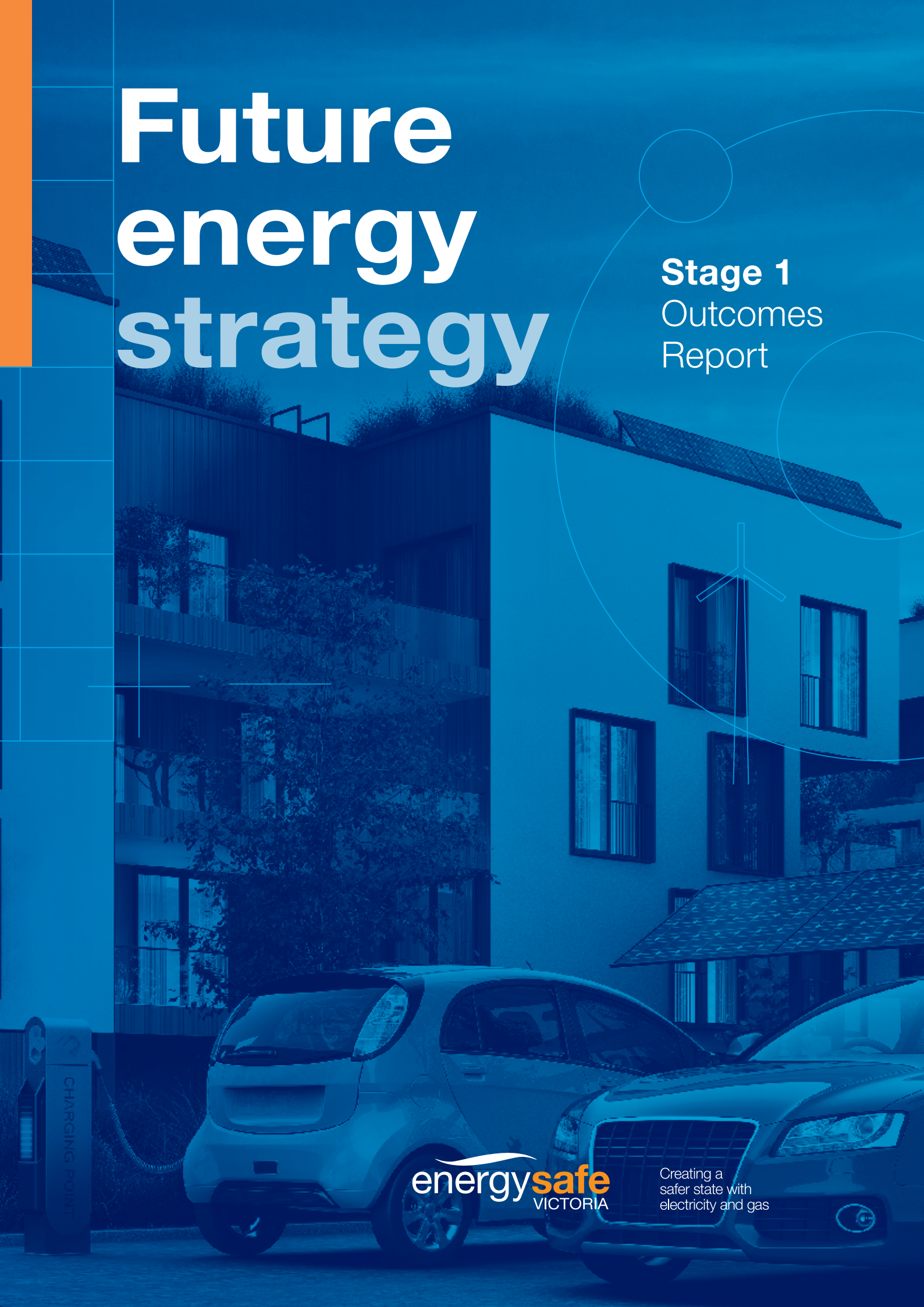
Future energy strategy

Stage 1
Outcomes Report



energysafe VICTORIA

Creating a safer state with electricity and gas

This report has been endorsed by the Director of Energy Safety in Victoria.

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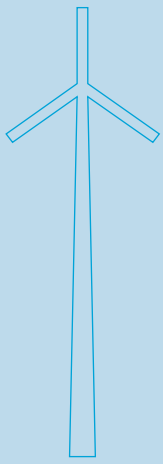
SJS STRATEGY

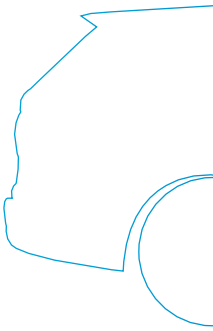
Creating structure in uncertainty

Disruptive technologies are emerging. Market and economies are undergoing global shifts.

What roles will ESV need to play, and which capabilities will it need to develop, to effectively address the safety risks of the future Victorian energy landscape?



Executive summary



"Giving up the illusion that you can predict the future is a very liberating moment. All you can do is give yourself the capacity to respond. The creation of that capacity is the purpose of strategy."

Lord John Browne | Group Chief Executive | BP (1997-2007)

The quote from Lord John Browne goes to the core of scenario planning; the recognition that we cannot accurately predict the future.

Energy Safe Victoria (ESV) recognises that the world is changing rapidly; developments in technology, society, politics and the economy are constantly coalescing, shaping ESV's longer-term operating environment in unpredictable ways. In response, ESV initiated its Future Energy Strategy that utilises scenario planning to address these issues head on.

Scenario planning is about creating structure in uncertainty. Scenarios do not describe just one future, but rather a range of plausible futures that illuminate all the corners of the 'playing field' in which we may need to operate. A good set of scenarios will force us to critically assess our conscious and unconscious biases and help prevent us from being blindsided.

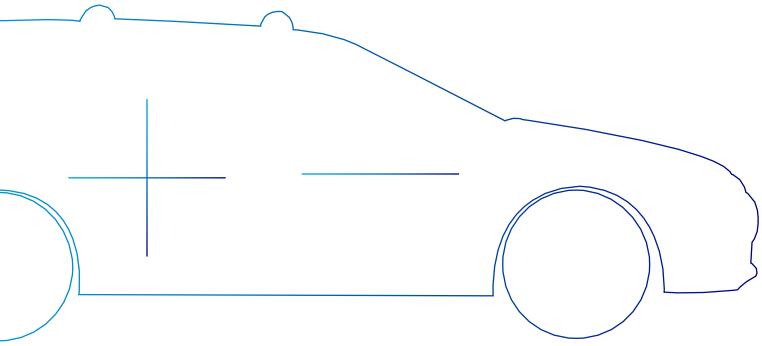
Despite not being predictions of the future, scenarios are particularly useful for having an informed dialogue about it. By providing structure in uncertainty, scenarios help us understand how different planning assumptions may play out over time, and thereby support decision-makers in building robust, adaptive, long-term strategies.

Scenario planning is based on a solid process and rigorous analysis. It allows us to collectively explore the future that ESV, the energy sector and, more broadly, Victoria and Australia might be faced with.

From April to August 2019, a diverse project team from across each line of business at ESV developed scenarios that address the following focal question: which roles will ESV need to play, and which capabilities will it need to develop, to effectively address the energy safety risks of the future Victorian energy landscape?

This Outcomes Report provides the outcomes and learnings of the project team's five-month journey.

This journey benefitted from having access to a broad range of national and international experts; interviewing them on topics ranging from new energy sources and market models to regulation and cyber-security. The resultant scenarios for ESV that have been developed by the project team are divergent, challenging, relevant and plausible.



The scenarios unearthed important challenges and opportunities for ESV. The challenges and opportunities were subsequently clustered into eight strategic themes. In response, the project team identified and formulated responses (strategic options) to each of these challenges and opportunities. The themes that these strategic options address are:

- Government, role and organisation
- Internationalisation
- Decentralised energy models
- Hydrogen
- Electric vehicles and fuel cell electric vehicles
- Qualified practitioners
- Internet of Things, data and automation
- Revenue model

The themes and associated strategic options underpinned the development of the adaptive strategic roadmap. Using the OGSM method,[1] the project team is translating the strategic options into concrete actions – determining timing, assigning ownership, and allocating people and resources to the strategic options that flowed from the scenarios.

Scenarios are especially useful when they are applied as a tool for learning and continually gaining new insight; a frame of reference in examining and responding to changes in the external environment. To that end, an (online) Early Warning System has been developed that assists ESV in determining which scenarios are becoming more probable as time progresses, and which ones less.

To deliver on the objective of Stage 1 of the Future Energy Strategy, the strategic options (developed from the scenarios) and the Early Warning System combine to provide ESV with an adaptive strategic roadmap to effectively address the energy safety risks of the future Victorian energy landscape.

The scenario planning detailed herein can be regarded as 'pre-strategy'. It provides decision-makers at ESV with a powerful framework and toolkit to have a deep strategic dialogue about the organisation's uniqueness and its role in the world, and the leadership's vision of how that translates into adaptive, longer-term strategies that reflect ESV's mission, mandate and subsequent responsibilities. It provides ESV with a solid base upon which to build strategies for the future that will allow ESV to continue to protect the safety of all Victorians.

1 Objectives, Goals, Strategies and Measures (see Section 5.1).

Contents

1. Introduction to the Future Energy Strategy

With the emergence of disruptive technologies and global shifts in markets and economies, Energy Safe Victoria (ESV) needs to be able to position the organisation and the regulations it administers to adequately respond to these changes. In this, the organisation needs to ensure that safety risks are appropriately addressed while ensuring that there are no unwanted regulatory impediments to the adoption of new technologies. ESV also needs to minimise red tape while ensuring its responses are appropriate and proportionate.

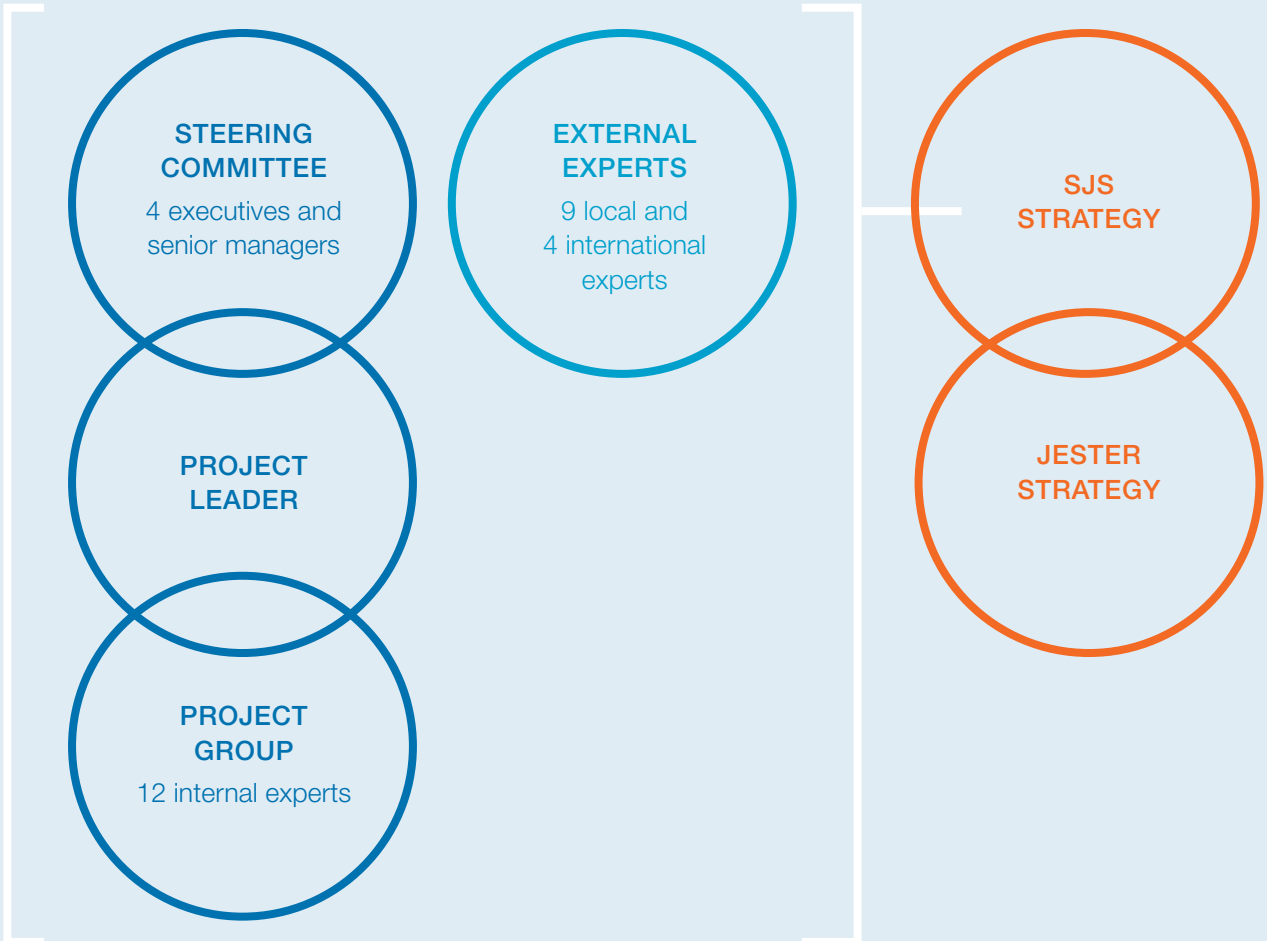
In response, ESV commenced a program of work that will develop, monitor and implement a planned strategic response to these emerging trends. The broader program will comprise:

- Stage 1: Developing the strategy and roadmap
- Stage 2: Monitoring emerging futures
- Stage 3: Implementing responses

To deliver Stage 1, ESV engaged SJS Strategy – a specialised scenario planning consultancy – to develop future scenarios for ESV and a subsequent adaptive strategic roadmap for the organisation. In this work, SJS Strategy were supported by Jester Strategy, their Dutch partner.

SJS Strategy worked with a Project Group, comprising subject matter experts from across ESV to develop the scenarios. Further inputs to the scenario planning were received from 13 local and international experts. Ultimately all outputs were tested with the Steering Committee and, where necessary, referred back to the Project Group for further development.

The structure of the project team



2. Introduction to scenario planning

Images of the future…

Scenarios are stories that describe possible future contexts in which an organisation's decisions might play out. The purpose of scenarios is to learn from the future and make better decisions. Scenarios are extreme and divergent pictures; meant to stretch the thought models of decision-makers and constitute a basis for decision-making.

Scenarios based on perceived key uncertainties

Decision-makers use scenarios to explore the possible impact of key uncertainties on the organisation. To identify key uncertainties, an outside-in perspective is taken in which key developments in the macro and business context are identified. External uncertainties with both a direct impact on the business model of the organisation and impact on other developments qualify as key uncertainties.

Where science meets art

Scenarios are based on rigorous analysis but written as stories that make potential futures vivid and lifelike. They do not provide a consensus view of the future but enable decision-makers to project their minds in a number of extreme, but conceivable, future contexts. Although scenarios may have a quantitative underpinning, they are superior in bringing the more intangible aspects of the future to the fore.

Overcoming psychological traps

Scenarios force decision-makers to think more broadly and challenge their 'official future' by creating divergent views of the world. Experience shows that the scenario planning process fosters a strategic conversation among decision-makers in which previously 'unmentionable' topics are opened up for discussion and surprising findings are found.

A more detailed explanation of scenario planning is provided in Appendix A.

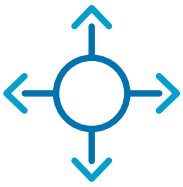
A five-step process underpins scenario planning:

STEP 1: DETERMINE THE SCOPE

- What is the focal question that we are trying to answer?
- What is the time horizon?
- What are the boundaries?

STEP 2: EXPLORE THE EXTERNAL ENVIRONMENT

- What are the trends – both macro and industry-specific – that ESV has no influence over, but which shape the future operating environment in which the organisation will find itself?



STEP 3: ESTABLISH KEY UNCERTAINTIES

- Of these trends, which are the ones that are most uncertain but will have the biggest impact?
- The two key uncertainties ('change drivers') form the scenario framework

STEP 4: DEVELOP SCENARIOS

- Once the scenario framework has been developed, one can detail the scenario stories; what could be the causes of the scenarios, and what are the characteristics of each scenario?

STEP 5: GENERATE AND VALIDATE STRATEGIC OPTIONS

- Once the scenarios have been developed, one can identify the key challenges and opportunities, as well as strategic options to address the challenges and capture the opportunities.

3. Developing the scenarios for Energy Safe Victoria

3.1 SCOPE: the focal question

A scope consists of several elements:

- focal question and strategic sub-questions
- time horizon
- boundaries.

The focal question and strategic sub-questions should help to answer or provide insights into the various scenarios. What is the goal of the scenario planning exercise and what are the topics it should address? This underpins the identification and selection of the relevant trends. A good focal question is an open question. It is a question one might be able to answer for the next few years, but further out into the future, multiple answers might be possible and plausible.

Which trends are relevant and how one assesses the impact and uncertainty of those trends depends on the time horizon. For instance, the progress or impact of a trend might be relatively 'knowable' for the next five years, but if one looks at how that trend will play out over the next 10 years it might not be so clear. A good time horizon should therefore be able to result in scenarios that are considerably different from the current situation – it should leave ample time for change to occur – in order to challenge our strategic thinking, yet it should not be too far into the future as to alienate the readers and users of the scenarios.

To make scenarios specific, one needs to define clear boundaries; i.e. what is 'in scope' and what topics are 'out of scope'. The more clearly defined – and the more limited the number of topics – the more concrete the scenarios will be. Boundaries can include the activities, locations/regions, and industries the organisation would like to explore.

Focal question

What roles will ESV need to play, and which capabilities will it need to develop, to effectively address the energy safety risks of the future Victorian energy landscape?

Strategic sub-questions

- What will the transitional phase (perception, regulation, sources, networks/infrastructure, etc.) look like, and what will be issues?
- What will be the effects of new energy technologies (generation and sources, storage, infrastructure, 'smart', etc.)?
- What role will other technologies (digitisation, IoT, blockchain, electric and/or autonomous vehicles, etc.) play in the future energy landscape?
- What new business models will emerge and how will this change the roles in the value chain market?
- What will the regulatory/standard setting and political context look like (international, national, state, local; and their interplay)?
- How will geopolitics, the global economy and trade patterns affect the future energy landscape?
- How will data (ownership, privacy, platforms, etc.) and cyber-security affect the energy landscape?
- How will demographics (including urbanisation, economic locations, social and spatial polarisation, safety issues) and workforce development (migration, skills requirements, certification, etc.) impact the energy landscape?
- What will be the effects of climate change (incidents, infrastructure, generation) and how will climate change be managed (crisis mode or strategically)?
- What motivations will investors have?
- How will public opinion and intergenerational conflict impact the energy landscape?

