inclusion and diversity to build an engaged and inspired workforce. Her ability to facilitate change on a foundation of safety is delivering Horizon Power's vision of innovative customer choices, reduced costs and cleaner, greener energy solutions for the future through reducing Horizon Power's carbon footprint, and investing in new technologies such as hydrogen.

> "Dealing with the problems of renewable intermittency gave us a technology gift for the planet."

If we do not embrace and address climate change, then we are only going to be takers of disaster rather than makers of the future. Looking back, significant progress has been made over the past decade, with decarbonisation pathways no longer a novel 2050 ambition but a here-and-now outcome. The push came increasingly from mainstream shareholders who collectively acknowledged that our heritage, our rivers and our natural environment has standing and the right to exist in a sustainable manner. Having a social licence to operate moved from a nice-to-have collection of words to fundamental principles that led to actual decision-making on the ground.

Hydrogen was a technology gift that emerged as a game changer for the planet. It was born from necessity on how to a create a cleaner energy source that also solved longer and deeper - seasonal, weekly, not just four hours or so - storage challenges. A great leap in innovation

occurred to take hydrogen into the energy space, for it to become an "un-locker" of fossil fuel-based industry processing. The cost reduction of producing hydrogen gave it the right to play in the energy system and heavy industry embraced it. In addition, just like the revolution that saw solar scale up, costs plummet and the take-up on solar PV on rooftops explode, so too did the option in technology to harness excess energy and make it available for use when needed most.

The duck curve[1] was a thing of the past, and the system planners could breathe again.

On a much bigger scale, we saw the same technology gift enable us to radically decarbonise and use our competitive advantage in vast scale solar and wind resources to create a burgeoning green steel industry onshore in Australia. We moved from just mining iron ore to making iron and steel. This bold audacious move to create a green steel industry, took ambition on the part of our political and industry leaders, supported by the enabling energy system infrastructure and our traditional landowners - with a focus on moving to fairer growth in a decarbonised economy.

Underpinning this green transition has been a much greater use of technology. It provided insight into all the moving parts, a real-time understanding of what was going on, where the energy was available and where it was needed.

In industry, we took the best of the world's technology into processing and created an outcome that started a new industrial wave in Australia – traditionally hard to abate sectors had the imperative to re-look at their opportunities and the technology to make change. Progress was hard at the start of the decade but a concerted worldwide push just made it non-negotiable by 2030. Those that stood back are wrestling with the issue of stranded product that no major economy wants to buy due to its carbon impact.

Within the utilities, technology was both the platform to orchestrate a complex multidirectional system and a mechanism to operate and maintain assets. For our employees it has enabled us to coordinate and optimise energy participants while real-time fault response systems, robotics and remote service delivery have meant our crews are now firmly behind the joy stick, not driving for hundreds of kilometres to manually identify and rectify a lightning strike to a line.

One of the features of the world in 2030 is that we see and hear everything through data capture and our crews and workforce are very digitally savvy. Our living labs tell us everything we need to know about the demand-supply equation, the weather, the availability of assets and how to best use these so our rooftops go first and maximise their contribution to the energy mix.

The regulatory environment had to reinvent itself. The 2021 environment was dysfunctional and at odds with the innovation needed to drive the right capital decisions. Regulators shifted gear and enabled technology expenditure to push through and drive infrastructure to be upgraded, changed and developed for the new economy. It was refreshing to see the regulator expand the forward-looking economic efficiency arguments to consider technology solutions for managing mass disruption, and distribution level generation with EV's back to the grid.

One of the smaller, but none the less remarkable achievements, in the decade is how we have moved our remote communities from reliance largely on conventional centralised diesel to their own green and smart microgrids. These work with their natural assets - the customer rooftops - and can also orchestrate and make use of the intermittency solutions in hydrogen and battery storage.

Commercial enterprises are happily creating their own microgrids - often bundling water and municipal service as part of their microgrid offering. This bundling - given the provision of water is at most times the biggest consumer of energy in these remote and regional towns - enables better load management, optimising the outcome for the system with each customer playing their part and reducing their costs as a result. We have developed products that make this fair - even if the rooftop is not owned - and the community shares in a virtual communal rooftop that lowers their bills. Hydrogen is playing its part using excess solar or wind for an always available fuel cell.

