Uranium Mining and Nuclear Energy in New South Wales

NSW Parliamentary Research Service
September 2019

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NSW PARLIAMENTARY RESEARCH SERVICE

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ISSN 1325-5142

September 2019

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ABBREVIATIONS

AAEC – Australian Atomic Energy Commission
ABS – Australian Bureau of Statistics
ACCC – Australian Competition & Consumer Commission
ACT – Australian Capital Territory
AEMC – Australian Energy Market Commission
AEMO – Australian Energy market Operator
AER – Australian Energy Regulator
ANSTO – Australian Nuclear Science and Technology Organisation
ANU – Australian National University
ARPNSA Act – *Australian Radiation Protection and Nuclear Safety Act 1998 (Cth)*
ARPANSA – Australian Radiation Protection and Nuclear Safety Agency
ASNO – Australian Safeguards and Non-Proliferation Office
ASX – Australian Securities Exchange
AUD – Australian Dollar
BWR – Boiling Water Reactor
CCGT – Combined-Cycle Gas Turbine
CCS – Carbon Capture and Storage
CfD – Contract for Difference
CO_2 – Carbon Dioxide
CO_2e – Carbon Dioxide Equivalent
COAG – Council of Australian Governments
CSIRO – Commonwealth Scientific and Industrial Research Organisation
CJ – Chief Judge
Cth – Commonwealth
DER – Distributed Energy Resources
DPE – NSW Department of Planning & Environment
DPIE – NSW Department of Planning, Industry & Environment
DSP – Demand Side Participation
ECA – Energy Consumers Australia
EDR – Economic Demonstrated Resources
EIA – Environmental Impact Assessment
EIS – Environmental Impact Statement
ESB – Energy Security Board
ESOO – Electricity Statement of Opportunities
EPBC Act – *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*
EPA – Environmental Protection Agency (NSW)
EV – Electric Vehicle
FANC – Federal Agency for Nuclear Control
FBR – Fast Breeder Reactor
FCAS – Frequency Control Ancillary Services
FDP – Funded Decommissioning Programme
GCR – Gas Cooled Reactor
gCO_2-e/kWh – Grams Carbon Dioxide Equivalent per Kilowatt hour

Gen III – Generation III Reactor
Gen III+ – Generation III+ Reactor
Gen IV – Generation IV Reactor
GFR – Gas Cooled Fast Reactor
GHG – Greenhouse Gas
GIF – Generation IV International Forum
GRL – Gloucester Resources Limited
GW – Gigawatt
GWh – Gigawatt hour
HIFAR – Hi Flux Australian Reactor
HTGR – High Temperature Gas-Cooled Reactor
Hz – Hertz
IEA – International Energy Agency
IAEA – International Atomic Energy Agency
Inc – Incorporated
INES – International Nuclear and Radiological Event Scale
IPART – Independent Pricing and Regulatory Tribunal
IPC – Independent Planning Commission
IPCC – Intergovernmental Panel on Climate Change
ISP – Integrated System Plan
kW – Kilowatt
kWh – Kilowatt hour
LCOE – Levelised Cost of Electricity
LFR – Lead Cooled Fast Reactor
LNG – Liquid Natural Gas
LWGR – Light Water Cooled Graphite Moderated Reactor
MIT – Massachusetts Institute of Technology
MLC – Member of the NSW Legislative Council
MMR – Micro Modular Reactor
MP – Member of Parliament
MRD – Mineral Resources Division
MSR – Molten Salt Reactor
Mt – Megatonne
Mt CO_2e – Megatonnes of Carbon Dioxide Equivalent
MW – Megawatts
MWh – Megawatt Hour
NAO – National Audit Office (UK)
NASA – National Aeronautics and Space Administration
NDC – Nationally Determined Contribution
NEA – Nuclear Energy Agency
NEL – National Electricity Law
NEM – National Energy Market
NEO – National Electricity Objective
NERL – National Energy Retail Law
NERO – National Energy Retail Objective
NGL – National Gas Law

…

NNPS Act – *Nuclear Non-Proliferation (Safeguards) Act 1987 (Cth)*

NSP - network service providers

NSW – New South Wales

NSW LEC – Land and Environment Court of New South Wales

NT – Northern Territory

NTNDP - National Transmission Network Development Plan

OCGT – Open-Cycle Gas Turbine

OECD – Organisation for Economic Co-operation and Development

ONDRAF/NIRAS – Belgian National Agency for Radioactive Waste and Enriched Fissile Materials