Time horizon

2035

Boundaries

- Wide energy scope: gas, electric, multiple energy sources
- Victoria (yet in a national and global context)

3.2 External environment (trends)

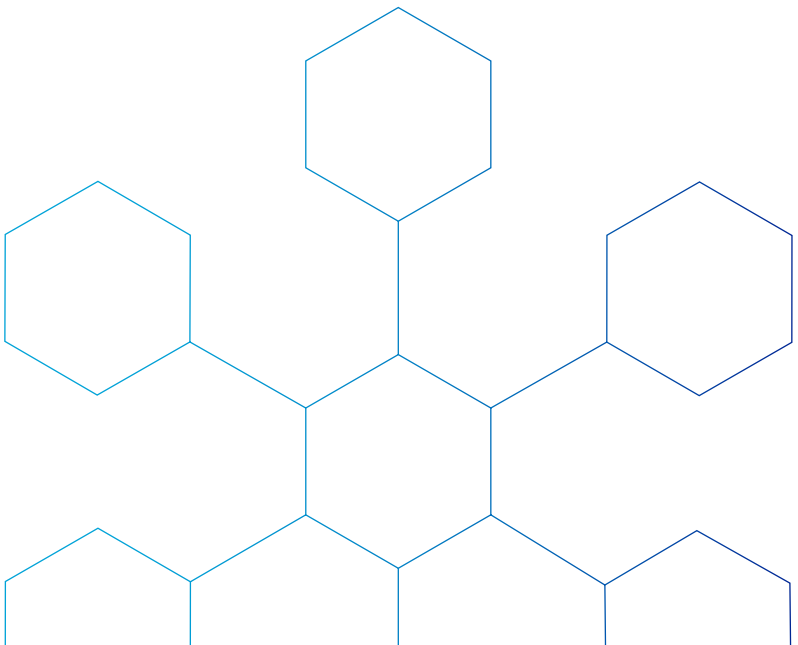
Trends are fundamental developments that can have a prolonged effect on organisations, businesses, consumers and regions. They have a different character from current issues and, for the purpose of scenario planning, one looks at two types of trends:

- **Macro trends:** Often called 'megatrends', macro trends are the large structural movements that are outside any single organisation's control, but that will fundamentally shape the future operating environment in which the organisation will need to compete and prosper.
- **Arena environment trends:** In the arena environment one finds trends more directly related to the region or industry. Trends in the direct environment of an organisation, industry, or region are more unique. These trends may not qualify as a macro/megatrend but might be instrumental in shaping the future of ESV's operating environment.

To identify the relevant trends the external environment is scanned for trends and developments. Trend research aims to explore those developments that might cause important changes for an organisation. The analysis identifies developments that impact on the focal question and which cannot be influenced. In doing so, trends and uncertainties are separated.

A gross list of the external developments is developed and external forces, which have little relevance in relation to the focal question or are not within time frame, are removed from the list. The remaining external forces are grouped into logical trend clusters.

As part of the scenario planning, ESV considered 115 macro and arena trends and consolidated these into the 24 trends described herein.



Increasing geopolitical instability

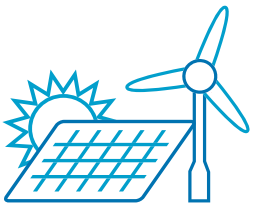
- After a period of globalisation, political, economic, societal, ecological and technological shifts are seeing the international system evolving into a period of divergence.
- Instability comes in many forms and causes; from climate change to terrorism and from nationalism to economic uncertainty.
- Geopolitical instability is one of the biggest drivers of a volatile energy landscape and will have broad-ranging consequences, including trade restrictions, fossil fuel prices, and accelerating or decelerating transitions to renewable energy systems.

Increasing legislative and regulatory uncertainty

- Climate and energy policies are increasingly politicised.
- Changing and uncertain short-term energy and climate policies are leading to an unstable investment climate in the energy landscape, creating unreliability and higher prices.
- Uncertainty about future energy mix, technologies (therefore safety risks), and market and regulatory roles.
- Other parties, such as local and state governments and companies are becoming increasingly proactive regarding energy and climate.

Increasing focus on national energy security

- Market mechanisms, price fluctuations and cyber-security issues are causing an increasing focus in national energy security, both in Australia and globally.
- Market transitions, cyber-security and international (in)stability all play a role in the severity of this trend.
- The potential impacts on the (local) energy landscape are wide-ranging; from import and export controls and subsequent energy price movements to the slowing transition to renewables.



From ownership to access

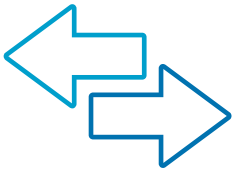
- Ownership is becoming less relevant while 'access and use' models are becoming increasingly important. The question "Do I need to own a car, or do I just want access to mobility?" will increasingly migrate to other areas of people's lives.
- While the private sector will drive the peer-to-peer economy, government can play an important role to support its growth while reducing any downsides.
- A number of factors play a role in the breadth and depth of this trend; urbanisation, regulation, generational differences and interest rate environments are among these factors.
- Business and consumers could take advantage of the lower cost of renting/leasing expensive energy equipment, creating greater supply and demand for new more efficient energy solutions.
- Regulators will have to retrain and retool to adequately keep up with a proliferation of new energy solutions.

The Asian Century

- As Asia is regaining its historical prominent role, the unipolar politico-economic system that characterised the post-Cold War world order will be replaced by a multipolar system.
- As Asia continues to rise, the continent could soon be home to the majority of the world's middle class.
- With the global 'centre of gravity' shifting to Asia, Australia's economy - and the country's position in the world - is likely to profoundly change.

Increasing export of renewables

- Hydrogen is regarded as a potential major Australian export by catering to a renewable energy hungry Asia-Pacific; pilots are already running, including in the Latrobe Valley.
- Solar and wind variable renewable energy could be exported as well by using underwater high-voltage Direct Current (HVDC), with overcapacity from such initiatives to be fed into the Australian grids.
- Export initiatives can create technology and scale necessary to create production capacity and scale to drive down costs for domestic renewable energy and increase renewables in Australian energy mix.



Increasing demand of consumers for choice, control, and services

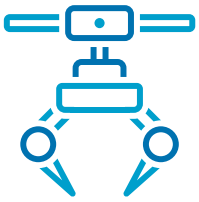
- With the rise of the digital era, consumers are becoming more aware of the range of products available in the market and the increasing price transparency thereof and want to reap the benefits of increasing competition among manufacturers and retailers.
- Renewable energy is becoming another factor in consumers' preferences, alongside price and service, which can force traditional parties to diversify.
- Increasing options for decentralised renewable energy and storage services (domestic and microgrids) will reduce demand for traditional grid-sourced energy, its retailers and generators, and can alter roles in the value chain (consumers becoming producers).
- Increasing competition and new roles in the value chain can erode margins and lead to lower asset investments and safety budgets, increasing safety risks.

Increasing demand for self-sufficiency

- There is a growing trend towards increasing individual ability to survive without external assistance.
- This is both as a response to increased uncertainty politically and economically, as well as a move towards more sustainability in response to climate change and other environmental concerns.
- Small scale renewables are encouraging customers to install independent grids potentially saving them thousands of dollars each year by producing their own energy.
- This creates challenges for regulators in managing safety across a series of complex and customised renewable energy grids/solutions.

Increasing social divisions

- There is a global perception that there is greater social division than a decade ago.
- Migration, technology, wealth distribution and alternate media are contributing factors to greater social divisions.
- Voters are becoming increasingly polarised and future energy solutions are becoming political hot button topics.
- The uncertainty created by divergent views has created complex environments for legislators and regulators who need to get ahead of emerging energy trends, as well as investors in the energy industry.



Increasing pace of technological advances and convergence

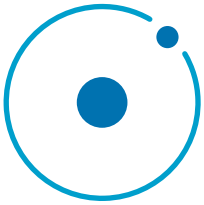
- We are in the early stages of the Fourth Industrial Revolution - characterised by a convergence of the physical, digital and biological worlds - that is set to yet again fundamentally alter the way we live, work and relate to one another.
- The speed of these changes has no historical precedent as the Fourth Industrial Revolution is evolving at an exponential, rather than linear, pace, while at the same time the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance.
- If action is coordinated across the economic, technological and socio-political systems, the transition to a new energy system will take place rapidly and transform the system beyond recognition.
- A major stimulus for energy transition is the convergence of technology and industry.

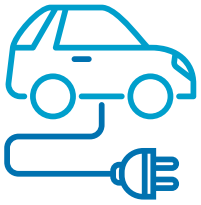
The rise of the Internet of Things and big data

- Big data and the Internet of Things will become a key basis of competition and create game-changing opportunities: production efficiency, distribution, and innovation all stand to benefit immensely.
- Not only government services, but virtually every sector in Victoria's economy is being, or will soon be, affected by the rapid developments in big data and the Internet of Things.
- The convergence of the Internet of Things, software, big data, analytics and the growth of renewables is revolutionising today's energy system. A new energy world is emerging, in which digitally enabled services allow opportunities for increased savings and greater efficiencies as well as new business models and market forces.
- The energy industry and regulators will have to grapple with data security and privacy issues to ensure the opportunities the Internet of Things present does not create new, more complex issues.

Increasing automation and robotisation

- Technological advances are ushering in a new age of automation and robotisation as machines match (and increasingly outperform) human performance in a range of work activities.
- A big question is to what extent will we see a productivity uplift across the economy balanced against the potential impacts on our current and future workforce?
- This trend will have a significant impact on the energy landscape, ranging from improved extraction and production to optimised supply and demand balancing at the industrial level right down to the individual consumer level.
- As 'Industry 4.0' becomes a reality, what will be the impact on the management of occupational health and safety?





The ‘electrification of energy’

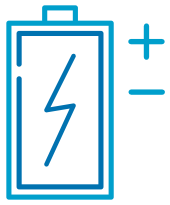
- Electricity will become increasingly important as an energy carrier due to fossil fuels being phased out and renewables being phased in.
- Electricity demand will increase, gas might be phased out.
- A new energy landscape with renewables (wind farms, hydrogen plants, solar batteries) will take shape.
- Appliances and equipment (gas and electrical) will need to be designed in order to function safely where the energy source/ supply is from, for instance, solar batteries.

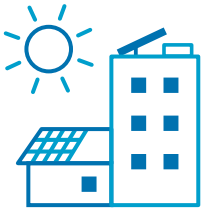
Migration to hydrogen

- Advances in hydrogen technology and attention/demand for it are rising globally.
- Green hydrogen is still not viable but grey and blue hydrogen are on the rise.
- Hydrogen can be used on small/ domestic scale (fuel cells), utility-scale (hydrogen storage) or in current gas infrastructure.
- Hydrogen is regarded as a future main export of Australia, which could be the catalyst for the uptake of it here as well.
- Safety will be a crucial aspect of and factor in the roll out of hydrogen energy generation and storage.

The rise of electric vehicles

- Transport is Australia’s second largest source of greenhouse emissions and has the highest growth of any sector since 1990.
- Other jurisdictions are phasing-out internal combustion engine (ICE) vehicle sales.
- 5% Electric vehicle (EV) penetration in Australian fleet likely by 2025-2030, moving to 15-35% by 2035 dependent on Government approach.
- A transition to larger mix of EV creates a range of infrastructure, security and safety challenges that require close consultation between government, business and community groups.





Increased energy storage capabilities

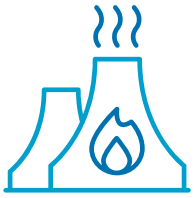
- Increased storage capabilities can provide utility-scale storage (wholesale arbitrage, ancillary services).
- Increased storage capabilities can allow domestic and commercial/industrial consumers to extend the value of their investment in solar panels and reduce their reliance on grid-connected power.
- Storage combined with ICT and software can enable new forms of energy trading and retail arbitrage.
- Specific storage technologies will come with their own safety risks and certification needs.

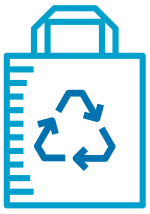
Increasing use of (variable) renewable energy

- Variable renewable energy has increased significantly over the past decade, both domestically (rooftop PV and storage) and utility-scale (wind and solar farms, pumped hydro, large-scale storage).
- Increases in renewable energy have led to decreases of other electricity sources (coal, gas), plant closures and systemic failures.
- Increasing domestic rooftop PV coupled with increased smart-grid technology and greater (battery and hydrogen) storage capacity can alter roles in the market/value chain (consumers becoming producers).
- A more fragmented energy landscape means ESV needs to adapt to the associated risks.

Internationalisation of technology regulation

- The emerging technologies of the Fourth Industrial Revolution, such as artificial intelligence and gene editing, present a challenge for international governance and cooperation.
- We are starting to see regulatory initiatives at the global and regional levels in response to some of these potent technologies.
- Similarly, in response to customer demands in electrical, gas and other technical infrastructure, equipment and installations, we are seeing regulatory changes increasingly emerging at the international level.





More noticeable effects of climate change

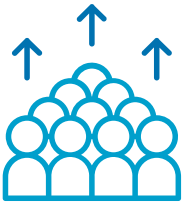
- The global scientific consensus is that climate change is real and that human influence is the dominant cause.
- 'Extreme weather events' and the 'failure of climate-change mitigation and adaptation' have been identified among the world's top risks in terms of likelihood and impact.
- The global and local implications include rising temperatures and sea levels, extreme droughts and precipitation, an increasing frequency of devastating tornadoes and hurricanes, flash floods and food shortages.
- The more noticeable effects of climate change are likely to result in a (significant) increase in investment in – and the subsequent speeding up of – the transition to renewable energy.

Increasing international coordination on emissions reduction

- International agreements on reducing emissions and increasing use of renewable energy are on the rise.
- Local and regional governments as well as companies are also setting targets.
- International action can speed up the energy transition and reduction of fossil fuel consumption.
- A lack of enforcement mechanisms and political opportunism and protectionism can hinder reaching international targets.

'ECOnomics': increasing demand for sustainable products and services

- Sustainability continues to grow as an issue in the public consciousness.
- A combination of factors is influencing the drive to greater sustainability, including concerns about climate change, resource scarcity and a desire to be more frugal.
- Governments and business are responding by driving more sustainable initiatives, which are ultimately changing the demand for renewable energy solutions and improving energy efficiency.
- The rate of change is unpredictable and is inconsistent across the globe.



Increasing urbanisation

- There is an increasing trend of population movement to cities.
- Victoria has one of the highest rates of urbanisation in the world, with 90.5% of its population living in towns and cities.
- There is increasing pressure on Melbourne's infrastructure, including the city's energy provision.
- Issues such as urban sprawl, shift to renewables, storage solutions and urban design are creating complex problems for energy distributions systems and safety solutions.

Changing demographics

- The world's population continues to grow with today's population of approximately 7.6 billion expected to reach 8.6 billion by 2030, with Australia's population reaching approximately 30 million by then.
- As the composition of Australia's population changes, so will the energy demands and the needs of our population change.
- Younger generations, for example, are generally more committed to a cleaner environment and will drive a transition to renewable energy as they become eligible to vote.
- Consumers and especially the elderly will have to learn to adapt to a change in lifestyle with new technologies, including, but not limited to, electric vehicles.

The rise of autonomous vehicles

- Autonomous vehicle technology is in rapid development with billions of dollars invested by major companies and investors.
- Autonomous vehicles can change patterns of transportation, commuting and location choices, spatial planning, and workforce dynamics.
- Autonomous vehicles will most likely be electric, increasing demand for electricity and reducing demand on fossil fuels.
- Autonomous cars 'as a service' can limit the car's potential as an energy storage medium.

3.3 Key uncertainties

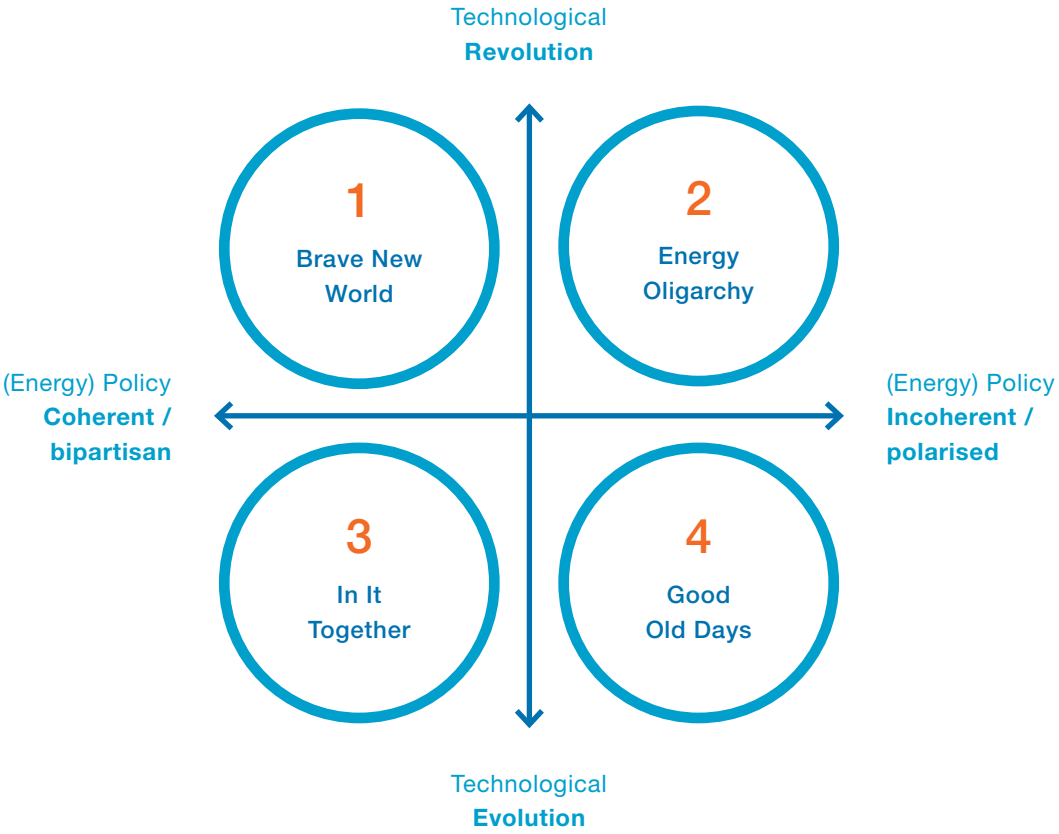
Key uncertainties are developments that have a significant impact and high levels of uncertainty as to how trends will develop. They are often also developments that influence many other trend clusters.

- **Impact:** Will a trend have a significant influence or minor influence; will the effects be beneficial or detrimental, low or high?
- **Uncertainty:** In the context of scenario planning, uncertainty refers to:
  - Effects a trend can have (for instance, we are relatively confident that a trend/development will occur, but we are unsure of what effects it will have); and/or
  - The pace with which the trend will develop or unfold (for instance, will the trend continue to pick up pace or is a counter-trend/slow down equally plausible or likely?).