As we consider where we are in 2030 and the way forward, Australia did emerge from a slower start on the world stage to be a de-carbonised industry and clean energy leader - it chose to embrace the gift of technology and couple this with its vast resources in the green economy for a lasting competitive advantage. The successful energy transition involved placing bets on numerous technologies and successfully transferring large parts of the workforce from the carbon economy to non-carbon sectors.

In 2030, the place Australia plays on the world stage is something to be proud of - a climate change leader, an advocate for our heritage and precious natural environment, an industrial player in harmony with a shared, clean environment where we are careful where we place our footprint and smart in how we do it.

1 A graph of power production over the course of a day showing the timing imbalance between peak demand and renewable energy production.

Stephen Harty

CHIEF EXECUTIVE OFFICER

GLADSTONE LNG (GLNG)

"In 2030, a premium LNG product is one offsetting Scope 1, 2 and 3 (end of use) emissions through CCS; GLNG is aiming to provide that service..."

WHAT ROLE HAS THE GAS INDUSTRY PLAYED IN THE TRANSITION TOWARDS NET ZERO OVER THE LAST DECADE?

The gas industry has played a significant role in reducing global carbon emissions in the lead-up to 2030. After the initial industry focus of reducing its own Scope 1 and Scope 2 emissions, the industry turned its attention to Scope 3 emissions - those emissions generated by the end consumer and their products. This was very relevant for the LNG industry as most of its emissions are defined as Scope 3.

The gas industry has contributed significantly as the key transition fuel on the path to lowering emissions by displacing coal in power generation, displacing liquid fuels in transport, and firming renewable power. In addition, the commercialisation of CCS technology has been crucial in providing high quality offsets for sectors whose emissions are harder to eliminate, such as airlines and steel mills.

The transition to net zero continues to rely heavily on the transfer of gas sector expertise. CCS is also a good example here. The gas industry has developed this technology and championed its development and acceptance. This was made possible by oil and gas industry scientists who used their understanding of depleted reservoirs to enable their use for carbon sequestration, process engineers that employ the technology to capture carbon dioxide from combustion exhaust streams, and materials engineers who manage corrosion issues in carbon dioxide transportation.

The gas industry has also facilitated the growth of carbon neutral fuels, notably the growth of blue hydrogen. Blue hydrogen is being produced at a substantially lower cost than green hydrogen, which has accelerated the uptake of hydrogen in Australia. Hydrogen is being widely adopted as the zero-emission fuel of choice where an electrical solution is not viable.

HOW HAS CCS TECHNOLOGY CONTRIBUTED TO THE ENERGY TRANSITION – IS IT NOW COMMERCIALLY VIABLE?

CCS technology has been around for a long time; what has changed over the past decade has been the development of the regulatory framework necessary to commercialise CCS. The pivotal moment for CCS was when CCS was approved as an ACCU methodology, meaning that CCS operators would receive an ACCU for every tonne of carbon dioxide injected into CCS. This provided the commercial incentive for the large-scale expansion of CCS in Australia.

One highly successful CCS project has been the Moomba CCS project in South Australia. Santos and its project partner Beach Energy are now storing 1.7 million tonnes of carbon dioxide per year in this project. The project has a capacity for up to 20 million tonnes annually across the Cooper oil and gas basin. The Moomba project is one of the lowest-cost CCS projects in the world.

LNG projects that have access to high quality carbon offsets like CCS have strong ESG credentials and can achieve a premium for their LNG sales. CCS operators have themselves generated alternate revenue streams and created new jobs from offering CCS services to third parties, and adjacent industries. The CCS industry has also unlocked the blue hydrogen market and has positioned it for massive growth.

WHAT DOES THE LNG INDUSTRY LOOK LIKE IN 2030?

Australia, as a major LNG exporter, continues to be an LNG price taker - accepting prevailing market prices. Its LNG exports have created an interconnectivity between the international and the Australian East Coast domestic market. The Australian east coast LNG industry continues to receive pressure from lobby groups with sometimes opposing demands, with climate activists saying the industry should never produce another molecule of gas, while domestic industry lobby groups say the industry should be producing more and limiting the export of gas.