ONR – Office for Nuclear Regulation

OPAL – Open Pool Australian Lightwater Nuclear Reactor

OTC – Over the Counter Market

PEPR – Program for Environment Protection and Rehabilitation

PHWR – Pressurized Heavy Water Reactor

PJ – Petajoule

PWR – Pressurised Water Reactor

PV – Photovoltaic

PVNSG – Photovoltaic Non-Scheduled Generation

QLD – Queensland

RICE – Reciprocating Internal Combustion Engine

RRO – Retailer Reliability Obligation

SA – South Australia

SCWR – Supercritical Water Cooled Reactor

SDS – Sustainable Development Scenario

SEA – Strategic Environmental Assessment

SFR – Sodium Cooled Fast Reactor

SMR – Small Modular Reactor

SSD – State Significant Development

TAS – Tasmania

TWh – Terawatt hour

UF_6 – Uranium hexafluoride

UK – United Kingdom

UN – United Nations

UNFCCC – United Nations Framework Convention on Climate Change

UNSCEAR – United Nations Scientific Committee on the Effects of Atomic Radiation

US – United States

USE – Unserved Energy

VHTR – Very High Temperature Gas Reactors

VIC – Victoria

VPP – Virtual Power Plant

VRE – Variable Renewable Energy

WA – Western Australia

WACC – Weighted Average Cost of Capital

WEM – Wholesale Electricity Market

FOREWORD

Following the introduction of the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019 (the Repeal Bill) into the NSW Legislative Council, the NSW Parliamentary Research Service was asked to prepare an issues paper on the bill. This paper has been prepared for the Legislative Council's Standing Committee on State Development which is currently seeking submissions for its inquiry into the bill. The closing date for submissions is **Friday 18 October 2019**.

The main focus of this paper is to provide Members of Parliament and the NSW public with an overview of the key issues surrounding uranium mining and nuclear energy in NSW.

The publication begins by outlining the inquiry terms of reference including details on how to make a submission (part A). The current state of energy in NSW is examined using the energy trilemma framework (security, equity and environmental sustainability) and safety issues (part B). A brief history of uranium mining and nuclear energy in Australia is provided as background to an overview of current international nuclear energy trends, industry opportunities and challenges, and next generation nuclear reactor designs. Selected economic, environmental and safety considerations associated with nuclear energy are also discussed (part C).

In order to assess the effect of the Repeal Bill, the current prohibitions on uranium mining and nuclear power plants in NSW created by existing State and Commonwealth laws are reviewed (part D). The publication ends by examining the question of how the community is included in all stages of the decision-making on uranium mining and nuclear energy in NSW (part E).

In reviewing the existing literature, questions are raised for further consideration. These include:

- What mix of current technologies will best meet the key energy opportunities and challenges in NSW? How might this change with future technological developments?
- What are the economic, social and environmental opportunities and risks associated with uranium mining and nuclear energy in NSW?
- What is the current level of support amongst the NSW public for uranium mining and nuclear energy?
- If a nuclear energy industry were to be allowed in NSW, what are the optimal regulatory settings to ensure the safe and secure operation of uranium mining, nuclear power generation and nuclear waste disposal?
- What model of community engagement should be used to include the NSW public in decisions about uranium mining and nuclear energy?

NSW Parliamentary Research Service
24 September 2019

A. BACKGROUND

1. Purpose

1.1 The Legislative Council motion

On 6 June 2019, Mark Latham MLC introduced the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019 (the Repeal Bill) into the NSW Legislative Council. On the same date the Legislative Council agreed to a motion that:

> 1. The Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019 be referred to the Standing Committee on State Development for inquiry and report …
>
> 2. As part of the Inquiry:
>
>   (a) The New South Wales Parliamentary Library prepare an Issues Paper on the Bill;
>
>   (b) the Committee commission the newDemocracy Foundation to facilitate community input into the bill, such as a citizens' panel or jury, to complement the traditional forms of evidence gathering by committees, such as seeking submissions and taking oral evidence; and
>
>   (c) the Committee respect the foundation's remit as an independent and non-partisan research organisation.
>
> 3. The House notes that the newDemocracy Foundation has offered to provide this service during 2019 and 2020 for no charge to the Parliament.[1]

The purpose of the Repeal Bill was explained by Mr Latham MLC in its Second Reading speech as:

> …to liberate a significant part of the New South Wales power and resource sector to create jobs investment and, most of all, to undertake the long-term planning needed to keep the lights on in New South Wales. The bill lifts the ban on nuclear power and uranium mining in our State. It repeals the Uranium Mining and Nuclear Facilities (Prohibitions) Act that has been in place since 1986…
>
> If you look at the possible power sources to keep the lights on in New South Wales, and go through them one by one, nuclear needs to be part of the equation. This is a vital question for the Parliament and the Government: What keeps the lights on in our State? Nuclear is banned. The coal-fired power stations are old and getting older and slated for closure, phasing out over time. Gas is limited in our State. … One looks at hydro. There is much talk about hydro but realistically, while it works in Tasmania, mainland Australia is the driest, flattest landmass on earth, so hydro has limitations...