Key uncertainties can be defined by scoring trend clusters on their impact and level of uncertainty and subsequently selecting the trend clusters with the highest scores. In order to make relevant and challenging scenarios, the most impactful and uncertain trends that have the capacity to exert their influence on many other trends (cross-impact), are selected.

Details of the impact and analysis scores and rankings can be found in Appendix B.

Based on the uncertainty and impact of the trends in Section 3.2, the Project Group and the Steering Committee selected the two key uncertainties below.



3.4 Framework selection

In selecting a framework for the scenarios, the following criteria are applied:

- **Plausible**
  - Is the combination of uncertainties plausible/ imaginable?
  - Can they reasonably co-occur?
- **Divergent**
  - Can you develop scenarios that are significantly different from each other?
  - Will it produce scenarios that are different from here and today?
- **Relevant**
  - Will the scenarios be relevant to the scope?
  - Will they enable you to 'answer' the focal question?
- **Challenging**
  - Will the scenarios be able to stretch the imagination, expand your frame of reference?
  - Are (some of the) scenarios 'disruptive' enough?

4. The Energy Safe Victoria scenarios

Scenario 1: Brave New World

Welcome to 2035. The world is a different place.

The effects of climate change have become more pronounced than we ever expected more than a decade ago. Droughts all over the globe have caused food shortages, international conflicts and climate refugee crises. Supply chains and logistical routes have been disrupted, causing economic problems.

In Australia, extreme weather events have had a great impact on the economy and the daily life of people; climate change has become too big to ignore. Large fluctuations in fossil energy prices have forced governments, businesses, and consumers to spring into action as well.

A sense of urgency to tackle climate change – by reducing emissions and transitioning to renewables – has been instilled in the international political arena as governments across the globe responded to the demands of their people. Climate change is widely regarded as

the major strategic issue by many countries. In Australia, bipartisan recognition arose that inaction was no longer an electorally tenable policy position. Citizens and businesses demanded change and came to understand that this would also impose changes and possible costs on them. Many countries have doubled down on cutting emissions and on speeding up the energy transition, employing both the 'carrot' (subsidising the development of, and transition to, renewables) and the 'stick' (such as carbon taxes).

Countries, including Australia, have made great efforts towards meeting the Paris Agreement goals, which have been expanded and recommitted to in the early '20s. A global baseline carbon tax, for instance, has been agreed upon and is universally enforced. A well-funded Climate Fund ensures that developing countries are supported as well.

'Canberra picks a winner': utility-scale hydrogen

The sense of urgency of climate change and the international 'level playing field' have largely depoliticised energy and climate policies. Canberra felt that a lot of resource and energy related jobs were on the line as well. An Australian National Energy Policy (NEP) has been developed nearly a decade ago with bipartisan support. The framework for the policy has been developed by a multi-party committee working with representatives from business, insurers, community groups, superannuation funds, universities and government. Based on the NEP, action plans have been developed for regional development, training and community transition. Management of the policy and its plans are vested in the newly formed Department of Science, Technology and Education and the Department of Finance and Climate Response. The NEP is also integrated with the country's climate policy. A carbon tax was introduced in 2025 and has been successfully enforced, with the income being earmarked for investments into renewable energy technologies as well as measures to stimulate rapid adoption of those technologies.

All in on hydrogen

The National Hydrogen Strategy is an integral part of this bipartisan national policy. Japan, South Korea, and to some extent China (which invested more heavily in its own green hydrogen capabilities over the years), have become big markets for Australian hydrogen exports. A steady and clear Australian energy policy, along with this increased demand, has created an attractive investment climate in hydrogen. Most government efforts have been directed at speeding up the transition to a hydrogen economy. It appears the government has 'picked a winner'. Especially large-scale hydrogen production and storage solutions have been stimulated, leading to not only increased public funding of those, but also to sizeable private sector investments. Big oil and energy companies have seen the opportunities in hydrogen as well and have invested heavily in it.

For Australia's coal and gas industries (and their workforce) hydrogen proved to be a saviour as well, after 'carbon capture and storage' (CCS) and plant conversions were facilitated and (financially) stimulated by government. Steam methane reforming (SMR) and electrolysis have witnessed a major price drop over the years as a result. The methane pyrolysis process has more recently been perfected (less energy and no need for desalinated water) on mass-scale to produce hydrogen and solid carbon (e.g., for graphene batteries) rather than CO2, thus requiring no CCS. This has reduced the cost and increased the capacity of hydrogen production for energy generation and storage even further, making it competitive with gas and coal.

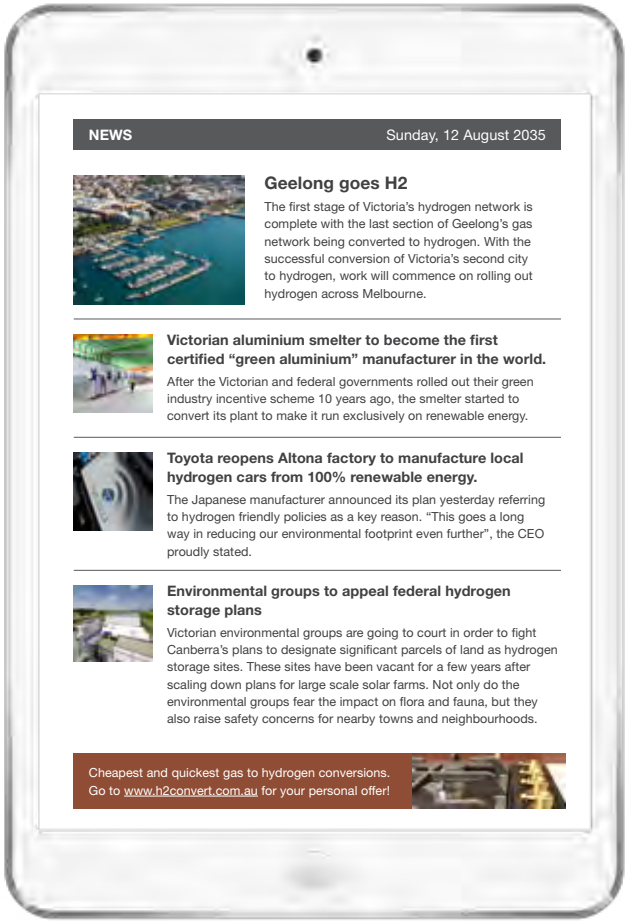
Investment, R&D, and ultimately, commercialisation of not only hydrogen, but also new and improved (next gen) battery and power to air storage technologies have also been helped by the harmonisation of international markets and standards (often dictated by the bigger markets or regional blocs) as other countries have made similar policies.

A government controlled technological revolution

More harmonised international standards have not only spurred advancements in energy technologies, but other technologies such as the Internet of Things (IoT), big data, artificial intelligence and robotisation. These technologies and industries are converging and reinforcing each other at a great pace.

These technologies proved to be quite disruptive on many industries, such as manufacturing, which triggered a reaction by governments to put in place policies to mitigate the knowledge and skills gaps of the workforce, through policies such as retraining programs.

Scenario 1
Brave New World



The 'digital revolution' has made data and algorithms, both on a utility as well as household level, critical parts of this renewable energy landscape. Examples include smart matching and managing of supply and demand during peaks (reducing loads) and in arbitrage and shifting (e.g., through hydrogen storage). Data is centralised and managed to ensure economic and safety uses are both met. Algorithms are identifying potential problems earlier and automatically sending alerts to the networks and households. As a result, fatalities, injuries and fires have come down.

Hydrogen powered grid as energy backbone

A hydrogen and large-scale renewables-focused energy mix has taken shape in Victoria, as well as in other states, with a strong focus on centralised, utility-scale solutions. Governments initially took the position that leveraging mostly on existing infrastructure and business models, yet with new hydrogen technologies replacing fossil fuel technologies, would not only speed up the energy transition, but also provide more control and direction over it. Investing in larger-scale projects had the additional benefit of focused stimulation of local and state economies and jobs provision, especially where coal and gas-related jobs would be lost.

Sizeable areas of Australia have been identified for large-scale solar and wind projects, with new transmission lines and hub substations developed by government to provide the backbone for future energy projects, such as green hydrogen. However, since the NEP has favoured large-scale investment in hydrogen, the development of large-scale solar and wind has been painstakingly slow and average energy prices have hardly come down.

High grid prices stimulate domestic alternatives

In order to offset the slow development of large-scale solar and wind due to the focus on hydrogen, the first adjustment of the NEP a few years ago has shifted some attention towards stimulating the burgeoning domestic energy trading market. This market has initially not taken off due to the focus on larger-scale energy solutions at which most public funding was directed. Rebates and subsidies were limited to direct more funds towards stimulating hydrogen. However, consumers, driven by high energy costs, have started installing large amounts of domestic solar and batteries in order to offset rising grid energy prices, even in the absence of rebates. Leasing arrangements offered by energy companies and banks alike have become a popular alternative to capital purchases by consumers, lowering cost barriers. In cities, where space for rooftop solar is sparse, some high-rise office buildings have been equipped with improved capacity photovoltaic windows. Yet, decentralised energy solutions seldom cover all the energy needs and grid electricity is still necessary to meet demand. Instead of seeing domestic energy solutions and data-driven trade as a threat to its large-scale hydrogen vision, the government has decided to make it work and incorporate it in their plans towards realising it.

Domestic energy powers utility-scale hydrogen storage

A new branch of the Australian Energy Market Operator (AEMO) was formed a few years ago to manage this big data-driven domestic energy market. Electricity networks and domestic energy solutions suppliers have been forced to share access to their smart meters' data with customer-designated service providers. The latter increasingly being new market entrants, often data-driven intermediary companies, owning no assets.

Distribution network service providers (DSNPs) have become operators of networks akin to toll roads where they charge those service providers for the use of their

infrastructure in buying and selling both domestically generated, or stored energy, and grid energy. Energy (producing) companies, having once feared the reduced demand for energy in the domestic market as a result of the storage options available to consumers, have seen enormous potential in this domestic energy trade.

Peak surpluses of rooftop solar generation during the day have proven to be an increasingly cost competitive and renewable source for enabling green hydrogen production; the next aim of the NEP. Investment in large-scale solar or wind for those purposes is, therefore, less necessary.

Other businesses have recognised the potential of tapping into rooftop PV surplus for hydrogen storage, as home batteries lack capacity to absorb most of the surplus. Some businesses liquify and store hydrogen near existing utility-scale (blue) hydrogen production facilities and/or hydrogen-powered electricity plants in remote locations. Others store it in utility-scale fuel cells on the outskirts of cities, supplying energy back when needed. Home fuel cells have not made it into many homes as a storage option. Large-scale, blue hydrogen (coal and gas with CCS), therefore, provides a significant amount of baseload power and domestically generated and traded power. However, utility-scale stored green hydrogen is increasingly delivering network firming and additional easily-dispatchable capacity to meet demand peaks.

Knowledge of safety risks of new technologies often lacking

The domestic energy upswing has had more benefits than just aiding the transition to a more renewable energy mix in Victoria. It also made renewable energy cheaper by democratising production and the trading of it.

Income generated from trading has been progressively taxed, ensuring access to domestic energy sources does not become a cause for social division.

The proliferation of domestic energy also created a significant boost to the use of data for multiple purposes, especially in Victoria where smart meter data offers opportunities to identify emerging faults within houses and businesses in order to pro-actively repair faults before they become a safety issue. However, this opportunity has not been seized on entirely. Consumers often take on risk as they become asset owners, yet they are often not fully aware of, or able to, manage safety risks. They are driven by the lowest price and often lack sufficient understanding of technical differences between the increasingly wide range of high-tech products for sale, which are not always readily compatible with one another or with the grid.

Electricians' knowledge is at constant risk of being outdated as new domestic energy technologies outpace their experience. This has driven older tradespeople to retire. Immigration intake to back-fill them is often insufficient given the global and regional push towards renewable energy, making people skilled in these trades challenging to find. Foreign trades' knowledge is not always compatible and up to par with Australian standards.

Cooking with hydrogen

The NEP not only set out to make hydrogen the dominant energy carrier for generating and storing electricity, it also identified hydrogen reticulation as the optimal way to leverage and decarbonise the existing gas infrastructure. Complete electrification of energy was deemed too costly.

In this endeavour Australia was not alone; all over the world cities, regions and sometimes entire countries have aimed for the same. International knowledge and technology sharing, along with massive public-private investments, have sped up this conversion immensely. International standards have ensured that many appliances are on the market that can operate safely on 100% hydrogen.

With blue hydrogen becoming more readily available and cost effective, the main bottleneck was the conversion of pipelines and appliances. The NEP framework dictated an 'all or nothing' approach; i.e., full conversion with a phased neighbourhood-by-neighbourhood rollout. After limited trials with 100% hydrogen reticulation to households in the more isolated markets of Western Australia and the Northern Territory concluded successfully, hydrogen conversion has started in Victoria, as well as the rest of the country, with the roll-out to be completed by 2040.

In order to lower the financial burden on the DNSPs and partnering gas companies, the conversion of the pipelines has been co-funded by the Federal Government through the renewable energy fund, paid for by the carbon tax on

natural gas during the (lengthy) transition years, during which biogas was blended in. Canberra also offers customers a rebate for the replacement of installed Type A gas appliances with new Type A appliances that can operate on 100% hydrogen. Despite this, not everybody is happy with this conversion as hydrogen prices for reticulation are rather high due to competition with export demand, just as had happened with natural gas in the 2010s. In addition, as had happened with electricians, not all gas fitters' and appliance installers' knowledge is up to par, causing frequent incidents. Yet, many households continue to choose the cheapest option.

(Shared) fuel cell mobility

The transition to hydrogen has not only impacted electricity and gas, but also transportation. China has gone 'all in' on fuel cell (autonomous) vehicles more than a decade ago. American and European manufacturers have followed suit making them and, to a much lesser extent, battery electric autonomous vehicles, an increasingly common sight on Victorian roads. Some of which are solar power generating, due to lowered prices as well as active Federal and State government policies.

A new material, "Kubas manganese Hydride-1", has been developed that can make hydrogen fuel tanks for vehicles a lot more compact and cheaper, while at the same time increasing their energy density. This fuel system is now five times cheaper than lithium-ion batteries and has advanced the uptake of hydrogen fuel cell vehicles (FCEVs). Customers prefer fast hydrogen refuelling times and longer range over slow charging times and limited range, as well as higher prices, of battery EVs. After some incidents, lithium-ion car batteries are also increasingly seen as a major waste and safety hazard. As part of the rollout of the NEP, Federal, State and Territory governments have committed to buying only hydrogen fuel cell vehicles for their government fleet vehicles as well as making it a condition of public transportation tender contracts.

Major oil companies have also invested heavily in hydrogen production and the necessary infrastructure for transportation, such as at gas stations, since it would require less change to their business models. Government has facilitated their hydrogen infrastructure by removing certain restrictions, such as allowing non-odourised hydrogen transport, and fast-tracking hydrogen refuelling stations on major highways between major and regional cities.

The smaller batteries of FCEVs make them less interesting for energy storage for both home storage as well as

grid-balancing purposes. This is further reinforced as autonomous ride-sharing schemes are deployed. Car ownership is down (due to increased ecological as well as cost-conscious consumers) with autonomous cars being in near constant motion. Such autonomous FCEVs often drive to large-scale charging points on the outskirts of cities and towns.

Less influence and smaller role of state regulators

Although the bipartisan national energy policy, including the constitutional changes to facilitate the implementation of it, has sped up Australia's, as well as Victoria's, transition towards a more renewable energy landscape, it has taken away flexibility to make policies and regulations on a state and local level. Canberra now has a bigger say on all sorts of issues. International standards have also become more important as countries saw this as a means to speed up the commercialisation and rollout of new energy technologies and appliances.

With a coherent energy policy, take up and adoption of new technology, and export of hydrogen, Australia is a major contributor to both ISO and IEC international standardisation to drive consistency, thereby reducing international trade barriers and enabling safe and reliable channels for both import and export. This has further enhanced Australia's ability to manufacture and develop leading-edge technologies in the energy sector. However, the downside of both the increased national involvement and international standardisation is that state regulators have less influence on regulation.

TIMELINE FOR SCENARIO 1: BRAVE NEW WORLD

2020	Australia experienced the worst droughts on record and large-scale climate change demonstrations forced Cabinet to develop more stringent and long-term energy transition policies.
2021	AEMO introduced planned "exit rules" whereby generators are required to provide five years' notice of their intent to decommission generation assets. Notices for decommissioning were received for five coal-fired power stations across Victoria, New South Wales and Queensland shortly after "exit rules" were introduced.
2022	The Japanese and Australian governments jointly agreed to double the funding for research into the commercial production and distribution of hydrogen. Japan committed to a 30-year trade agreement for the purchase of hydrogen from Australia.
2023	The Republican Party made climate change a priority in the run-up to US presidential election race after years of major fires and poor harvests due to extreme weather conditions.
2024	A National Energy Plan was passed through Parliament to encourage increased generation of renewable energy to support future hydrogen development and the emerging electric vehicle market. A carbon tax was implemented to support the transition.
2025	The National Hydrogen Plan was finalised and received its first tranche of funding in the Federal budget. The plan received opposition support in Parliament.
2026	Four big Super funds announced to the market the intent to invest $10b in hydrogen production and export.
2027	The Victorian Government funded exploration of prospective underground storage locations for the by-products of electrolysis.
2028	The first large-scale green hydrogen plant opened in Victoria (designed and developed by the CSIRO) to smooth out excess renewable energy generation.
2029	International standards for hydrogen production, storage, distribution and transport were established by a United Nations committee.
2030	The H21 plan in the UK achieved commercial production levels and reticulation transition was rolled out in stages. The Victorian Minister for Energy attended kick-off ceremonies.
2031	Energy demand across the South Australian power grid reduced to close to zero consumption on multiple days. This was largely attributed to PV and behind-the-meter and utility-scale batteries and storage solutions.
2032	The second Victorian pilot hydrogen plant opened and started producing commercial hydrogen for export.
2033	Electric and fuel cell vehicles sales outstripped internal combustion engine vehicle sales by 3:1.
2034	Hydrogen and fuel cell safety incidents rose in Victoria due to the speed of the hydrogen transition and lack of qualified installers.
2035	The Federal Government mandated the Australian Energy Regulator to take control of state regulated bodies.

Scenario 2:
Energy Oligarchy

Welcome to 2035. The Fourth Industrial Revolution that started in the 2010s has taken the world by storm.

Technology has changed and disrupted virtually every major industry. After the early 'victims' in the music, transport, and accommodation industries, other sectors ranging from banking and healthcare, right through to education and energy, have seen profound realignments. Software has 'eaten the world' and many sectors have seen non-traditional and disruptive players enter the market through the use of data and their matching technologies.