Cost pressures, regulatory challenges in new developments and long-term demand uncertainty have led new gas exploration to be substantially reduced. These days producers are focussing on developing their existing resource base as efficiently as possible.

Gas industry economics have also changed. "Financial activism" has made it more challenging to attract investment into the industry. It means that gas investment has been constrained and as a result supplies have been struggling to keep up with demand globally. As a result a growing proportion of LNG supply is being produced in OPEC+ countries.

Demand for gas and LNG generally remains strong; the bulk of demand comes from countries with net zero targets, particularly in Asia. China is still the largest LNG consumer in the world, along with Japan and South Korea, and increasingly India. These countries are predominately using LNG to reduce emissions as they transition away from coal.

The story of the gas industry in this decade has been one of an industry stepping up to the challenge of the energy transition. It has been progressive in achieving emissions reductions and building its ESG credentials. ESG constraints in developing new supplies have stifled and delayed development, resulting in elevated LNG market prices at times. The companies succeeding are those who have maintained a strong ESG strategy, enabling them attract investment, and to not only sustain their production base but also grow their business with carbon neutral products.

Stephen Harty joined GLNG Operations Pty. Ltd. (GLNG) as Chief Executive Officer in 2019 and has responsibility for the overall management, safety and operation of GLNG's assets, which include 7.8 mtpa of LNG liquefaction capacity and over 500km of high-pressure gas pipelines.

Stephen has over 25 years of experience in the oil and gas industry. He commenced his career with Mobil Oil Australia holding engineering and management positions in the downstream organisation. In 2001 Stephen began his career in LNG when he joined the Ras Laffan Liquefied Natural Gas Co (RasGas) in Qatar.

Stephen subsequently joined ConocoPhillips and initially worked on the development of the Qatargas3 LNG project. Stephen later transferred to the United Kingdom with ConocoPhillips where he held various management positions in the Europe Commercial organisation, including Carbon Portfolio Director, Director European Market Analysis and Manager Global LNG Trading. In 2015 he returned to Australia to lead the marketing organisation at Australia Pacific LNG.

Stephen holds a Bachelor of Engineering (Hons) from the University of Ballarat Australia, a Master of Business Administration from Deakin University Australia, and is a graduate of the Australian Institute of Company Directors.

Ted Surette

ENERGY TRANSITION ADVISOR AND NON-EXECUTIVE DIRECTOR

Ted Surette is a Senior Energy Transition Advisor and Non-Executive Director at Providence Asset Group - an investment firm developing a regional community solar and hydrogen storage portfolio. He advises on clean energy technologies and strategic growth opportunities. Ted was a partner with KPMG for 33 years and was most recently the Head of KPMG's Global Power & Utility Sector. He is a Board Advisory Member of the Hydrogen Energy Research Centre - a collaboration with University of New South Wales and Providence Asset Group.

"The last decade has been a call to action – how to solve the net zero puzzle..."

WHAT HAVE BEEN THE BIGGEST CHANGES IN THE ENERGY MARKET OVER THE LAST DECADE?

As the energy market transitions toward net zero, there has been a significant decline in sector emissions. This is primarily due to the greening of the electricity generation sector, or, more specifically, the decline of coal fired power generation. In Australia, the alignment of federal government net zero ambitions with those of the Australian states and the energy industry accelerated the transition. This situation, where government, businesses and consumers all supported a common goal and created the actions needed to get there, means that faster progress has been made during this decade toward decarbonising the energy system than any other so far.

In Australia, wind generation has further accelerated. Back in 2021, while there was already a strong onshore wind industry across all states, offshore wind generation was in its nascency; since then, we have seen exponential growth in offshore wind, primarily on the east coast of Australia. Australia has also continued to expand its solar generation industry, meaning today, it still has one of the highest rates of per capita rooftop solar generation in the world. Over the past ten years, large scale utility solar has extended to regional areas across the nation, facilitated by the creation of multiple renewable energy zones (REZ's).

In addition, new investment in energy storage (bigger and flexible batteries, pumped hydro and even hydrogen) as well as in new transmission infrastructure, means today, Australia has a world class distributed energy network which operates flexibly and efficiently. More importantly, it provides affordable, reliable and clean energy to all residents and businesses across the nation.