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[1] Latham M, Standing Committee on State Development, *NSW Hansard*, 6 June 2019, p 59-60 (proof).

> The best insurance for keeping the lights on and doing something positive about emission reduction is nuclear. Renewables have a place but they must be supplementary to base load power. If the sun is not shining and the wind is not blowing, there is nothing to despatch. There is no dispatchable base load power.

1.2 Role of the NSW Parliamentary Research Service

The NSW Parliamentary Research Service was originally established to provide all Members of the NSW Parliament with equitable access to non-partisan research services. As such, it works independently of both Houses of Parliament.

The aim of the Research Service is to provide Members of Parliament and their staff with:

- An impartial, independent and evidence-based source of research and analysis on legislation and/or policy issues.

The Research Service has subject matter expertise in the areas of law, social issues, health, media, politics, environment and planning. It enhances the Library's research capacity by providing analysis and interpretation of information, statistical data and other reference material.

In addition to providing confidential responses to Member requests for research, the Research Service also prepares publications for all Members of Parliament and the NSW public. All of the Research Service's publications are available on the Parliament's website.

1.3 Purpose

This issues paper has been prepared by the NSW Parliamentary Research Service, which sits within the NSW Parliamentary Library, in response to point 2(a) of the motion set out above. This issues paper is separate and unrelated to the process involving the newDemocracy Foundation established by clause 2(b) and (c) of the motion.

The Research Service has released this issues paper: to assist individuals and organisations to prepare submissions to the inquiry; and to inform Members of the committee.

1.4 Methodology

This issues paper was prepared by the Research Service after conducting independent desktop-based research into relevant literature, reports, statistics, legislation and caselaw. In effect, it follows the style and format of the Service's previously published series of briefing papers. These papers are designed to address issues of current relevance to the Parliament through a review of the existing literature. This paper differs from our previous approach to briefing papers only through its inclusion of a set of questions for further consideration by readers. The material presented is current as at 24 September 2019.

Submissions received by the Legislative Council inquiry into the bill that were released publicly at the time of writing have been excluded from consideration.

The questions included at the end of each part of the paper identify issues that remain open to debate and where additional information is required by the inquiry. However, individuals and organisations should not feel restricted to comment only on the content of this issues paper. The inquiry is seeking commentary on those issues considered relevant to the inquiry's terms of reference.

1.5 Inquiry submission details

The NSW Legislative Council's Standing Committee on State Development is seeking submissions for its inquiry into the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019.

The closing date for submissions is **Friday 18 October 2019**.

You can lodge a submission by:

- uploading it to the committee's website
- emailing it to state.development@parliament.nsw.gov.au

writing to The Director, Standing Committee on State Development, Parliament House, Macquarie Street, Sydney NSW 2000.

You can find further information about making a submission and the inquiry on the committee's website or alternatively by contacting the secretariat on (02) 9230 3081.

1.6 Other parliamentary inquiries

At the time of writing, two other parliamentary inquiries are currently examining the future role of nuclear energy in Australia. The latest available information on each inquiry is provided below:

- Federal Inquiry into the prerequisites for nuclear energy in Australia; and
- Victorian Parliament Inquiry on nuclear power.

B. ENERGY IN NSW

Part B of this paper sets the scene for the discussion of uranium mining and nuclear energy in part C. It examines energy in NSW in light of the energy trilemma (security, equity and sustainability), a framework often used by key stakeholders such as the International Energy Agency (IEA) when discussing the future of nuclear energy. Particular attention is given in part B to the electricity supply chain and electricity markets for several reasons:

(1) The operational and regulatory framework is complex and multifaceted, posing challenges for any new generation technology that may be introduced in NSW, such as nuclear power;

(2) Recent and forecast trends in electricity supply and demand play a significant role in shaping decisions by governments and industry about how to select technologies that best address the energy trilemma; and

(3) There are ongoing policy, operational and regulatory responses to issues facing the supply chain and electricity markets.