A polarising technological revolution

However, the technological revolution has also caused the world to enter what is now referred to as the 'Second Gilded Age', where Bezos, Zuckerberg, Ma and Musk have become synonymous with the 'robber barons' Rockefeller, Carnegie and Vanderbilt of the late 19th century. Just like with previous industrial revolutions, where enormous productivity improvements drove wealth

creation which only slowly trickled through to the general population, so too are we now witnessing what seems to be ever-increasing inequality.

This high-tech, highly automated economy has produced distinct 'winners and losers'. Automation and robotisation have not only displaced repetitive and low-skilled jobs, in for instance manufacturing, transport, and some service industries, but have also had tremendous impact on 'white collar jobs', ranging from financial services and insurance through to the medical professions. Middle-class jobs in particular have taken a hit and governments across the world are still grappling to deal with the consequences.

Aside from economic inequality, pervasive technological advancements have continued to polarise societies with artificial intelligence now customising not only our economic activities, but also our information sources. The Westminster parliamentary system has proved ill-equipped to deal with the new realities of the Fourth Industrial Revolution. The polarised political climate of the 2010s in Australia continued and was expanded upon by new fringe parties, fragmenting the political landscape further. 'Traditional' parties felt the pressure to compete with these extreme parties on the fringe of the political spectrum; as a result, the political centre dwindled. Politicians have long stopped talking to the community at large and focus only on "their people". The impact of technology is the main driver behind public and political debates regarding important matters, such as climate change, taxation, identity, and privacy. Yet, agreement on stable, broadly supported policies to tackle these issues still seems far away. While governments all over the world, including Canberra, are squabbling over (reactionary) responses to this technological revolution, the (international) development and implementation of revolutionary new technologies and disruptive concepts 'steamrolls' on, driven by business and consumer demand in the absence of clear government direction and updated free market, World Trade Organisation (WTO) rules.

Lack of direction leads to lack of investments

Political strife also impacted energy policy, or rather the absence of it. Although the effects of climate change became ever more noticeable, a pro-coal agenda continued to be pushed and renewables were hardly stimulated. Vested interests successfully applied a 'divide and conquer' strategy, managing to get governments to underwrite 'legacy' assets, at least for a while. Price controls to keep energy prices stable for both consumers and investors were also intermittently introduced, but hardly successful. A bipartisan, broadly supported energy policy never emerged. Energy and climate policies have remained heavily polarised. Every time the seats of power changed, the opposition vowed to do the opposite to what the party in power proposed. However, it is not always 'left versus right' or 'Liberals versus Labour' that form the political fissures; generational conflicts are becoming more and more tangible as younger voters are increasingly alienated by the democratic process and feel that the social contract is broken.

Investments flow elsewhere

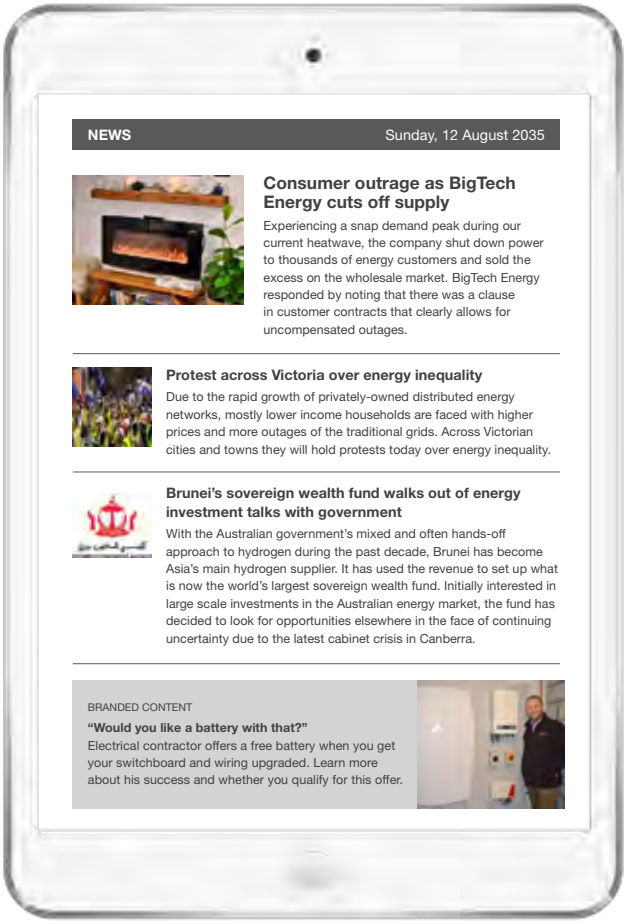
From the early 2020s onwards, faced with continued political infighting and the resulting uncertainty, many energy companies and investors looked to other markets, especially in Asia, but also in the United States and Europe. As a result, significant investment in large-scale, grid-based electricity generation has been lacking. With no coherent national energy policy in sight, nor investment certainty – and the occasional populist threat of price capping – overseas investors and owners sought to divest themselves of their (network) businesses. While the revenues continued and ring-fencing rules were never adjusted – and despite some governments even continuing to offer to underwrite – the networks grew concerned about managing their end-of-life assets without certainty about the future.

Blackouts and brownouts became commonplace as generating assets were decommissioned and not replaced, while ageing assets were operated well past their design lives with little maintenance. Energy prices have risen as utility-scale capacity has become scarcer and less reliable.

The world moves on while Canberra fights

While Canberra, but also other levels of government, were busy with political infighting, the world, as did many individual Australians, moved on. The increasingly noticeable impacts of climate change could no longer be ignored and instilled a sense of urgency for emissions reductions and targets on an international level.

Scenario 2
Energy Oligarchy



'Paris 2.0', including a global CO2 trading and pricing scheme as well as an energy transition fund, was signed by the majority of countries in 2025. In its wake, a 'Green New Deal' even became a reality in the United States. A divided Australia, however, did not sign on.

The international political impetus towards decarbonisation, as well as rising fossil fuel prices due to international carbon pricing schemes and emissions reduction targets, created an increasing appetite for renewables among businesses and consumers across the globe. Large multinational technology companies and major investors have seen a great opportunity in this demand. In parallel, governments around the world have seen great potential in taking a leading role in the energy transition and employing that for economic growth and innovation. Billions of public and private dollars were invested globally in developing and facilitating new energy technologies, which in turn has driven innovation-driven price reductions. The big 'blocs' in the world, such as the United States, the European Union, China and India, all ensured that new technologies saw few obstacles in their way. Capital, knowledge and talent were freer than ever to cross borders; however, true international coordination and harmonisation (e.g. standards) have proven elusive.

Initially, many of the new energy innovations came from start-ups and scale-ups but were quickly incorporated by a select number of 'tech giants'. Technology options – ranging from photovoltaic roof tiles and windows to advanced high-capacity home graphene batteries and wireless energy transmission – hit the market at increasing speeds as well as reduced prices. This created a further uplift in consumer and business choice and uptake, reinforcing this cycle. The global character of these energy innovations has ensured that economies of scale have been leveraged.

Missing out on hydrogen

Australia, however, has failed to take a leading role in, and profit from, the green energy revolution, particularly regarding hydrogen. The economic feasibility of shipping hydrogen to Japan, either through liquefaction as ammonia or as methyl cyclohexane, has been established since the '20s. Yet, due to local governments being slow to move, a lack of national direction and investments in order to scale up, as well as regularly conflicting state and federal regulations (e.g., regarding carbon capture), Australia has missed the opportunity to be a main player in the Asian export markets, such as Korea, Japan, and China. Other countries, such as Norway, Saudi Arabia and Brunei, were quick to seize the opportunities.

Trials of reticulated hydrogen have been positive. However, there has been no coordinated approach among the Federal, State and Territory governments to collectively learn from these trials. A lack of harmonised regulation between the states and territories has resulted in an inability to reticulate hydrogen on a national level. Governments could not agree on a transition to a hydrogen economy resulting in reticulation of hydrogen in some jurisdictions, but not all.

Consumers and businesses take matters into their own hands

Faced with government inaction and a policy vacuum, as well as rising energy prices in an outdated energy infrastructure environment, Australian consumers and businesses (facing other countries' carbon tariffs when exporting) have increasingly sought their own renewable energy solutions and arrangements since the mid-2020s. This was further facilitated as ever more new (international) decentralised energy solutions and providers came on the market. "We'll sort it out ourselves" is the motto. Business runs its own agenda, as do states and cities, although the latter are also plagued by polarisation and hyper-partisanship.

Individual households have increasingly turned to rooftop solar and home storage solutions, which have matured rapidly to make a positive 'business case' rapidly stack up for those who can afford to invest in them. Not everyone opts for their own energy solution though. Energy cooperatives are increasingly common, with like-minded people investing in their own smart grids and local neighbourhood storage. New businesses offer turn-key, subscription-based solutions for such arrangements.

By 2035, a decentralised, fragmented network with all sorts of new, non-traditional business models and (foreign 'big tech') companies has rapidly taken shape; blindsiding many governments and planners. A lack of regulation makes barriers to entry virtually non-existent. New financing options are also offered by the ('big tech') suppliers of energy solutions as well as smaller specialised companies. Banks and leasing companies are now also offering energy solutions. Yet, given the competitive economic landscape, the banks and leasing companies apply strict lending conditions regarding consumers' job and income security. Therefore, new renewable decentralised energy solutions are not available to all.

Given that a large number of consumers are now taking charge of their own energy solutions, investments in large-scale, grid-based electricity generation has taken a sharp downturn. As a result, coal plants are now often at the end of, or past, their life span (even though they are still responsible for the majority of utility-scale production).

Data-driven energy landscape

A few years ago, significant economic reforms introduced new competitive pressures that forced the electricity networks to transfer ownership of their smart meters (including undertaking fault finding) to data-driven, customer-centric service providers of which many were initially eager to step in. These days, however, the number of new entrants has been reduced; big tech companies have either taken them over or have simply 'pushed' them out.

A data-driven, consumer-to-consumer (C2C) energy trading system has taken shape, with online platforms and apps, cryptocurrencies, smart contracts and avatars facilitating the energy trade. Tech giants provide various services at a significant discount or even for 'free' in exchange for customer data on energy usage. They sell energy as part of their 'smart home' packages, often locking customers into two to five-year contracts, with 'pay as you go' options available. Data is shared within the 'Internet of Things' ecosystems, akin to the smartphone ecosystems from a few years ago, providing only consumers and companies within that ecosystem the ability to monitor, and sometimes even manage, energy supply and demand by means of smart appliances and arbitrage algorithms. BigTech Energy provides a range of energy supply services over the internet from their base in Singapore. Their discounted energy plan, for instance, is available on a two-year contract where a customer receives discounted energy pricing for energy supplied to supplement any energy shortfall, outside of energy generated by the customer's own self-serve energy solutions. In return the customer agrees to share energy usage data from their smart meters.

Safety as an afterthought

While artificial intelligence (AI) and pricing and subscription models keep the demand for electricity in check, this dynamic energy landscape is proving increasingly difficult to regulate and manage.

Consumers often connect to specialised grids that sometimes lack the necessary rigour to safety-proof them. The suppliers of energy solutions and technologies often adhere to international standards due to the lack of harmonisation with Australia's energy policy. Standardisation in the energy sector is in disarray; state governments and local councils have mostly developed individual and different codes of practice, thereby making the import and export of technology cumbersome. What is sold in one jurisdiction is prohibited in another and the legitimate supply of innovative technology from overseas markets is limited. It is now common practice for consumers to 'grey import' leading technology themselves.

Safety is an afterthought for many companies; especially the new (tech) entrants to the energy market who seem to take little interest in the quality control and safety of their affiliated installers. There is a rapid rise in the number of incidents, including fatalities and injuries and fires that cause property damage., Governments at all levels find it harder to oversee and control this fast-paced and fragmented energy landscape. Although the problems

Scenario 2
Energy Oligarchy

are recognised by all, and pressure mounts on regulators to drive safety, a political agreement on solutions and standards has not come to fruition. With regulation spotty, inconsistent, and at times rather scaled-down with minimal 'carrots and sticks', regulators such as the AER, AEMO, ACCC, and ESV are primarily focused on 'putting out fires', at times literally.

Hasty implementation to catch up

How much the country has been lagging has become apparent in transportation. Australia has remained one of the few countries in the world that has not set clear long-term targets concerning emission reductions and introducing electric vehicles, causing a low (initial) uptake. However, major car manufacturers were faced by stringent regulations on ICE and EV targets in their biggest markets, especially in Asia and Europe.

Battery electric vehicles (and to a lesser extent fuel cell electric vehicles) therefore are the only options in 2035, whether Australians want them or not. New ICE vehicles are seldomly offered anymore. The same goes for trucks, buses, and other vehicles. Both energy and digital technologies enable vehicles to play a storage as well as firming role in the energy landscape. Yet, rules regarding this are hardly present. Additionally, having not prepared for this quick transition to renewable transportation, Australia, as well as Victoria, must rapidly play catch up in 2035. A hasty and spotty rollout of both (battery) charging and, to a lesser extent, fuel cell refuelling stations, both public and at homes, did not come without opportunistic companies and ill-trained staff . This is exacerbated given that many highly skilled tradesmen and women have sought greener pastures elsewhere over the years as Australia is increasingly regarded as an innovation backwater and late adopter of technology. Government has failed to generate an effective policy response. Highly skilled technical personnel are now more expensive than ever and not every technician has the motivation to play by the rules as 'cashing in fast' has become alluring to some.

The 'energy gap' has widened

This high-tech economy with its clear 'winners' and 'losers' has translated into not just major social and political divisions, but spatial ones as well. Differences between neighbourhoods have grown. 'Electrified', sometimes even 'gated', neighbourhoods with their own blockchain-driven microgrids and other renewable energy solutions (generation, storage, and trading) that they leverage off (i.e., profit from) look very different to the lesser-off neighbourhoods. Despite their ability to be more independent from utility-scale grids, these neighbourhoods are often located in areas with relatively well-maintained existing networks in and near cities that ensure energy availability in case their own storage and microgrids run out.

Areas with a high proportion of low-skilled and low-income groups, as well as young renters and pensioners – often further away from cities – have a low penetration of decentralised energy solutions. They are still largely reliant on the expensive and increasingly unreliable traditional grids and gas networks, which have fewer fully dependent customers to carry the necessary maintenance and overhead costs. As a result, the lesser-off are therefore not only faced with higher energy bills than the more well-off, they also experience less reliable energy provision. In areas like these a thriving second-hand fossil fuel aggregate market can sometimes be found with pollution and fires not being uncommon. Energy, with unequal access to new technologies and business models popping up, has become an integral part, and at times even a catalyser, of a polarised Victorian community in 2035.

TIMELINE FOR SCENARIO 2: ENERGY OLIGARCHY

2020	Energy retailer AGL released bundled offerings; free mobile phones with internet, mobile subscription offerings and integrated energy plans.
2021	Electricity prices continued to rise as government and business squabble over causes and lack of long-term plans and policies.
2022	The Federal election was dominated by arguments about Australia's energy future, with 'coal' versus 'renewable'. Both sides were lacking a plan to manage the energy transition. Tesla announced its withdrawal from the automotive industry to focus its resources on energy storage solutions.
2023	Australia pulled out of Paris Climate Agreement. Major foreign energy companies and investors made the decision to pull out of Australian market.
2024	A record number of brownouts and blackouts were experienced in Victoria and New South Wales. Experts blamed low investment in generation capacity as well as substandard maintenance of energy infrastructure assets.
2025	The EU, US, China, India and many other countries signed Paris 2.0; Australia was a notable non-signatory. All new commercial property construction in Victoria now come standard with PV and 50% of these properties installed some form of energy storage in order to reduce dependence on grid.
2026	US tech and data firms had the largest market shares in Australian energy retail market.
2027	Norway, Denmark and the Netherlands exported more hydrogen to China and Japan than Australia as the country struggled with forming a clear hydrogen export policy.
2028	BigTech Energy built the largest renewable energy plant in Victoria to supply power to its data centre, which holds millions of people's energy consumption data.
2029	A record number of new housing estates were marketed as gated communities with internal microgrids; solar PV, batteries and IoT appliances were integrated into 'smart' houses, managed by big (foreign) tech firms.
2030	Last internal combustion engine vehicles produced in Germany and Japan.
2031	Energy regulators battled the widespread influx of unsafe and non-compliant appliances that were purchased from the 'black market'.
2032	The bottom 20% of income earners pay 150% more for their energy than the top 20%. With higher income earners going off the grid, the network distribution costs passed through to those remaining on the grid have increased exponentially.
2033	Energy safety and prices are dominant themes in Federal elections, yet parties differ widely on the policies to address the issue.
2034	Four fatalities and 20 serious injuries occurred in Victoria over the year, which resulted from poorly-maintained solar PV and battery systems.
2035	A fuel cell refuelling station caught fire in NSW (or New South Wales) due to poor compliance to safety standards. A Royal Commission was set up to investigate the poor installations of car refuelling and charging stations.

Scenario 3:
In It Together

Welcome to 2035. Australia has transformed.

The division and polarisation that loomed over a decade ago has subsided. Voters demanded stable leadership, which was reflected in the governments that were voted into office. The political landscape has shifted back to the centre. Fragmentation made place for consolidation. The impact of climate change has become more noticeable and with more frequent incidents the transition to a more renewable energy landscape is high on the agenda of all parties. A bipartisan, long-term diversified energy strategy, the National Energy Policy (NEP), with evidence-based policies, has now been in place for quite some years.

Although not without its pains for vested fossil fuel interests and 'legacy' parties, all sides of the political aisle recognised that Australia needed to double down on the energy transition. Across the globe this recognition was shared; climate change related conflicts and refugee crises created a sense of urgency. A new 'pragmatism'

entered world affairs with many countries emulating the 'Singapore-style' of government; business-focussed, socially protective, accepting of diversity, and with a reluctance to intrude in the internal affairs of others.

After years of reluctance, but helped by Australia as a conduit, the United States followed the Asian Integrated Economic Zone and the European Union to finally commit to deep emission cuts and a new 'Green Deal'. It rid the world of the climate change 'prisoner's dilemma', levelling the playing field. International emissions reduction and clean energy targets are now enforced to various degrees the world over, with both 'sticks' (i.e., an international carbon trading scheme) and 'carrots' (i.e., the stimulation of renewables on a national and international level).

Scaling up proven technologies preferred over disruptive innovations

Better informed and more environmentally conscious consumers, both globally as well as in Australia, demanded renewable energy. However, new renewable energy technologies have not become ubiquitous, nor disruptive. Early cyber-security attacks, combined with safety incidents with home batteries and fuel cells, have made consumers, businesses, investors, as well as governments, wary of new technologies and disruptive new businesses. It has also slowed down the convergence of energy and IT technologies. Automation and robotisation have slowed down as well, not only due to lower investments after some major big 'tech bubbles' burst over a decade ago, but also because the public's ethical concerns led to regulations limiting the reach and impact of such technologies on the economy and society at large. In this climate, many governments' energy policies, including Australia's, are focused on scaling up proven technologies rather than on investing in new 'revolutionary' technologies. International coordination on standards has increased. Having at times been an early adopter in the past it is no longer the case for Australia, mostly adopting ISO standards rather than developing them by itself.