WHAT IMPACT HAS THE ENERGY TRANSITION MADE ON BUSINESSES? WHICH BUSINESSES ARE DOING WELL AND WHY?

Companies have now moved beyond ambition and pledges and are implementing specific actions towards net zero - decarbonising through better energy efficiency measures and using more firmed and flexible renewable power generation. Australia today still has a vibrant resource-based economy but has fast tracked the use of dispatchable renewable power generation in heavy industries such as mining, which is now mostly electrified.

As ESG targets moved centre stage, organisations better understood the decisions they needed to make. As companies translated their ESG purpose and commitments into actual business strategy, in 2030, it is fully integrated into day-to-day business operations. Some of the larger Australian companies in the 2020's did this by aligning their ESG climate metrics - based on objective science-based targets - to executive compensation. Others adopted the many external stakeholder reporting frameworks, firstly across the breadth of their sustainability portfolio, and then to the whole of their business.

Companies have also really taken advantage of the declining costs of new and emerging clean energy technologies. As businesses became more familiar with their cost and value stack and what it meant for them to make those investments, they have employed the latest battery technology, machine learning and other artificial intelligence (AI) technologies to support greater energy efficiencies and carbon footprint reductions in their operations.

Early movers in battery technology, in particular, have done well. These were primarily governments and energy companies - one of the first big batteries to support renewable generation, was the Hornsdale battery in South Australia - which was enabled and financed largely by the South Australian government. Back in 2017, this was the largest lithium-ion battery in the world and is still providing essential grid-support services today. This trend continues; large advanced emission reduction technology investments continue to be assisted by partnerships with government and the scale of these projects further supports innovation and technology cost reductions.

Also, as Scope 3 emissions targets were actioned, many companies focused on how to make their supply chains more efficient and transparent. As companies looked further downstream and decarbonising end use consumer products and services became a critical focus area, they have been able to address how they can transform their whole supply chains to perform at net zero.

HOW WELL HAS AUSTRALIA EXECUTED THIS ENERGY TRANSITION?

Australia has experienced one of the fastest and most radical energy transitions of any country. This was made possible by its abundance of sun, wind and critical minerals, but not to be underestimated is the success of its clean energy collaborations. The Australian federal government and states have worked well with business and academia, supporting, developing and scaling energy innovation and technology. For example, the creation of hydrogen hubs across the country have spearheaded innovation to produce, export and use hydrogen across a diversity of use cases.

These clean energy collaborations and consortia are helping to solve the puzzle of how to best achieve net zero. Today, Australia is a world leader in distributed clean energy. World leader status means decarbonising domestic industrial sectors such as heavy manufacturing, progressing new sectors like carbon capture and sequestration, hydrogen, and green steel, while also becoming a major green commodity and technology exporter. That is how you action for net zero.

Tim Buckley

DIRECTOR OF ENERGY FINANCE STUDIES, AUSTRALASIA

INSTITUTE FOR ENERGY ECONOMICS AND FINANCIAL ANALYSIS (IEEFA)

"Capitalism has been redefined – companies who destroy the environment find it very hard to operate."

Tim Buckley is the Director of Energy Finance Studies, Australia/South Asia at the Institute for Energy Economics and Financial Analysis. Tim has 30 years of financial markets experience, including as a top-rated analyst and head of research with Citigroup and as co-founder of Arkx Investment Management, a global cleantech startup.

WHAT HAS BEEN THE FINANCIAL MARKET RESPONSE TO THE ENERGY TRANSITION BY 2030?

The financial risks of climate change have played a huge part in redefining attitudes in global financial markets. Over the last 10 years, weather-related disasters have been pivotal in changing investment behaviour. Governments realised the extreme cost of inaction, while high carbon emitting companies understood that they could see swathes of their operations become uninvestable and uninsurable. Without insurance, business activity is virtually impossible.

In financial services, these changes started to gain traction back in 2021, following the former Bank of England Governor, Mark Carney's net zero emissions finance alliance. This was a pledge by over 160 institutions, with $88 trillion in assets, to steer the global economy towards net zero emissions and a 1.5 degrees C limit. In 2030, net zero goals are entrenched across all mainstream financial sectors.