Not actively facilitating or stimulating new technologies, while strictly regulating energy industries, has made scaling up in Australia complicated and slow. This caused the country to lose its competitive advantages (e.g. roof top solar penetration) and its innovative capacity in the renewable energy industries.

Smoothing over the energy transition

The framework for the National Energy Policy (NEP) has been developed by a multi-party committee working with representatives from business, insurers, community groups, superannuation funds, universities and government. It was adopted with overwhelming bipartisan support in Canberra well over a decade ago. The NEP offered not only sticks by pricing in and limiting carbon emissions, but also a carrot by stimulating and facilitating renewables. The carbon tax revenue is earmarked for phasing out non-renewable energy sources, investing in renewable energy projects, and managing the social impact of the energy transition. The NEP's technology-agnostic character – making it willing to integrate new carbon neutral sources of energy as they become commercialised – has also ensured wide backing from politics and business by sharing the costs and benefits of an accelerating energy transition more widely. This ensured that impacted communities and businesses were looked after with action plans that have been developed with regional development, training and community transitions in mind. As part of the rollout of the NEP, various sources and technologies have been facilitated or invested in by governments, which has allowed the renewable energy sector to flourish, while in parallel coal and gas plants approaching their end-of-life were phased out 'softly'.

Utility-scale grid remains the backbone of the energy landscape

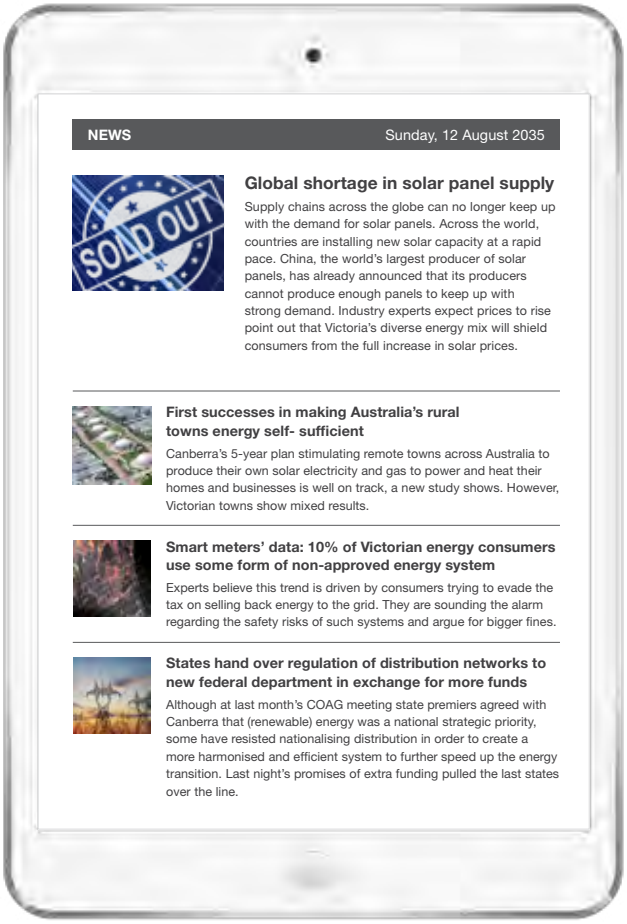
During the energy transition, a truly decentralised energy landscape – dominated by rooftop PV, home storage, and microgrids – has not come into being. Although the uptake of such energy options has increased, most people still expect a top-down, well-regulated, centralised grid to be the backbone of the energy landscape. That backbone has been the focus of the NEP, recognising that building on, enhancing, and repurposing existing infrastructure and business models would be the fastest way to transform the economy. The public recognised that a government directed, unified approach should guide these efforts. Given the herculean nature of the task at hand, citizens and businesses alike demanded that the Federal Government take charge of the issue. With the NEP it has done just that. Canberra urged state and local governments to follow the Federal lead and hedge

Scenario 3
In It Together

their energy strategies and policies, slightly favouring large-scale renewables over decentralised energy technologies. Canberra itself adopted a more active role in the energy landscape by investing in the development (and sometimes even ownership) of wind and solar capacity, hydro (such as Snowy 2.5) and, to a lesser (successful) extent, hydrogen. Even some smaller modular nuclear reactors have been developed in order to reduce emissions as more renewable sources are coming online.

However, the government intervention has not gone without some initial friction between 'public' and 'private' stakeholders. Yet, government managed to sweeten the deal for the latter. Companies with higher emission assets operating at a loss due to carbon pricing and cheaper renewable energy prices have either received CCS subsidies (coupled with price guarantees) or have been compensated to decommission these assets earlier. Energy companies and other investors have been enticed by fiscal (both federal and state) benefits to invest more in utility-scale renewable energy generation as well as storage.

Sizeable areas of Australia have been identified for large-scale renewable energy projects with new transmission lines and hub substations developed by government to provide the backbone of future energy projects. As a result, investments in constructing large wind and solar farms in these locations have soared. Utility-scale batteries are embedded in these hubs to avoid the need for inclusion in these development projects. These batteries provide integrated system services, the most important of which is managing energy transfers and reducing peak loads on the networks. These large-scale renewables provided the majority of power to the grid as early as 2030. The economies of scale these renewable initiatives created drove down the costs of network augmentation as well as renewable energy prices and triggered the early closure of some coal and large gas plants. Smaller gas plants were increasingly powered by biogas (with CCS) and, in smaller numbers, blue hydrogen, both of which were providing most of the utility-scale firming capacity to the grid.



Regulated decentralised solutions to take the load off utility-scale grids

The uptake of decentralised energy arrangements did see a small increase but has more or less plateaued years ago. As the focus of the NEP has shifted to utility-scale renewables, subsidies for domestic solar and home batteries have been limited and phased out, especially for higher-income groups. Selling back to the grid is also heavily regulated and progressively taxed, in order to limit energy (income) as a cause for social division, as well as generating additional public funding for large scale renewable generation and storage projects. In order to make decentralised energy solutions financially viable for lower-income groups and renters, both groups continue to enjoy either limited rebates or lower taxes on their feed-in sales.

Virtual power plants with solar panels and batteries, (affordably) leased to both households and renters – but owned and maintained by larger energy suppliers with mature safety systems (including DNSPs due to relaxed ring-fencing rules) – have prevented making decentralised energy solutions the exclusive domain of the well-off. Although the income-generating aspects of decentralised energy solutions have been limited by government regulation, another function of these technologies has

actually been stimulated. Governments, including the Victorian, offer consumers incentives for IoT appliances that allow the peaks on the utility-scale grid to be better managed. Strictly regulated (e.g., regarding cyber-security) and standardised smart meter data is being managed by the various energy suppliers in an integrated manner to reduce peaks in the grid by reducing loads ('IoT shutdowns') and shifting loads, including both domestic battery storage control and utility-scale storage and networks flows. while at the same time pro-actively managing household safety. Decentralised energy solutions subsequently contribute to network "gold-plating". However, wary of the cyber-security and privacy aspects, not everyone finds these energy solutions appealing.

Hydrogen is 'late to the party'

The initial drive towards electrification stimulated by the NEP has reduced the demand for natural gas, yet gas remains an important source of energy for many Victorians. In order to meet their emission reductions targets, as well as improving their environmental credentials, gas companies have invested in feeding biogas into the existing gas infrastructure. Locally sourced biogas from waste and sewerage has been stimulated and subsidised by both federal and state governments. Hydrogen feed-in has been limited, however.

The increased demand of Asian economies for renewable and clean energy, as well as (limited) government subsidies into R&D, has stimulated Australia's hydrogen industry and has made it a rising star in the country's exports. The resultant upscaling of projects reduced its prices enough to become commercially viable for some consumers and businesses. Since 'green' hydrogen cannot reliably be produced at scale yet, most of the hydrogen is produced using proven coal and natural gas processes along with CCS, which has received considerable support of the Victorian government seeking to honour its commitments to emission reductions targets.

The (partially subsidised) upgrade of the distribution network to polyethylene is completed, although there are still unresolved technical issues with hydrogen embrittlement of transmission pipelines. Governments subsequently agree to continue transmitting natural and biogas, but also blend hydrogen through the distribution network. 'Blue' hydrogen is still more expensive than biogas and Australian consumers don't regard it as 'green' enough. Therefore, its share in the blend is rather small. Higher blends, or sometimes full hydrogen reticulation, is more the domain of industry.

Steadily improved battery storage capacities, lower battery prices, improved battery waste management, and recycling, have made hydrogen a less attractive storage proposition, given its still prohibitive costs (due to lower maturity) and more stringent safety requirements. In addition, more affordable wind and solar generation at the onset of the energy transition has driven some consumers to opt for electric stoves and other appliances.

Hydrogen, in other words, is 'late to the party'. Therefore, despite being blended into the natural and biogas network in small numbers, it is mainly an export product; produced in dedicated (remote) production facilities and moved through secure pipelines to storage facilities far away from traditional freight docks to be shipped overseas for the peak demand season, primarily in Asia.

Electrification of transport has taken off

An increasing number of (non-autonomous) battery electric vehicles are on Victorian roads due to enforced government targets. The development of fast-charging, efficient graphene batteries is a game changer leading to a sizeable uptake in battery electric vehicles, rather than hydrogen fuel cell vehicles. Governments prefer the speed and relative simplicity of electricity-based charging infrastructure over hydrogen refuelling, leading to an uptake of battery electric vehicles at the expense of hydrogen fuel cell vehicles. The target for EVs in the National Energy Policy has been set at 50% of new vehicles sold by 2030. This was recognised as a moderate target and governments sought to increase this as technologies have become more readily available, particularly long-distance batteries and fuel cells, successfully addressing issues of distance which is pertinent to countries like Australia.

Public debate regarding the EV target brought to the public's attention that it would take time for new sales to flow through to the existing vehicle fleet. The country not only recognised the need to make the technology work for its people, but also that it needed to happen. In 2035 this approach has proven rather successful. EVs are a

Scenario 3
In It Together

now a common sight in Victoria, making up 60% of new vehicles sales. However, not all these vehicles are sold to individual consumers.

Sharing concepts have taken off with large manufacturers, Mobility-as-a-Service (MaaS) providers as well as financial services firms offering subscription and pay-as-you-go services. These business models seek to maximise the time on the road of the vehicles over charging and discharging, limiting the use of EVs for balancing the grid.

The downside of rapid rollout of battery EVs, and to a smaller extent fuel cell EVs, is that the charging infrastructure has not caught up and people have little patience waiting for a certified installer.

Canberra defines the rules of the game

A Federal Government taking charge of the energy transition with proven technologies has forced a closer relationship between, for instance, the AER, AEMO, federal departments and DELWP, to ensure the energy transition proceeds without incidents and no-one is left behind. It also resulted in these government bodies having a stronger role in shaping the market and prices. The balance is hard to strike between market and government, and cumbersome and light regulation, and is in need of constant adjustment. More government price-setting and stricter regulation have resulted in thin margins, favouring bigger companies over start-ups (i.e., scale over innovation). Complicated regulations are also making innovation hard for start-ups. A more directive Canberra has also come at the expense of the authority of state and local governments, leaving them with fewer options to regulate.

Costs are another issue. Australia is surely making progress towards its emissions reduction and renewables goals, yet due to a lack of technological progress, as well as a lack of bold choices and scale in unproven new disruptive technologies – in combination with the compensation paid to 'legacy' industries in order to retain support for the NEP – the bill is paid for by the people or simply passed on to future generations. Australia had to issue additional bonds to pay for the NEP measures. As such, there is a lot pressure on keeping the costs of regulation and inspection limited.

TIMELINE FOR SCENARIO 3: IN IT TOGETHER

2020	Rising food prices and climate refugee crises put climate change high on political priority lists across the globe.
2021	Major nations agreed on further emission reduction measures and renewable targets in order to meet Paris Agreement. Several home battery fires resulted in a decline in home battery sales.
2022	The new Federal Cabinet set up a multi-party committee to develop a National Energy Policy (NEP) and energy transition plan. The committee included representatives from business, insurers, superannuation funds, unions, universities and government.
2023	The NEP passed by a near-unanimous vote across both Houses of Parliament. It included a National Energy Transition Plan and Regional Action Plans with a focus on rural employment through utility-scale renewable initiatives.
2024	Group 2 of AEMO's Integrated Service Plan was completed. The first major investment in NEM was made by the Federal Government.
2025	Second major investment in NEM was completed. Snowy 2.0 opened. Rooftop PV Rebate Scheme ended, with funds redirected in favour of large-scale solar farm stimulation.
2026	Cyber-attacks in several countries made consumers and politicians wary of excessive integration of IoT and energy technologies. Largest Australian offshore windfarm in Bass Strait (Star of the South 2) online.
2027	Australia met the Paris emissions reduction target of 26%.
2028	Federal department took over management of electricity distribution.
2029	Strict regulations imposed by the Federal Government on decentralised energy arrangements to bring them into the national grid.
2030	Smart meters mandated across the NEM.
2031	Renewable energy industries became a top-3 employer in rural areas. Samsung and LG forced to join forces in the Australian home battery market as a result of disappointing sales numbers.
2032	Snowy 2.5 approved by Federal and state governments.
2033	First nuclear reactor opened on Australian soil, with two more close to completion at the time.
2034	Although the percentage of hydrogen in Victoria's gas mix was raised, the significant majority (approx. 90%) of blue hydrogen was destined for export to Asia.
2035	60% of Victorian new vehicle sales were electric. 50% of CCS subsidies stopped due to increased renewable alternatives.

Scenario 4:
Good Old Days

Welcome to 2035. The Australian economic miracle is over.

Geopolitical instability and protectionism slowed down global trade. The trade battle between the United States and China escalated and forced other economies to take sides. Tariffs, immigration restrictions and other protectionist measures span the globe. Australia is no exception. Australia's record run without a recession came to an end a decade ago. In this unstable geopolitical climate, international emissions reduction schemes have become paper tigers as countries sought to protect their domestic economies, fearful of putting their businesses at a disadvantage by imposing strict targets and regulations.

Blame game divides the country

The effects of Australia's economic downturn have not been evenly spread. Many people think that the economy is rigged to benefit the rich. Populism abounds and social instability and polarisation have taken hold of Australia. Fringe parties in this polarising political landscape have

come and gone but there is broad support for platforms purporting to represent those that feel they have been left behind. Most of these parties have reactionary agendas, seeking to exploit a polarised society.

They also claim that the fix to the problem is to simply blame the elites that they feel are benefitting at the expense of them. Progressives seeking to lead Australia into a pro-international engagement, pro-technology, decarbonised economic direction have also been regarded with suspicion. Similarly, science is seen as a tool of progressive elites. As a result, there is increasing rejection of scientific evidence as a basis for decision-making.

Reactionary and politicised short-term energy policies

Frequent changes of prime ministers and cabinets have become the new normal. Coalitions include more parties, making them less stable. Policymaking has been short-term driven and reactive for quite a while now. There is an expectation that government agencies will abandon long-term solutions to pursue politically expedient short-term agendas. A clear and stable (long-term) national energy policy, integrated with Australia's climate policy, was never on the cards.

Climate change sceptics are commonly found in politics, business and the electorate. Extreme weather events have increased, but are often politically framed as a nuisance, a new fact of life we need to deal with – certainly not significant enough to instil a sense of urgency. Even when people agree on the urgency of climate change, they can still be far apart on the policy options to address it. In this political climate, energy policy is still heavily polarised between people in favour of 'good, old coal' and 'renewables', between 'right' and 'left', as well as 'open' versus 'closed' world types. Positions are more entrenched than ever.

Due to the economic downturn, short-term profitability wins out over long-term investments. In the public and political debate around which energy sources should receive government support, fossil fuels like coal and natural gas gain more support than renewables such as solar and wind.

Without a complete 'green' package of technologies that can provide 100% replacement of coal, conservative forces have successfully argued against an integrated and long-term national energy policy (NEP) or any associated taxes and incentives to bring about an energy transition. A carbon tax to limit emissions is still political suicide. Additionally, renewable energy has been successfully blamed for the lack of investment in existing fossil fuel infrastructure. A reactionary push to return to the "good old days" took hold and led to the funding of new coal power stations and the nationalisation of end-of-life coal assets due for decommissioning. As a result, Australia is lacking a national energy transition policy. National standards and regulations are either lacking or in near-constant flux. Investors in (renewable) energy therefore have fled to greener pastures, mostly in Asia.

Backlash against / headwind for new technologies

Global economic instability has caused a hostile climate for technological advances. Investors prefer short-term profits by leveraging existing technologies over longer-term investments and innovation. Protectionist measures have not only slowed down the free movement of talent and ideas but also of the capital needed for investment in many new technologies, both globally and domestically. (Cyber) safety scandals concerning autonomous vehicles, the Internet of Things, as well as early home battery fires have made consumers and investors wary of purchasing or investing in new technologies. In these uncertain times, people seek certainty in proven technologies. Governments across the worlds have put more stringent regulations in place to govern new technologies. Differences in national regulations and standards have made the development and commercialisation of new technologies particularly cumbersome: convergence between industries has slowed down as a result.

A hostile climate for innovation

Protectionism has also proved disastrous for Australian hydrogen exports, as Asian countries start to either produce and/or consume their own natural gas. Emission reductions and clean energy targets are hardly an issue since international coordination and enforcement is lacking. No country wants to unilaterally impose costs on its citizens and businesses by either taxing emissions or forcing the adoption of more expensive renewables.

Scenario 4
Good Old Days

Foreign demand for Australian coal and gas therefore remained strong. As a result, Australian companies felt little need to invest in new hydrogen-producing technologies and facilities.