The energy transformation intensified the risk of stranded assets for fossil fuel companies. Today, many younger investors haven't even heard of some of the oil companies; they have fallen out of the top indices and headed into terminal decline. This is not true for all energy companies. Some transitioned fast; with change led by a new CEO, chair or board, like the CEO of BP, Bernard Looney, who announced a radical climate alignment back in 2020 on his appointment. Strong independent leaders implemented new stakeholder engagement policies which were open about the company's core business having no future. They were brave enough to say: "we are in terminal decline, we will clean up the mess we spent over 50 years creating, and we won't just fob off onto someone else the rehabilitation liabilities our firm created."

The legal system has also played a key role. Back in the early 2020s there were landmark legal cases, including in Holland and Australia, which enacted that governments and energy companies owed a fiduciary duty of care to young people to not cause physical harm from climate change. These cases took evidence from the Intergovernmental Panel on Climate Change to stop the expansion of the fossil fuels industry, recognising that their decisions would have consequences for the future generations. Judges decided that, in the absence of any leadership from politicians, they would institute court-imposed leadership predicated on intergenerational equity.

WHAT FINANCIAL INSTRUMENTS OR INITIATIVES HAVE INFLUENCED CLEAN ENERGY INVESTMENT DURING THIS DECADE?

The most impactful has been the emergence of the now universal price for carbon. Back in 2015-20, a globally accepted high carbon price seemed fanciful - particularly here in Australia, where the mere idea of it was politically toxic and a repeated Prime Minister killer. The EU introducing first their Emissions Trading Scheme (ETS) and then the carbon border adjustment mechanism in the 2020s changed everything; this EU and US border tax on high carbon imports meant companies throughout the world had to reassess their global supply chains. Now in 2030, it's the global norm that we have a carbon price of $150/tonne and it has been one of the best performing commodity indices.

Another important change was earlier this decade when both the EU and the USA mandated that key development banks cease funding fossil fuels. The only subsidised funding for fossil fuel development came from Chinese banks. But even this has been in decline

in recent years with China's renewed world leadership in clean energy and its relaunch back in 2022 of its Green Belt and Road Initiative. The G-BRI has been a huge success, helping developing countries across the Middle East, Eurasia and Africa and allowing two billion people to leapfrog the now obsolete fossil fuel energy system and transition to cleaner energy centred on rooftop solar, batteries, electric scooters and microgrids.

In Australia, the government and financial community have had to introduce policies and take risks to catch up with the clean energy leaders. Australia was a clean energy laggard, sitting in the naughty corner along with a few recalcitrant Middle Eastern and Latin American countries. Change came with the states selling out of fossil fuels and new federal legislation making it illegal for fossil fuel companies to do government lobbying, "greenwash" and/or to divest their way out of the clean energy challenge. This gave many of Australia's leading companies the confidence to invest in new energy. We forget that it was only in this last decade that Australia became the world's largest exporter of seaborne traded green ammonia and green iron ore, and soon to be the largest in green hydrogen, as the "blue" hydrogen figleaf has been retired as the desperate last roll of the dice by the fossil gas industry.

HOW HAVE BANKS AND RATING AGENCIES DEVELOPED SOLUTIONS AND RISK ASSESSMENTS FOR CLEANER ENERGY?

The financial community was asleep at the wheel in the early days of the energy transition. While trillions of dollars of capital were at risk from stranded assets, the central banks in the early 2020s seemed to accept that the large financial risks just had to be accommodated. The major rating agencies were buying up independent ESG and climate risk analysis firms to get skills in evaluating climate risk on property, businesses, fires, flooding and satellite tracking of methane leaks. But it then took a long time for that analysis to be integrated into their financial products and indices. Today, climate change and clean energy are an integral part of financial risk assessment, as modern slavery was back in 2021, and tobacco the decade before that. What was once niche is now fundamental to good corporate governance, with companies required to report under the Task Force on Climate-related Financial Disclosures as a pre-requisite to accessing global capital markets.

WHAT IS THE ROLE OF ACTIVISTS IN THIS NEW ENERGY WORLD OF 2030?

In 2030, environmentalists aren't actively campaigning on climate change anymore, they have stopped locking themselves to buildings and heavy machinery. Boards gave in when their young staff would just leave to join the protesters, and the police were too busy locking up corrupt politicians caught by the Federal ICAC to worry about protesters like the now Swedish Prime Minister Greta Thunberg working for the public good. Companies have had to stop and listen, with social licence becoming critical to their right to operate once we had the redefining of capitalism that McKinsey called for back in 2020. In 2030, you cannot operate a company which destroys the environment or doesn't treat workers of all ages, genders and races respectfully - and in many countries you cannot legally build new fossil fuel infrastructure due to the now legally mandated 'intergenerational equity' protections. Companies have realised their brands were bound up with their workforces' values; sustainability, respect for the environment and operating within our planetary boundaries.

Tim Nelson

EXECUTIVE GENERAL MANAGER, ENERGY MARKETS

IBERDROLA AUSTRALIA

"In 2030, politicians are looking back with a sense of confusion - how did something based on science become such a political football? "

HOW DID THE MAJOR CHANGES IN ENERGY MARKETS HAPPEN?

Climate change shifted from being an emotive political issue to a more risk-based issue backed up by science. What facilitated this shift was many countries directly experiencing its impacts such as huge wildfires and flooding - it meant clean energy rose to the top of government and board agendas.

Energy market changes were also consumer driven. People were making clean energy into a lifestyle choice, they wanted to minimise their own environmental footprint. Solar PV, battery storage, electric vehicles, autonomous vehicles were all novel in previous decades but have now become mainstream as consumer interest in them grew.

Australia, like many countries, changed its politics and policies as pressure around climate issues became more pronounced. The government developed a "just" transition policy, supporting communities previously reliant upon emissions intensive fuels to develop alternative industries. This has allowed energy businesses in Australia to develop clean energy supply chains and create new value. Australia has seized the opportunity to transition an economy which derived nearly half of its export revenue from emissions intensive commodities to one which is now based on hydrogen, green metals, and in general has a cleaner industrial sector.

HOW HAS INVESTMENT IN THE ENERGY SECTOR CHANGED?

The energy transition has seen a huge shift in technology investment towards cleaner energy. The disruption in the electricity sector in the late 2010s was already a leading indicator of what was to come - clean energy technologies becoming cheaper. Technology has allowed consumers, both large and small, to embrace their own solutions. The early proliferation of solar PV was matched this decade by the adoption of behind the meter storage and behind

the meter smart technology. This has allowed the consumer to embrace their own technological solutions behind their meters, allowing them to better manage their energy consumption and better employ the diversity of energy choices. Big data and machine learning also means smaller retail businesses can tailor their solutions more actively to individual consumers. This has created a retail energy market which is much more competitive, and an environment where consumers are far more satisfied with their utility provision than they were 20 or 30 years ago.

Clean energy has also transformed energy industry notions of investment and value. In previous decades, even the most emission intensive projects could still find financing, as people had a view that they were necessary to keep the lights on. Over time, as the stranded asset risk became so material, write downs were common. As the image of the industry became more tarnished and the risk of stranded assets grew, it also became very important for businesses to better integrate their social licence to operate - in order to maximise shareholder value, energy businesses needed to address the societal issues most material and relevant to them. Before, energy businesses were often chasing what they thought was the lowest cost production, but it was only the lowest cost for the proportion of energy that the asset delivered, not the lowest cost for them overall.

Energy investment today is smaller and is creating new business models. The ability to raise $50 million for a new solar plant or a wind farm is easier than raising $2-3 billion for a new thermal plant. Also, as the renewable storage industry develops, it is supporting investments in batteries or small zero emission fuel turbines and fuel cells, allowing companies to build portfolios of clean energy solutions rather than having one or two large assets. This portfolio approach gives companies a better platform to explore a wider set of new energy technologies and solutions with many now routinely using big data and machine learning to build their own models. Utilities today understand and manage the risks of this energy market much better than they had done previously.

WHAT DOES THE ENERGY WORKPLACE LOOK LIKE IN 2030?

The COVID-19 crisis of the early 2020s provided the springboard for people to reassess how work gets done and it has resulted in a lot more people working from home. In 2030, there is a greater acceptance by employers that people can work remotely permanently which has created a more diverse workforce and is leading to better shareholder returns.