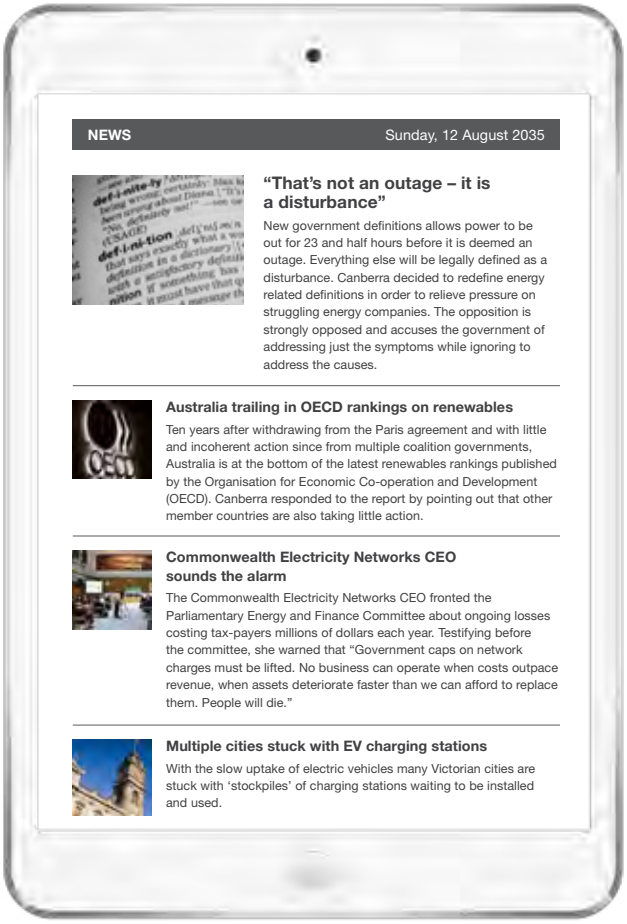
Fluctuating national energy security policies of recent governments have made foreign investment in the Australian and Victorian energy market unattractive, leading to uncoordinated, and sometimes a reactionary, implementation of foreign investment and technology. New business models and technologies have not been able to disrupt the energy landscape. Economic ring-fencing rules have remained in place, but there is less concern about this as new business models seldom arise. Private companies, both foreign and domestic, hardly innovate or invest. Instead, most divest. Distribution businesses have even engaged in the re-nationalisation of networks as the assets hit the 'bathtub curve'. In some Australian markets, governments have been forced to re-nationalise energy generation, transmission, distribution, and even retail. Prices have gone up. Therefore, one of the key words in the Victorian energy landscape nowadays is not innovation, but efficiency; fossil fuel efficiency as well as increased efficiency in renewable generation.

'Traditional' energy mix with frequent capacity issues

Fossil fuels are still dominant for baseload. Coal is still in use with minimal investment in maintenance, while ageing gas generation is used more frequently, especially given declining global gas market prices.

Large-scale renewable projects are only being built when occasional price spikes spur some governments to invest in renewables. Private investment in renewables has taken a dive given the uncertain returns, as well as the unstable policy and regulatory environment.

In this environment, hydrogen did not witness the technological progress that some had hoped for. The Victorian Government allocated some money into commercialising hydrogen generation from coal with carbon capture and storage that can be scaled-up to commercial levels. However, Australia's increased economic isolationism and the resulting export limitations have lowered the potential for economies of scale. Hydrogen is still far from being cost competitive.



Occasionally, a new government runs trials of reticulated hydrogen, but these never gain much traction. Victorians, as well as Australians in general, are more conscious of their wallets than environmental concerns. This has also held back the uptake of fuel cell cars.

Due to protectionism, the prices of rooftop solar have risen. Government subsidies and rebates have also been discontinued due to them being regarded as unwarranted market interventions. Storage technology has not developed into a viable, cost effective measure for storing overcapacity of the slightly increased solar and wind generation. Commercially viable technological breakthroughs have hardly occurred, and international tensions have made certain resources extremely expensive. Home batteries, given their steep prices and only slightly improved capacity, are not a frequent sight in many Victorian homes. Waste scandals regarding depleted lithium ion batteries have also turned people away from batteries, regardless of the technology they use.

Government investment in utility-scale battery storage has also been wound back. Electric vehicles, with no government policies or subsidies to stimulate their uptake, have met the same fate; internationally there is still a big market for internal combustion engine vehicles.

Blackouts and brownouts have become commonplace as generation is decommissioned and not sufficiently replaced, or ageing assets are operated well past their design lives. Even though coal and gas plants have been subsidised, underwritten by various governments, or even nationalised, investors lack regulatory certainty or have simply lost interest in the Australian market. This applies both to baseload and firming capacity. Capacity issues are especially common around big population centres such as Melbourne, which has continued to increase in size, although at a slower pace than during the 2000s and 2010s due to immigration restrictions. Rural customers are increasingly forced off the grid as they struggle to connect to the centralised network, while investments in extending these grids are far and few between.

Skills drain

When the recession hit Australia, many experienced trades people left for opportunities overseas and have since settled there. While occasionally relaxing the strict immigration rules in an attempt to attract foreign tradespeople to fill the deficit, these temporary measures are often not successful since Australia is no longer the attractive migration destination it once was. The rest of Asia is now more attractive. Skilled tradespeople are therefore hard to find and their services now come at a significant premium, at a time when the need for them has never been more urgent. Given the high prices skilled tradespeople command, the quality of local services has gone into decline, with maintenance on dwellings often not being conducted. Electricity and gas faults are on the rise, with injuries, fatalities and fires increasing considerably.

Energy 'black market' and theft

An energy divide has emerged in Victoria, with the poor, the elderly and young renters losing out. Victorians who can afford the capital costs feel they have no choice but to install home solar and batteries to provide some level of certainty of supply as well as control over their energy prices. Domestic (gas and even diesel) generators and battery storage without solar are on the rise as households seek to have the capacity to not be impacted by blackouts in their areas. Retaining such surpluses has had adverse effects on (official) energy trading and on energy prices. Those that can, invest in their own microgrids, often using second-hand and outdated assets. Cost takes priority over proper and safe installation. Cables over fences are an increasingly common sight in lesser-off neighbourhoods. Even more drastic approaches, such as power theft – either through the grid, tapping storage or even battery theft – is becoming more and more common. In the absence of standardised and government-approved energy market protocols, and enabled by dubious data technology players, dark networks lead to the formation of a growing black energy market in Australia. The lack of data sharing or low-quality data leaves regulators with sparse, or sometimes no, lead indicators.

Navigating a complex and confusing regulatory landscape

Lacking regulatory certainty and with cost-conscious consumers, energy companies are investing less in their assets and maintenance. Safety risks and (lethal) incidents are increasing as a result, although companies often attempt to cover these up. People feel a growing need for an 'energy police'; however, a desire for lower energy prices somehow always trumps the willingness to pay for safety, education and/or prevention.

With the political landscape being in so much flux and vacillating between extremes of laissez-faire versus nationalisation, regulators are often a step behind. Regulators are constantly putting out fires and reacting to incidents. Due to the nationalisation of some assets, regular conflicts arise as government agencies are exposed to oversight by the economic and safety regulators. It is difficult to contain the blame games between governments and regulators on various levels.

Another challenge is in standards; national standards and regulations, as well as safety benchmarks, are either lacking or in near-constant flux. Large businesses therefore resort to international standards, or those of their biggest markets, as a basis for safety to try to by-pass inconsistencies nationally. This has put pressure on regulators to enforce inconsistent and cumbersome standards and regulations.

Scenario 4
Good Old Days

TIMELINE FOR SCENARIO 4: GOOD OLD DAYS

2020	US-China trade war caused global recession; Australia had its first recession in nearly 30 years. Tech companies across the world heavily impacted by 'tech bubble' bursting.
2021	Federal Government bought and upgraded the Liddell coal-fired power station to prevent it from being decommissioned. AGL continued to manage the generator under contract. EU imposed large tariffs on energy imports to protect the European economy.
2022	Emissions reduction was not an issue during Federal elections as the economy and jobs took centre stage. International venture capital investments in technology companies were at an all-time low.
2023	A hung Parliament resulted in new Federal elections; a minority government installed post elections. BigTech Energy's market value halved due to protectionist measures globally.
2024	Germany and France extended ICE vehicle sales deadlines in order to promote competitiveness and improve overall employment numbers of national manufacturers. Natural gas prices lowest in 20 years.
2025	Increased tensions between electricity network operators and the Federal Government over escalating network charges. The Federal Government threatened to transfer energy infrastructure assets to new owners or nationalise the assets if prices were not brought under control by the incumbents.
2026	Australian National Audit Office report concluded that Government measures to cut emissions and to stimulate renewables were largely ineffective and insufficient.
2027	Maintenance budgets of energy and distribution companies down 30% in 10 years.
2028	Record number of properties were disconnected due to "inappropriate" use of electricity. Renewable stimulation measures stopped after just one year as the current Federal Government lost power.
2029	Queensland and the Northern Territory suffered the worst summer in history, killing thousands of cattle and leading to huge agricultural losses. Massive bushfires erupted in Victoria killing 50 people. Parliaments, both Federal and State, failed to agree on energy and emissions measures and policies.
2030	Diesel generator sales tripled in 5 years.
2031	Electricity rules were changed that allowed for extended periods of power outages before compensation is required be paid to consumers.
2032	Blackouts and brownouts tripled over a 3-year period in Victoria; lower income households without the means to install home storage or backup options were hardest hit by power outages.
2033	Australian campaign to attract skilled trades fell well short of required targets.
2034	A strong New Zealand economy based on a stable political environment attracted the largest number of immigrants from Australia on record.
2035	Australia had the largest percentage of coal in its national energy mix of any OECD country.

5. Adaptive strategy roadmap

5.1 The OGSM method

The scenarios explore a range of plausible futures which ESV may be faced with. As such, the scenarios allow one to identify challenges and opportunities for the organisation across the range of futures and to develop strategic options in response to these challenges and opportunities.

The strategic options are subsequently clustered into eight themes that they address:

- Government, role and organisation
- Internationalisation
- Decentralised energy model
- Hydrogen
- Electric vehicles and fuel cell electric vehicles
- Qualified practitioners
- Internet of Things, data and automation
- Revenue model

The OGSM method is then used to develop Objectives, Goals, Strategies and Measures for each theme, with the Measures comprising both actions to be implemented and the performance indicators used to measure progress towards implementation.

In developing the strategic roadmap, Stage 1 has developed objectives, goals and strategies for each of the eight themes. These are detailed in Section 5.3. The measures are still under development. These will be finalised with input from ESV's Future Trends Advisory Committee, once the terms of reference are approved and appointments are made.

5.2 Tying scenarios to strategies

The themes and associated strategic options identified in Stage 1 provide the strategic framework that underpins the development of a strategic roadmap. Now the project team needs to translate the strategic options into concrete actions – determining timing, assigning ownership, and allocating people and resources to the strategic options for each of the themes.

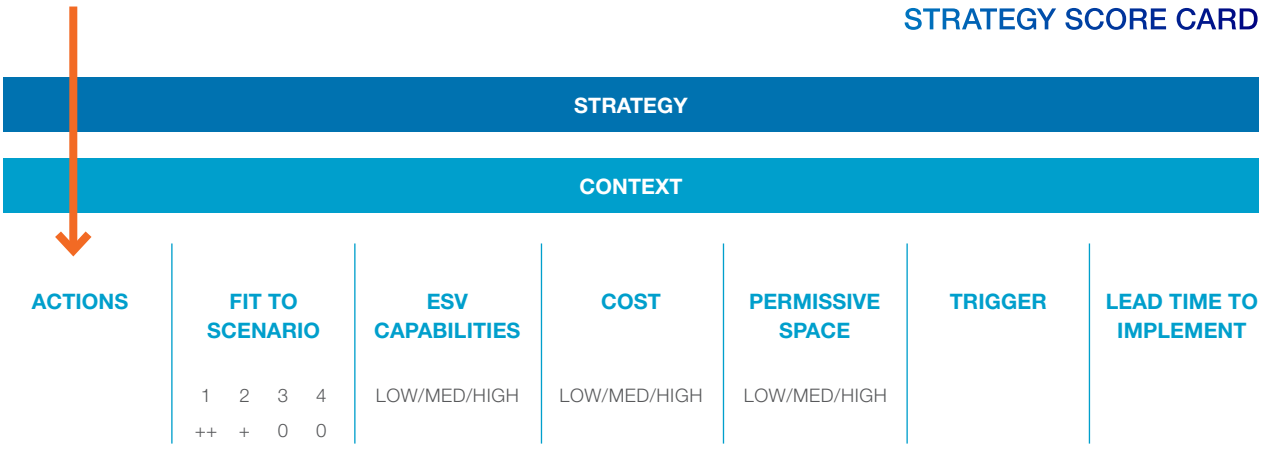
In developing these actions, the project team will ensure the actions are tied back into the scenarios by assessing each action for its fit to the four scenarios; some have a strong fit, some a weak fit and others have no fit. As the different scenarios emerge, the mix of actions to be implemented evolves depending on their respective fits.

Score cards for each action will be used to assess:

- whether ESV has sufficient capability to implement the action
- the relative cost of implementing the action, including capacity building
- whether ESV is able to implement the action independently or needs support from other stakeholders (permissive space)
- the lead time needed to implement the action
- the triggers that indicate when the action needs to commence.

The process of identifying actions, triggers and lead times will be an iterative process, with consideration given to whether there is sufficient lead time to implement the action once the trigger is activated. Insufficient implementation time will either require an action to be modified or a different trigger identified that provides greater lead time.

The process of developing concrete actions will be undertaken as part of Stage 2 (see Section 6). This will then form the strategic roadmap. And like a good map, it will help us steer our course as the destination evolves and moves.



5.3 Objectives, goals and strategies

GOVERNMENT, ROLE AND ORGANISATION — GOVERNMENT AND ROLE

OBJECTIVE: IN ORDER TO ENSURE THE SAFE USE OF GAS AND/OR ELECTRICITY WITHIN VICTORIA, ESV HAS CAPABILITIES TO FULFIL ITS ROLE(S) UNDER LEGISLATION AND IN ITS INTERACTION WITH GOVERNMENT

GOALS	STRATEGIES
ESV has developed a capability to operate in an environment of ongoing change and ambiguity	**1.** Conduct ongoing monitoring of environment in which ESV is operating.
	2. Develop and maintain an ongoing dialogue with other relevant regulatory authorities to ensure understanding of the relevant roles and responsibilities of each entity.
	3. Ensure Victorian energy legislation remains adequate to ensure public safety in light of emerging technologies, new and changing business models and the formation of new markets.
	4. Ensure ESV has adequate technical knowledge and regulatory capabilities to perform its roles.
	5. Enhance ESV's ability to respond to changing operational demands.
ESV is in a position to promptly and effectively respond to changes in technology, underlying licensing structure and emerging utility-scale projects.	**6.** Advocate for the formation of a life-long training system to maintain high levels of competency, in addition to licensing, as a mechanism to ensure the quality of installation work.
	7. Develop and maintain licensing structures to reflect changes in technologies and practice.
	8. Understand safety implications of emerging technologies to inform department policy development.
	9. Develop ESV's policy position on our required level and form of engagement in the area of new energy technology trials.
	10. Process and accept trials of emerging technologies, or new approaches to existing technologies, with emphasis on the risks and relevant controls to minimise risks to the public.

GOVERNMENT, ROLE AND ORGANISATION — GOVERNMENT AND ROLE

ESV is a well-known and respected source of information on the safety risks associated with emerging technologies for government, industry and the general public	**11.** Develop positions on the safety of new technologies as they emerge.
	12. Provide technical knowledge, including information in support of ESV's position, for consideration in the development of government policy.
	13. Provide public documentation to industry (including appliance retailers, energy companies and tradespeople) regarding emerging technologies, the associated safety risks and the obligations of the public, tradespeople and industry.
	14. Develop a communication program to better inform the general public on risks associated with emerging technologies by providing factual and independent information.

GOVERNMENT, ROLE AND ORGANISATION — ORGANISATION AND CULTURE

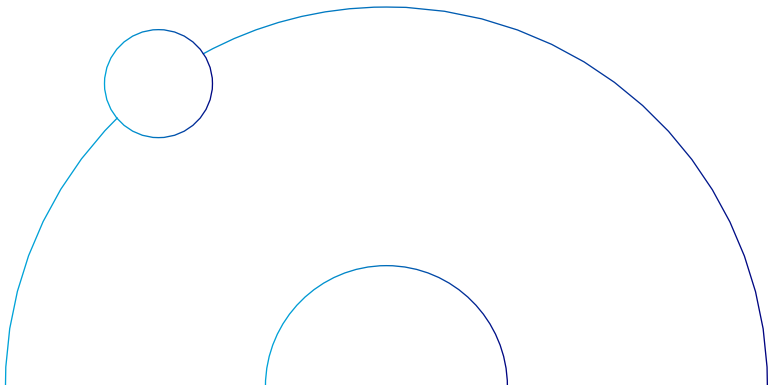
OBJECTIVE: ESV IS ABLE TO EFFECTIVELY AND SAFELY ADAPT TO A CHANGING ENERGY LANDSCAPE

GOALS	STRATEGIES
ESV develops a capability to gather intelligence, analyse it and apply into decision-making and action	**15.** Develop a longer-term strategy building capability that goes beyond the three-year Corporate Plan time horizon, and that can inform ESV's corporate planning process.
	16. Develop a mechanism for ESV to translate new intelligence into strategic changes and, therefore, become an adaptive organisation.
Ensure ESV maintains the skills needed to effectively regulate safety within a changing energy industry	**17.** Improve knowledge acquisition and sharing process.
	18. Instil a culture of continuous improvement within the business that drives improvement and efficiency.
	19. Ensure that ESV retains key skills within the business.
	20. Re-assess procedures and policies for the safety of ESV personnel as required.

INTERNATIONALISATION

OBJECTIVE: ENSURING ESV IS PROACTIVELY IDENTIFYING AND RESPONDING TO THE CHANGES IN GLOBAL MARKETS

GOALS	STRATEGIES
All gas and electrical goods supplied to Victorian consumers are safe and compliant with relevant standards	**1.** Proactively monitor developments in the area of emerging and changing gas and electrical goods.
	2. Develop a draft policy position in relation to any potential safety concerns related to emerging and changing gas and electrical goods.
	3. Conduct ongoing monitoring to determine whether there is a need to develop new certification programs, or modify the existing programs, for emerging and changing gas and electrical goods.
	4. Develop knowledge and skills in regards to emerging technologies and formulate appropriate monitoring approaches.
The consumer's safety is assured regardless of the origin of the product or the means of supply ESV has quantified the safety risks from changes to supply chains and has developed tools to manage our audit functions in a digital marketplace	**5.** Proactively monitor the supply of goods entering the Australian market through established and new/emerging supply chains.
	6. Define the scope of the regulatory framework in relation to new/emerging ways to sell or supply gas and electric goods.
	7. Conduct ongoing monitoring of new/emerging supply chains.
	8. Develop knowledge and skills for monitoring and assessing new/emerging supply chains.



DECENTRALISED ENERGY MODEL

OBJECTIVE: ENSURING THE SAFETY OF THE ELECTRICITY AND GAS NETWORKS AS VICTORIA TRANSITIONS TO A DECENTRALISED ENERGY MODEL

GOALS	STRATEGIES
ESV is positioned to ensure that the transition of the networks to a decentralised energy model occurs with public safety incorporated into its design, implementation and governance. ESV has prepared its stakeholders to operate in a decentralised environment ESV has adequate oversight and data on distributed energy networks in order to effectively manage safety risks	**1.** Develop an understanding of the safety and other risks associated with a decentralised energy model, including the economic and social risks that could affect energy safety. **2.** Consult with stakeholders to understand their perspective. **3.** Develop a policy position to inform our response. **4.** Clarify the scope of the regulatory framework and ESV's role in it regarding distributed energy, including microgrids and off-grid systems.
Prepare ESV and its stakeholders to operate in a decentralised environment	**5.** Develop or source a register/database of new energy installations. **6.** Educate industry and consumers regarding risks associated with new technologies, products and solutions. **7.** Ensure ESV continues to maintain its credibility as a regulatory expert in energy safety. **8.** Engage other regulators and parties to identify regulatory gaps. **9.** Develop ongoing working relationships with other regulatory bodies: – ESC, DELWP at the state level – AEMO, AER, ERAC, GTRC at the national level.
ESV understands the implications of an evolving energy mix and continues to be able to provide strong regulatory oversight	**10.** Develop an understanding of the investment strategies of new business models as they emerge. **11.** Develop an understanding of how safety is factored into the decision-making under the investment strategies of the existing network businesses and new, emerging businesses. **12.** Develop an understanding of how safety is factored into the decision-making.