Today, this new hybrid workforce is not only based in the inner cities but also in the more remote parts of Australia. This has led to a shift in government planning - instead of making big cities the focus, more regional communities are being supported and developed. This all goes some way to alleviate the chronic underemployment, income, and wealth inequality we have seen across Australia and in many other countries too.

The energy transition has also provided a platform for the industry to think about career evolution and upskilling. Many workers involved in the thermal generation industry have been retrained through a focus on 'just transition' and have found work in some of the new innovative industries in and around clean tech.

What the transition has ultimately done is redefine an energy workforce. A person working for an energy company is not only an individual, but also an accumulation of investment made in their skills, and companies need to make sure that the best return on that investment is made. The pace of energy industry change means companies must continue to develop strategies for reshaping this workforce, not just annually - such as determining headcount and labour costs - but in the longer term. Continually investing in their workforce so they can best adapt to this industry as it rapidly changes is now critical.

Tim Nelson is the Executive General Manager, Energy Markets at Infigen Energy (now Iberdrola Australia) where he oversees the optimisation of Iberdrola Australia's portfolio of energy production, energy pricing, risk management, customer sales and various other channels to market. Previously, Tim has worked for the Australian Energy Market Commission (AEMC) and was the Chief Economist of AGL Energy and led the company's public policy advocacy and its sustainability and ESG strategy.

He is also a member of the Westpac Stakeholder Advisory Council and is on the Research Committee for the Centre for Policy Development.

Tim is an Associate Professor at Griffith University and holds a PhD in economics for which he earned a Chancellors Doctoral Research Medal and a first-class honours degree in economics. Tim is also a fellow of the Governance Institute (FGIA and FCIS) and a graduate of the Australian Institute of Company Directors (GAICD).

Tom Ridsdill-Smith

SENIOR VICE PRESIDENT CLIMATE

WOODSIDE ENERGY

As Senior Vice President Climate, Dr Tom Ridsdill-Smith is leading Woodside's approach to climate change and has oversight of the initiatives Woodside is pursuing to limit emissions and prepare for a low carbon future. Prior to this, Tom worked in a variety of roles at Woodside including VP Geoscience, VP Science, Chief Digital Officer, Chief Scientist and Chief Geophysicist.

Before joining Woodside in early 2000, Tom worked for 5 years in airborne geophysics at World Geoscience.

Tom is also an Adjunct Professor of Physics at the University of Western Australia.

"In 2030, the natural gas industry still has a lot to offer..."

The 2020s have been a decade of action on climate change. Against a backdrop of increasing energy demand, driven by a global population that has grown by 750 million people and the huge expansion of the middle class in developing Asia, countries have started to make major progress towards decarbonising the world's energy system. There is now increasing optimism in the global community that the goals of the Paris agreement are within reach.

This hasn't been easy and we've had to pull on every technological, political and financial lever we have to achieve these gains. Governments and companies took early action in the 2020s to reduce emissions, focussing on practical solutions that could be rapidly implemented to meet the specific needs of their economies and markets, breaking the deadlock from the previous decade created by the effort to seek the "perfect" global pathway and wait for a "silver bullet" technology.

Massive investment in solar and wind energy has resulted in these technologies now delivering over 10% of global energy supply, a nearly five-fold increase over the decade. But that still means that other options are critical to supply most of the remaining energy needs of the planet.

Most importantly, global coal use is finally on the decline and this has had the most significant impact of all the levers in reducing global emissions as well as in improving local air quality. In the place of coal, we've seen the growth of a range of low carbon options including renewable electricity, natural gas and nuclear power.

Low carbon hydrogen and ammonia are also starting to play a minor but important role replacing traditional "grey hydrogen" in industrial applications, as well as in newly created markets in power and heavy transport. This includes both "green" hydrogen generated from renewables with no direct emissions and "blue" hydrogen generated from natural gas with carbon capture and storage used to create a carbon-neutral process.

Looking forward, the demand for hydrogen and ammonia is going to skyrocket as the pilot-scale projects from the 2020s expand into full-scale production in the 2030s to supply rapidly maturing energy markets in Asia. Much of the hydrogen and ammonia supply to Asia is likely to come from large-scale export projects in Australia and the Middle East that have access to cheap renewables for green hydrogen, as well as natural gas feedstock and carbon capture and storage (CCS) for blue.