HYDROGEN

OBJECTIVE: ENSURING THE SAFE INTRODUCTION OF HYDROGEN RETICULATION, PRODUCTION, EXPORT AND UTILISATION

GOALS	STRATEGIES
ESV has achieved the highest standards of community safety by ensuring that the safety risks arising from hydrogen are minimised, pipeline safety hazards are mitigated, and energy safety and efficiency are promoted	**1.** Proactively monitor developments in this area to be ready to influence.
	2. Develop draft policy positions for hydrogen reticulation, including utilisation (domestic and industrial) and hydrogen production and export
	3. Develop up to date hydrogen standards and regulations.
	4. Conduct ongoing risk assessments to determine whether there is a need to develop a hydrogen licensing and certification program for qualified practitioners and/or equipment standards.
	5. Develop the knowledge and skills to better understand the interdependence between electricity and hydrogen.
	6. Determine and develop the required knowledge, capacity and capabilities to address the increased domestic and industrial use of hydrogen.
	7. Determine and develop the required knowledge, capacity and capabilities to address the increased production and export of hydrogen.

ELECTRIC VEHICLES (EVS) AND FUEL CELL ELECTRIC VEHICLES (FCEVS)

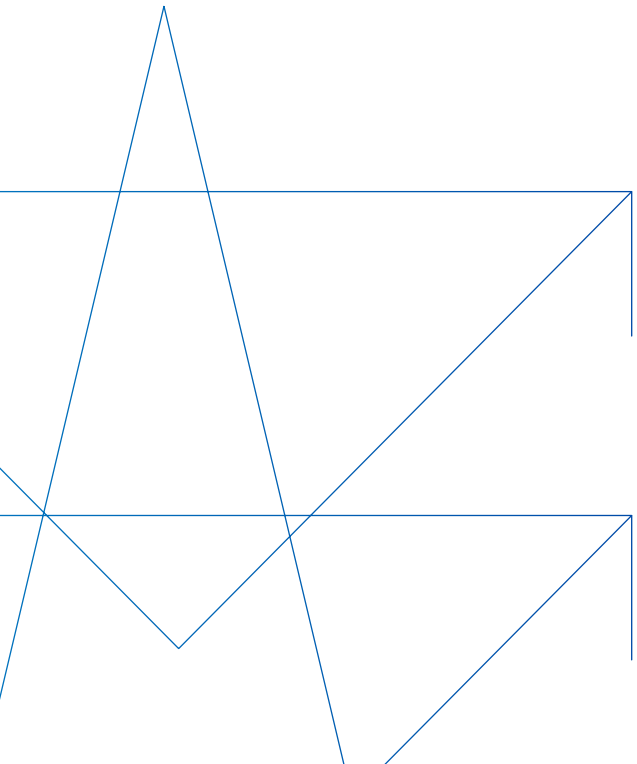
OBJECTIVE: ENSURING ESV IS POSITIONED TO SUPPORT THE SAFE ROLL-OUT OF EV CHARGING AND FCEV REFUELLING INFRASTRUCTURE WITH CLEAR REGULATIONS, STANDARDS AND LICENCING REQUIREMENTS

GOALS	STRATEGIES
ESV develops an awareness campaign for new EV owners and follows this up with an inspections program to ensure domestic owners are meeting their obligations for safe domestic charging ESV is able to confirm the various regulations, licences, standards and levy arrangements required to roll-out commercial and domestic EV and FCEV charging and/or refuelling infrastructure across Victoria	**1.** Identify regulatory and standards gaps for charging and refuelling infrastructure (domestic and commercial) and its installation. **2.** Ensure the clarity of regulations, licences and standards for charging and refuelling infrastructure and installation. **3.** Identify jurisdictional responsibilities and boundaries among regulators in relation to charging and refuelling infrastructure and installation. **4.** Lead, or assist with, the development of regulations, licenses and standards for charging and refuelling infrastructure and its installation. **5.** Ensure EV vehicle owners understand the safety risks with domestic vehicle charging. **6.** Ensure FCEV vehicle owners understand the safety risks associated with domestic fuel cell refuelling with hydrogen.

QUALIFIED PRACTITIONERS

OBJECTIVE: ENSURING THE CONTINUED COMPETENCE OF QUALIFIED PRACTITIONERS IN A CHANGING ENERGY MARKET

GOALS	STRATEGIES
ESV develops a process for assessing needs for new competencies and monitors the effectiveness of training from a safety perspective ESV develops strategies to more effectively identify and minimise uncertified and illegal electrical and gas works	**1.** Work with government and education providers to ensure there are suitably trained (and re-trained) qualified and competent practitioners to service the new energy market. **2.** Lobby for the development of a system of ongoing professional development for qualified practitioners. **3.** Conduct ongoing risk assessments to determine whether new energy business models are adequately captured under the existing regulations and whether there is a need to develop a licensing program for qualified practitioners in these businesses. **4.** Ensure ESV is positioned to effectively licence and regulate new energy market practitioners to prevent energy businesses and service providers from operating outside the regulations.



IOT, DATA AND AUTOMATION

OBJECTIVE: ENSURING ESV IS POSITIONED TO UTILISE EMERGING DATA-RELATED TECHNOLOGIES IN ORDER TO ENSURE THE SAFE USE OF GAS AND ELECTRICITY

GOALS	STRATEGIES
ESV is achieving its strategic objectives by developing and applying Analytics and Business Intelligence capabilities, utilising IoT and AI technologies for regulatory purposes	**1.** Ensure ESV understands what our key stakeholders are doing in this space.
	2. Ensure ESV has access to key data sources needed to conduct analytics to improve safety outcomes, including smart meter data.
	3. Develop an understanding of how Internet of Things could assist in improving the safety of electricity and pipeline networks.
	4. Formulate ESV's strategic approach (policy position) to cybersecurity in the electricity and gas networks.
	5. Invest in the development of artificial intelligence technologies to improve operational efficiencies.
	6. Ensure processes, procedures and systems are in place to facilitate sharing of information for the safety of the energy system.

REVENUE MODEL

OBJECTIVE: ENSURING ESV'S FUTURE RESOURCE BASE IS SUSTAINED BY A MATCHING REVENUE MODEL THAT ALLOWS ESV TO FULFIL ITS ROLES AND ACHIEVE ITS OBJECTIVES

GOALS	STRATEGIES
ESV continues to be sustained by a solid revenue base	**1.** Develop an understanding of the changing energy market from a revenue generation perspective.
	2. Identify resource requirements to match the scope of ESV roles.
	3. Ensure all regulated parties fairly contribute to ESV's ongoing operations, including emerging business models that are not included in current revenue streams.

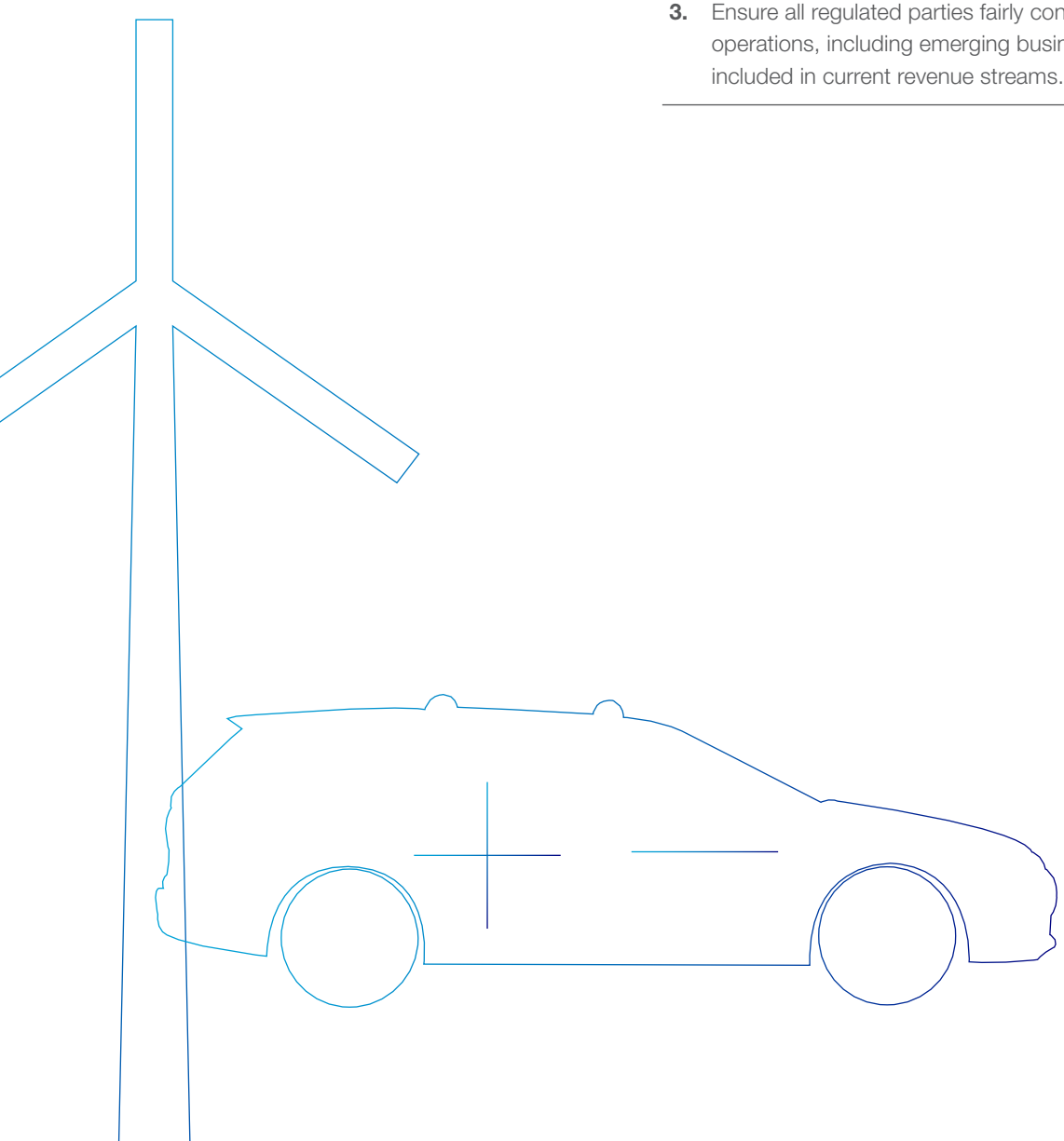
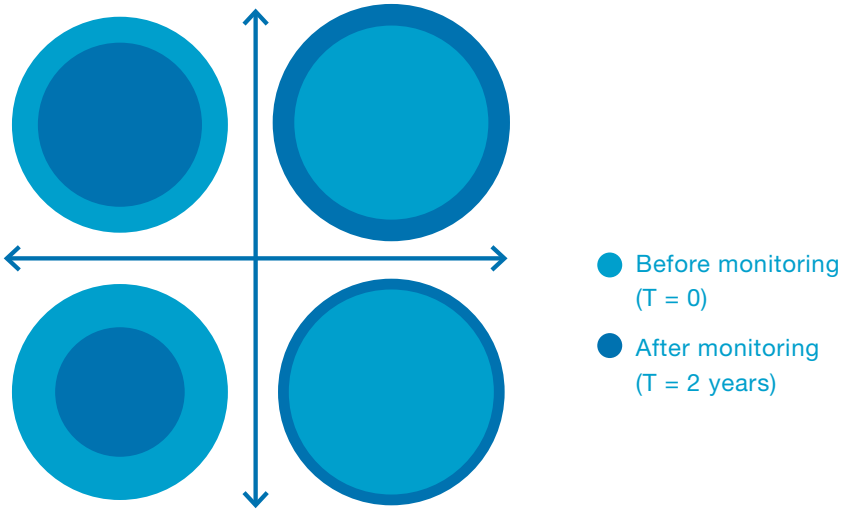


FIGURE 1

Example of changing probabilities of scenarios before and after monitoring



5.4 Early Warning System

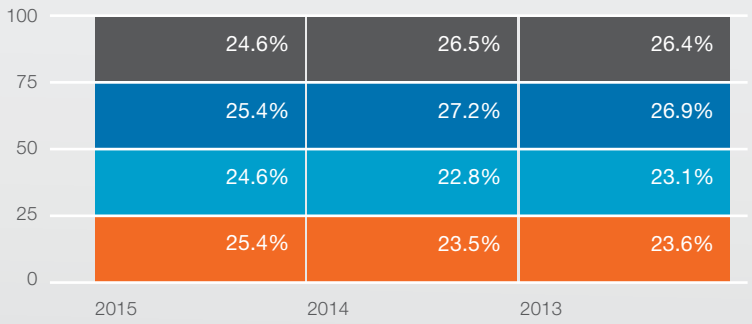
Developing scenarios are helpful in identifying the challenges and opportunities of the future and developing robust, future-proof strategies to address them. However, this does not make an organisation adaptive in itself. In order to be an adaptive organisation, ESV needs to be able to adjust course when needed. Monitoring how the scenarios develop is a great way to assist in this.

Theoretically speaking, the chance of occurrence (probability) of each scenario is 25 percent. After all, they are based on key uncertainties; trends of which we are unsure (nearly '50/50') whether they will develop towards one end or the other. We see signs of, or can plausibly argue for, both. However, the world does not stop turning once you have developed scenarios. The trends and uncertainties we have identified are constantly evolving due to other trends, events, and decisions in an ever-changing world.

Over time certain patterns emerge. A key uncertainty we assess as a '50/50' today, might lean towards a '60/40' assessment tomorrow. This means that as time progresses the likelihood or probability of the scenarios will change. Some scenarios will become more likely, others less. Monitoring these changes enables Energy Safe Victoria to dynamically identify and adapt to such changes.

'Hard' or 'objective' data are an important strategic tool, but the astute observer will acknowledge the considerable limitations when you use them to think about the (more distant) future (over five years away). 'Hard' data can only look at the past and the current situation. Projections based on that data can be made and might prove accurate in the short term. Yet what held true for the past might not hold true for the future, especially if one looks 16 years into the future (2035). Sometimes things occur faster than the data predicts, sometimes rapid growth plateaus or even reverses, for instance. In hindsight we can always clearly explain what the 'hard' data did not capture. Promising technologies that proved to be disruptive often score low in hard data.

PROBABILITY OF THE SCENARIOS



Development of the key uncertainties

– Increasing pace of technological advances and convergence
– Increasing legislative and regulatory uncertainty

The only way to anticipate such things is to supplement 'objective' data by expert opinions. What is their (collective) expert feeling about changes towards the future? Monitoring scenarios with an Early Warning System (EWS) makes use of such expert insights and therefore always is more subjective in nature. An EWS asks experts to think about the likelihood of something occurring in 2035, towards the future, of which 'datapoints' have not been recorded yet. Taken together, the collective expert opinions are as accurate an assessment of which way the future is headed as can be.

An EWS is based on change indicators. The Project Group has developed 10 change indicators for each extreme end of the axes of the scenario framework (i.e. each end of the key uncertainties; 4 × 10 in total). An online EWS will facilitate the monitoring for ESV. A digital survey with the change indicators will be sent to internal and external experts. They will be asked about the likelihood of a certain indicator occurring in 2035. Based on their collective assessment, a probability score of the scenarios (as well as individual indicators) will emerge. The higher the probability of a scenario, the higher the priority of strategic options that match with that scenario should be in ESV's strategy.

Brave new world
Energy oligarchy
In it together
Good old days

6. Next steps

The scenario planning exercise detailed in this report has been undertaken to help ESV:

- identify the major trends that it needs to be preparing for as it moves into the future
- develop scenarios that encompass the range of conceivable futures that may emerge
- structure its thinking about the strategic framework that needs to be developed to address the emerging risks from these futures.

In essence, this work can be regarded as 'pre-strategy'.

It provides decision-makers at ESV with a powerful framework within which the organisation can develop adaptive, longer-term strategies that reflect ESV's mission, mandate, and subsequent responsibilities.

Building on the scenario planning undertaken in Stage 1, ESV will continue this work over the next 12 months by:

- developing measures (actions and performance indicators) and score cards for each strategy, including triggers for action
- appointing an expert advisory committee to help advise on emerging trends and possible changes to regulatory settings
- developing processes for regular updating of the strategy and the EWS
- developing processes for implementation of responses as triggers in the EWS are met.

With that work in place, ESV will be well-positioned to undertake ongoing monitoring and staging of responses ahead of the emergence of disruptive changes in Victoria's energy sector.

STAGE 1

Strategic roadmap

- Scenarios that capture a range of conceivable futures
- Using the scenarios to develop an Adaptive Strategic Roadmap
  - Develop and test measures and score cards

STAGE 2

Monitoring emerging futures

- Develop tool to determine which scenarios are emerging
- Populate the tool with preliminary information that will allow ESV to adjust the strategy accordingly
  - Develop processes for regular updates of the strategy and tool

STAGE 3

Implementing responses

- Receive early warning of emerging disruptions
  - Stage timeframes for emergence of disruptions in 1-3, 3-5, 5-10 and 10-20 year periods
  - Identify lead-times to mount the required responses
  - Action appropriate responses

Appendix A: Introduction to scenario planning

What is scenario planning?

Scenario planning is a method to deal with uncertainty and unpredictable developments. Uncertainties are developments external to an organisation, such as ESV, on which one can exert little influence, but at the same time have a big impact on the external environment in which one wants to realise strategic goals.

Developments external to an organisation can be found in the macro environment and business environment of the organisation. For instance, changes in regulation and legislation, the rise of new technologies, social changes, changing consumer preferences, new competitors and new business models. Scenarios can help one get a better grasp on such developments by enabling one to explore such trends and translate them into several 'futures' that might come into being.

Scenarios are not prognoses or forecasts of the future; they can best be characterised as 'pictures' or 'explorations'. They explore different possible future circumstances. They are rich stories of what the future might look like as shaped by the most important uncertainties. Since scenarios always illustrate the extreme consequences of uncertainties, one always needs to explore several scenarios.