Natural gas remains an important part of the energy mix in 2030. Countries with existing natural gas and LNG infrastructure are keen to continue to utilise it, allowing them to prioritise their financing towards the decommissioning of coal and the build-out of renewables in the power sector. In these countries, natural gas is seen as complimentary to renewables, providing flexibility to the energy system through its ability to be easily transported and stored to support seasonal variations in energy demand still beyond the capability of battery storage in 2030. Natural Gas from LNG continues to supply towns and cities without access to pipeline supply and has evolved to also allow smaller parcel-size deliveries to enhance its flexibility to respond to market demand.

Natural gas is considered in many countries, particularly in Asia, to have a long-term role in the energy mix in the 2030s and 2040s as the LNG becomes increasingly decarbonised across the entire value chain. Emitting only half the amount of carbon dioxide per unit of energy compared to coal, natural gas has proved economically attractive to couple with carbon-removal technology, in order to produce produce a carbon neutral energy source.

Expanding the global Paris-aligned carbon budget by creating a much larger carbon-removal market over the 2020s has allowed countries more flexibility in their energy choices in the 2030s. For example, Japan and South Korea, with geographies and climates that limited their ability to expand wind and solar, plan to continue to use natural gas together with carbon-removal services to meet their energy needs and their ambitious decarbonisation targets over the next decade. Again, looking to keep decarbonisation options open rather than narrowing them down has proved key.

The growth of the global carbon-removal market in the 2020s covered a range of technologies including CCS and various nature-based solutions such as native reforestation and soil carbon. This was greatly boosted by the successful adoption of global standards and certification for these solutions, and the ratification of global carbon-trading agreements during the early part of the decade. Together these breakthroughs created the trust, transparency and liquidity needed for carbon removal to be considered as essential in the world's decarbonisation efforts and to attract the significant investment needed to deliver it at scale.

Oil and gas companies have played an important role in the energy transition over the last decade. Their skillsets in large-scale energy production have proved invaluable in the establishment of a global hydrogen and ammonia supply chain. The energy transition has needed investment on a scale never before seen in history, and oil and gas companies have been significant contributors to this too, redirecting their significant funding capacity from oil and gas projects into building profitable low carbon energy and carbon-removal businesses that will thrive in the coming decades as the world steers relentlessly towards Paris success.

"As the energy transition progresses and is dominated by technology, there is increasing evidence of the technology haves and have nots."

JUSTINE JARVINEN
CHIEF EXECUTIVE OFFICER
UNSW ENERGY INSTITUTE

Acknowledgments

This report was very much a team effort.

A special thank you to Sofia Lanfranconi, Laura Woolford, Ania Bokina, Louisa Keegan, Lisa Maroun, Ashley de Silva, Ted Surette, Julie Adams, Chris Whiting, Nyk Loates, Bridget Leonard, Charlie Hunter, Steve Keast, Phil Marsden, Ken Chung, Barry Sterland, James Arnott, Christiane Brendel, Ryan Wolton, Scott Mesley, Mark Davis, Jackie Sharp, Adrian Farrant, Theodora Iliadis, Merriden Varrall, Alistair Fraser, Ben Twartz, Janenie Mohgan, Jacob Hacker, Sophie Tversky, Sandrine Foskett , Yolanda Stead, Steve Clarke, Praveen Thakur, Ben Ellis, Jon Benton, Rebecca Alexander-Heard, Sophie Finemore, James Copsey, Marjorie Johnston, Kat Parry, Yuki Takeda, Rachel Yeung, Rory McLean, Clinton Botha, Kirsten Brown, Naomi Rahim, Ning Hadiningsih, Rob Catalfamo, Cat May, Elli Schroeder and Linda Davies.

Contact us

Cassandra Hogan
National Industry Leader
Energy & Natural Resources
cjhogan@kpmg.com.au

James Mabbott
Partner in Charge
KPMG Futures
jmabbott@kpmg.com.au

Matt Pearce
National Sector Leader
Power & Utilities
mpearce1@kpmg.com.au

Nick Harridge
National Sector Leader
Mining
nharridge@kpmg.com.au

Jonathon Peacock
National Sector Leader
Oil & Gas
jjpeacock@kpmg.com.au

KPMG.com/au/30voicesonenergy

August 2021. 696709516ENR.