A set of plausible (imaginable), consistent (with a sound and logical reasoning and structure) and challenging scenarios enables organisations to contemplate the future and to identify opportunities and risks. The goal of a good scenario set is to stimulate people to challenge wishful thinking, or too rosy a picture of the future, and to break with old patterns. This can sometimes be rather confronting but is most of all a source for inspiration and newly gained insights.

Scenarios are not…

Scenarios are a powerful tool to explore the future. Not everyone has the same conception or image of scenarios, however. Therefore, it is important to emphasise what scenarios are not. They are not predictions, nor are they visions, choices, options or sensitivity analyses.

Scenario planning is often confused with making predictions. Even though it is very appealing to attempt to predict the future – something that many futurists claim to do – they more often than not miss the mark. Scenarios are not meant to predict, but to explore the full width of the range of plausible possibilities within which the future might unfold.

Scenarios are neither a future vision. Visions are often inspiring images of the future role and position of an organisation. A vision is often developed in an 'inside-out' way and is based on the strengths and competencies of the organisation. Although these are valuable exercises, they only paint one part of the picture. Scenarios therefore explicitly offer a different perspective. They are based on 'outside-in' thinking and can be used to test whether the vision of an organisation is viable and whether it needs adjustments or improvements. Scenarios are also not choices, options or sensitivity analyses. They do form a frame of reference that can be used to stress-test policies or investments on their robustness, to generate strategic options, or to determine the impact of the external environment on, for instance, a (financial) business case or initiative.

Although scenarios are neither a future vision nor present a ready-made strategy, they are invaluable as a starting point for thinking about a robust strategy. Scenarios offer a shared frame of reference for a strategic conversation at ESV, both internally as well as with external stakeholders. Scenarios aim to inspire, and are sources for, generating new ideas. At the same time, they also offer a sound framework to test strategic options and actions one could invest in.

How are scenarios developed?

Scenarios are developed by closely examining which external developments (in both macro and business/ industry environment) have the propensity to cause the most change. By means of several analyses, two key uncertainties will be defined. These uncertainties have a large impact on the future of the research and innovation landscape but are highly uncertain. The basis for a scenario set is made by first determining two extreme and opposite results of such a development (for instance, high versus low, strong versus weak) and then combining the two key uncertainties in a 2 × 2 matrix.

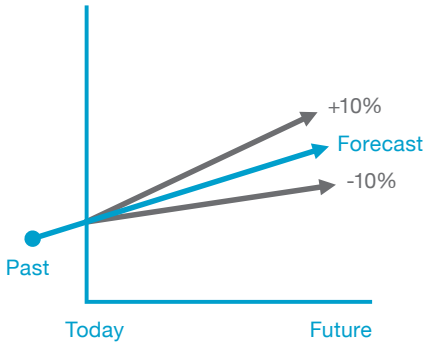
Every combination of extreme outcomes (four in total) will be the premise of a scenario. A total of four possible futures will be imagined and explored. They will each contain a narrative and visualisations, such as 'timelines' and 'headlines'. The scenarios are extreme, stylised stories, but are all plausible and conceivable. The future is unlikely to exactly resemble one of the scenarios. Instead, the future is likely to contain elements of all of them and also be more akin to one rather than another. Exactly how is difficult, if not impossible, to say at the moment of developing the scenarios.

How can scenarios be used?

The scenarios that have been developed have been used to identify challenges and opportunities, as well as to generate and test options. Options that are 'robust' (i.e., they perform well under each scenario) are of a more strategic nature and merit serious consideration in the organisation's strategic plans regarding the future. Riskier, 'scenario-specific' initiatives can also have their place in strategic plans, but are in need of risk-mitigating measures, such as ample 'go'/'no-go' milestones as well as opportunities to scale up or down when needed.

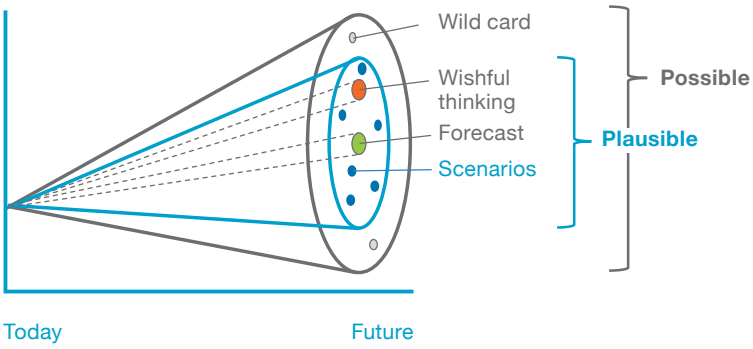
FORECASTING

Extrapolating from the past



SCENARIO PLANNING

Exploring the range of plausible futures



Appendix B: Trend analysis

Possible key uncertainties score high (above average) on three criteria:

- Cross-impact
- Impact
- Uncertainty

The impact and uncertainty of a trend were assessed by the Project Group and the Steering Committee[2]. The cross-impact was validated by SJS Strategy[3]. The cross-impact denotes how influential a trend is on all the other trends (the trend complex). A high score means that a trend affects many other trends and is therefore a 'driving force'. A low score means that a trend only affects a few other trends. Therefore, its ability to drive change is more limited. A possible key uncertainty needs to be able to influence many other trends.

When combining two key uncertainties into a framework, the scenarios it produces need to be divergent, challenging, relevant and plausible.

The Project Group selected a scenario framework combining the legislative and regulatory uncertainty trend with the pace of technological advances. This has been validated by the Steering Committee.

2 The impact and uncertainty scores were determined by a survey of the members of the Project Group, the Steering Committee and the external experts. Each individual independently scored each trend, and the results were averaged to produce the impact and uncertainty scores.

3 The cross-impact scores were calculated by SJS Strategy using a proprietary approach.

Increasing geopolitical instability

Impact	3.33
Uncertainty	3.89

Increasing legislative and regulatory uncertainty

Impact	3.56
Uncertainty	3.00

Increasing focus on national energy security

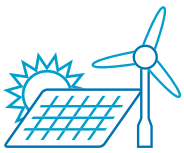
Impact	3.89
Uncertainty	2.44

From ownership to access

Impact	2.67
Uncertainty	3.00

The Asian Century

Impact	3.78
Uncertainty	2.67



Increasing export of renewables

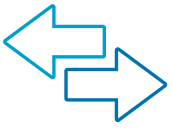
Impact	3.44
Uncertainty	2.78

Increasing demand of consumers for choice, control, and services

Impact	3.78
Uncertainty	3.22

Increasing demand for self-sufficiency

Impact	3.56
Uncertainty	2.67



Increasing social divisions

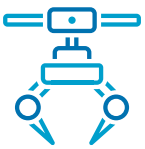
Impact	3.00
Uncertainty	3.00

Increasing pace of technological advances and convergence

Impact	4.33
Uncertainty	3.44

The rise of the Internet of Things and Big Data

Impact	3.78
Uncertainty	2.78



Increasing automation and robotisation

Impact	3.44
Uncertainty	2.78

The 'electrification of energy'

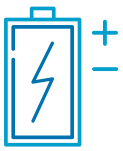
Impact	3.56
Uncertainty	3.33

Migration to hydrogen

Impact	4.00
Uncertainty	2.78

The rise of electric vehicles

Impact	3.78
Uncertainty	2.33



Increased energy storage capabilities

Impact	3.67
Uncertainty	3.11

Increasing use of (variable) renewable energy

Impact	3.56
Uncertainty	2.78

Internationalisation of technology regulation

Impact	3.11
Uncertainty	2.44

More noticeable effects of climate change

Impact	4.11
Uncertainty	3.11

Increasing international coordination on emissions reduction

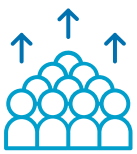
Impact	3.33
Uncertainty	2.56

'ECOnomics': increasing demand for sustainable products and services

Impact	3.00
Uncertainty	3.11

Increasing urbanisation

Impact	3.22
Uncertainty	2.22



Changing demographics

Impact	3.56
Uncertainty	2.22

The rise of autonomous vehicles

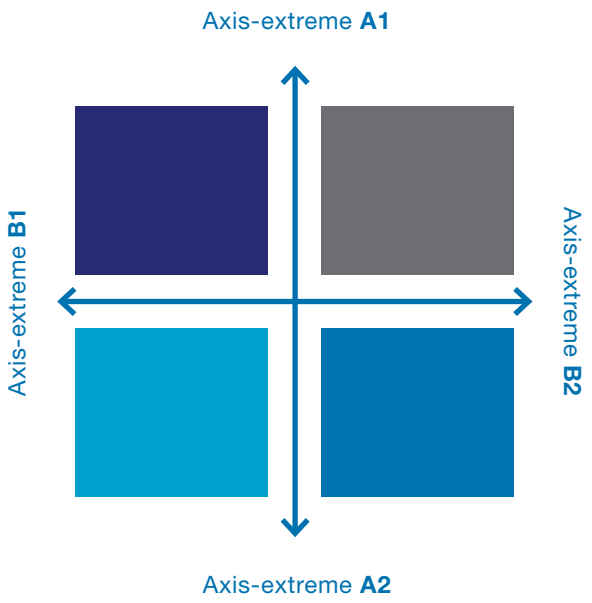
Impact	2.89
Uncertainty	2.56

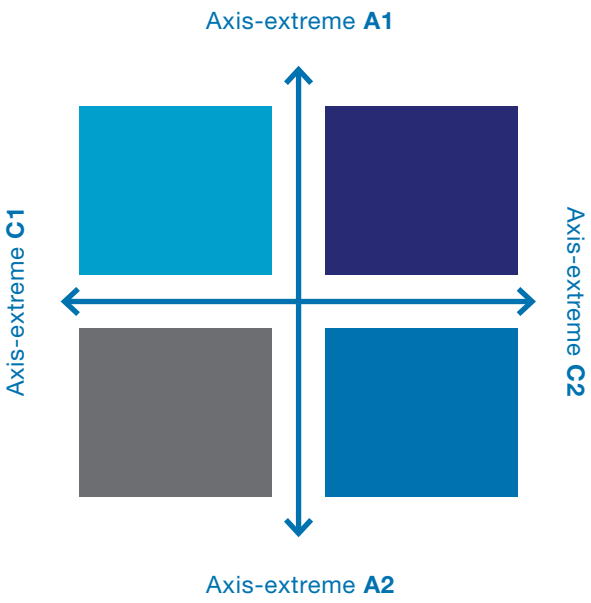
		CROSS-IMPACT	IMPACT	UNCERTAINTY
1.	Increasing geopolitical instability	**1.5**	3.33	**3.89**
2.	**Increasing legislative and regulatory uncertainty**	**1.2**	**3.56**	**3.00**
3.	Increasing focus on national energy security	0.6	**3.89**	2.44
4.	From ownership to access	0.5	2.67	**3.00**
5.	The Asian Century	**1.5**	**3.78**	2.67
6.	Increasing export of renewables	0.5	3.44	2.78
7.	Increasing demand of consumers for choice, control, and services	0.8	**3.78**	**3.22**
8.	Increasing demand for self-sufficiency	0.5	**3.56**	2.67
9.	Increasing social divisions	**0.9**	3.00	**3.00**
10.	**Increasing pace of technological advances and convergence**	**1.1**	**4.33**	**3.44**
11.	The Rise of the Internet of Things and Big Data	**1.0**	**3.78**	2.78
12.	Increasing automation and robotisation	**1.1**	3.44	2.78
13.	The 'electrification of energy'	0.5	**3.56**	**3.33**
14.	Migration to hydrogen	0.7	**4.00**	2.78
15.	Electrification of transport	**0.9**	**3.78**	2.33
16.	Increased storage capabilities	0.8	**3.67**	**3.11**
17.	Increasing use of (variable) renewable energy	0.5	**3.56**	2.78
18.	Internationalisation of technology regulation	0.6	3.11	2.44
19.	**More noticeable effects of climate change**	**1.2**	**4.11**	**3.11**
20.	Increasing international coordination on emissions reduction	**1.1**	3.33	**3.56**
21.	'ECOnomics': increasing demand for sustainable products and services	0.7	3.00	**3.11**
22.	Increasing urbanisation	**1.0**	3.22	2.22
23.	Changing demographics	**0.9**	**3.56**	2.22
24.	The rise of autonomous vehicles	0.7	2.89	2.56
	average scores	*0.86*	*3.51*	*2.88*

NOTE:
Above average scores in the table are bold.
The three trends that qualified as candidates for the key uncertainties are in blue.

Appendix C: Framework selection

The three key uncertainties identified were put into pairs and combined on a scenario framework. The selected combination yielded four distinctive scenarios (**divergent**), were **challenging, relevant** in relation to the scope and could possibly become a reality (**plausible**). In addition, the two axes should not influence each other (or as little as possible). The chosen framework combines the legislative and regulatory uncertainty trend with the pace of technological advances.

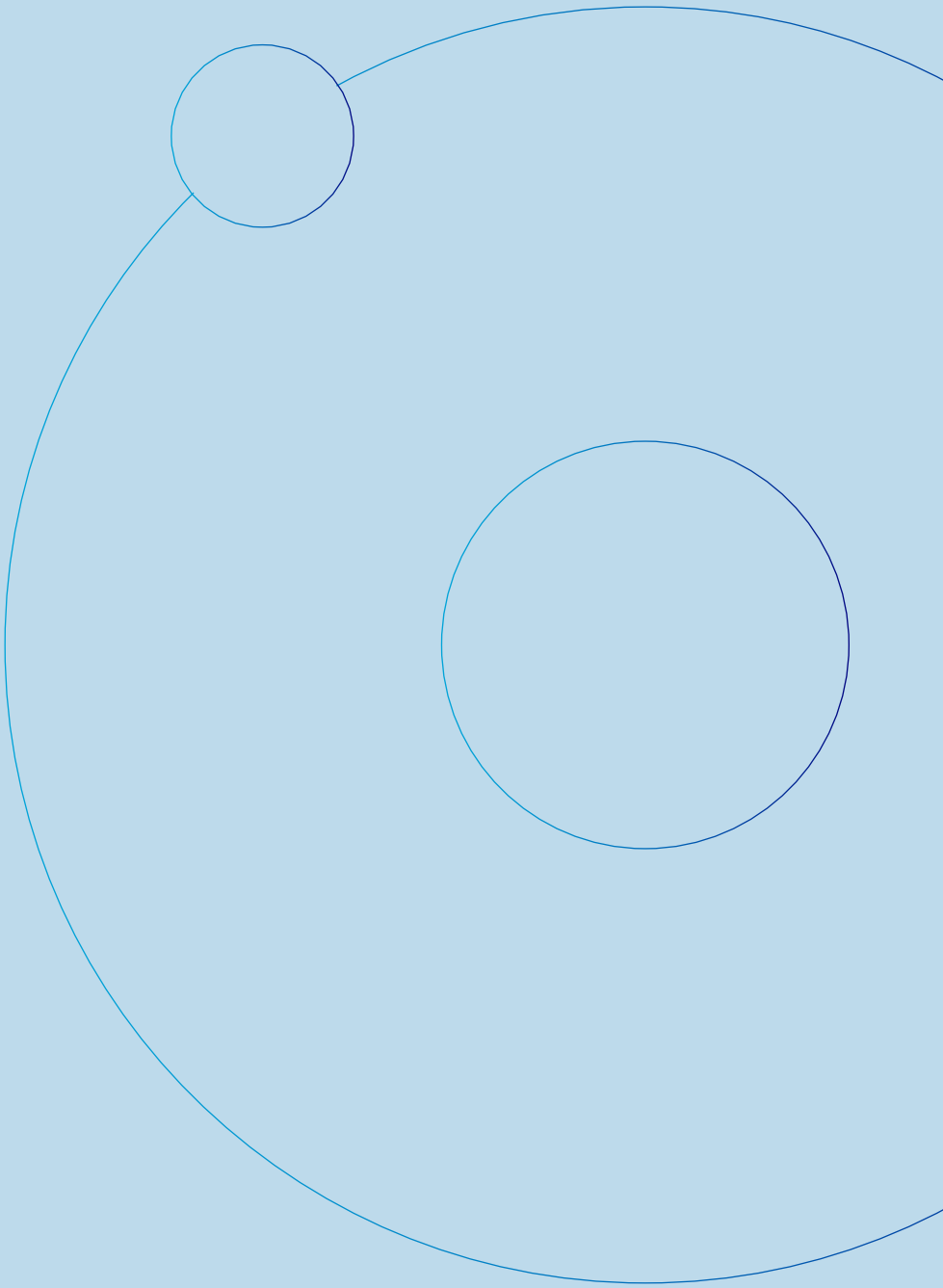


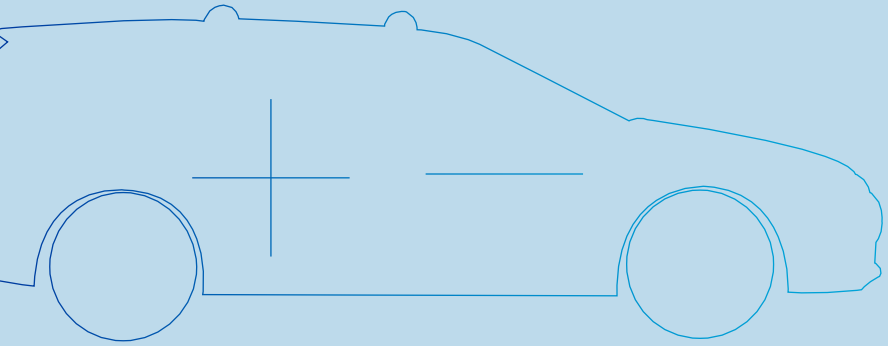


Chosen Framework

Appendix D: Interviews — Subject Matter Experts

NAME	ROLE	ORGANISATION	LOCATION
Stuart Johnston	Principal, Future Networks	Energy Networks Australia	Melbourne
Claire Johnson	Chief Executive Officer	Hydrogen Mobility Australia	Melbourne
Tony Wood	Energy Program Director	Grattan Institute	Melbourne
Damien Sanford	Chief Operations Officer	Australian Energy Market Operator	Melbourne
Ross Jamieson	President	Gas Appliance Manufacturers Association of Australia	Melbourne
Leon Bogers	Vice-President	Gas Appliance Manufacturers Association of Australia	Melbourne
James Seymour	Chief Executive Officer	Centre for New Energy Technologies	Melbourne
Andrew Gordon	Partner - Cyber	PwC Australia	Melbourne
Noriko Wynn	Futures Research Leader	AURECON	Melbourne
Keith Owen	Head of Energy Strategy	Northern Gas Networks	Leeds, United Kingdom
Prof. Dr. Ad van Wijk	Professor of Future Energy Systems	Technical University of Delft	Delft, The Netherlands
Margien Storm-Van Leeuwen	Manager New Business, Marketing and Communication	Bredenoord	Apeldoorn, The Netherlands
Christian Pilgaard Zinglersen	Head of the Clean Energy Ministerial Secretariat	International Energy Agency	Paris, France





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