The energy trilemma framework, as it is generally expressed, does not appear to address the issue of safety. Where relevant, this part identifies safety issues in the current energy system in NSW.

Chapter 2 of this part introduces the energy trilemma as a conceptual framework for understanding energy in NSW. Chapter 3 provides an overview of the State's energy resources. Chapters 4 to 6 set out background material on the electricity supply chain and electricity markets. Energy trends, forecasts and policy developments are considered in chapter 7. This part finishes with a brief consideration of environmental sustainability in the electricity sector (chapter 8).

2. The energy trilemma

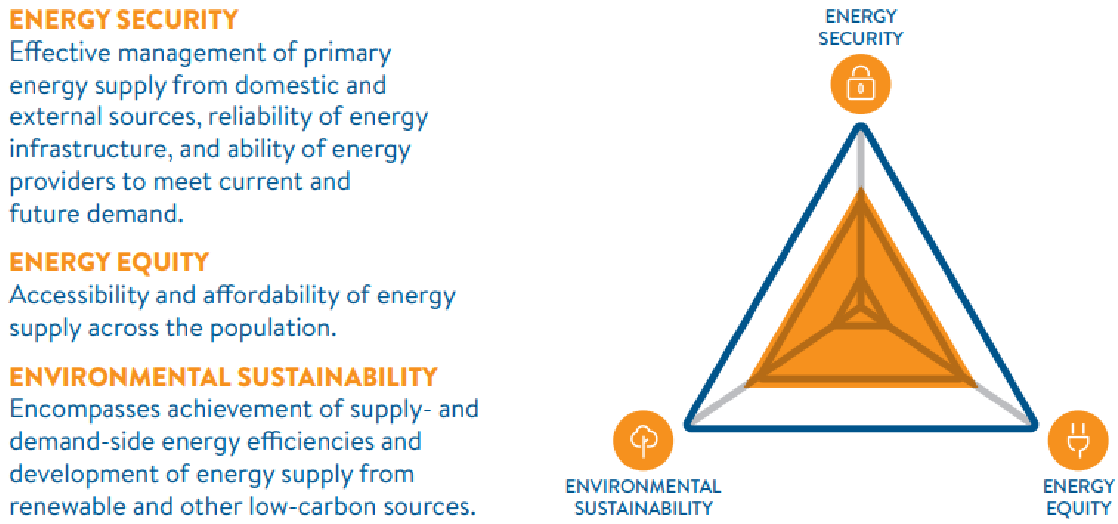
According to the World Energy Council, our understanding of current energy issues can be framed around the energy trilemma (Figure 1):[2]

- Energy security;
- Energy equity (accessibility and affordability); and
- Environmental sustainability.

The trilemma concept implies that implementing improvements in one dimension has potential positive and negative implications for the other two dimensions.

[2] See for example: Legislative Council Select Committee on electricity supply, demand and prices in New South Wales, *Electricity supply, demand and prices in New South Wales*, 22 November 2018; Byrne D, Australia's energy trilemma explained, *Pursuit*, no date [website – accessed 8 July 2019]

Figure 1: The energy trilemma[3]



The World Energy Council publishes an annual Energy Trilemma Index, in which it ranks countries on their ability to provide energy against the three dimensions. In 2018, Australia was ranked 38 in the world, receiving a:

- B for energy security;
- B for energy equity; and
- D for environmental sustainability.

3. Resources

This chapter provides an overview of energy resources in NSW. Chapter 7.1 contains information on the amount of current and projected electricity generation capacity by fuel type, as well as the amount of electricity generated by fuel type.

3.1 Non-renewable resources

NSW has significant amounts of non-renewable energy sources (Figure 2). As at December 2016, NSW had 632,823 petajoules (PJ) of Economic Demonstrated Resources (EDR) of black coal.[4] This was equivalent to 33.0% of total black coal EDR in Australia. In total, NSW had 901,768 PJ of Identified Resources of black coal, which also included 7,721 PJ of Subeconomic Resources (9.3% of Australia's total) and 261,244 PJ of Inferred Resources (12.6%).[5] These coal resources include both thermal coal (used for electricity generation) and higher quality metallurgical coal (used for industrial processes such as steel making). In 2019, there are 40 coal mines operating in NSW, most of which are producing thermal coal.[6] Thermal and metallurgical coal are also significant export

[3] World Energy Council, *World Energy Trilemma Index 2018*, 2018, p 9

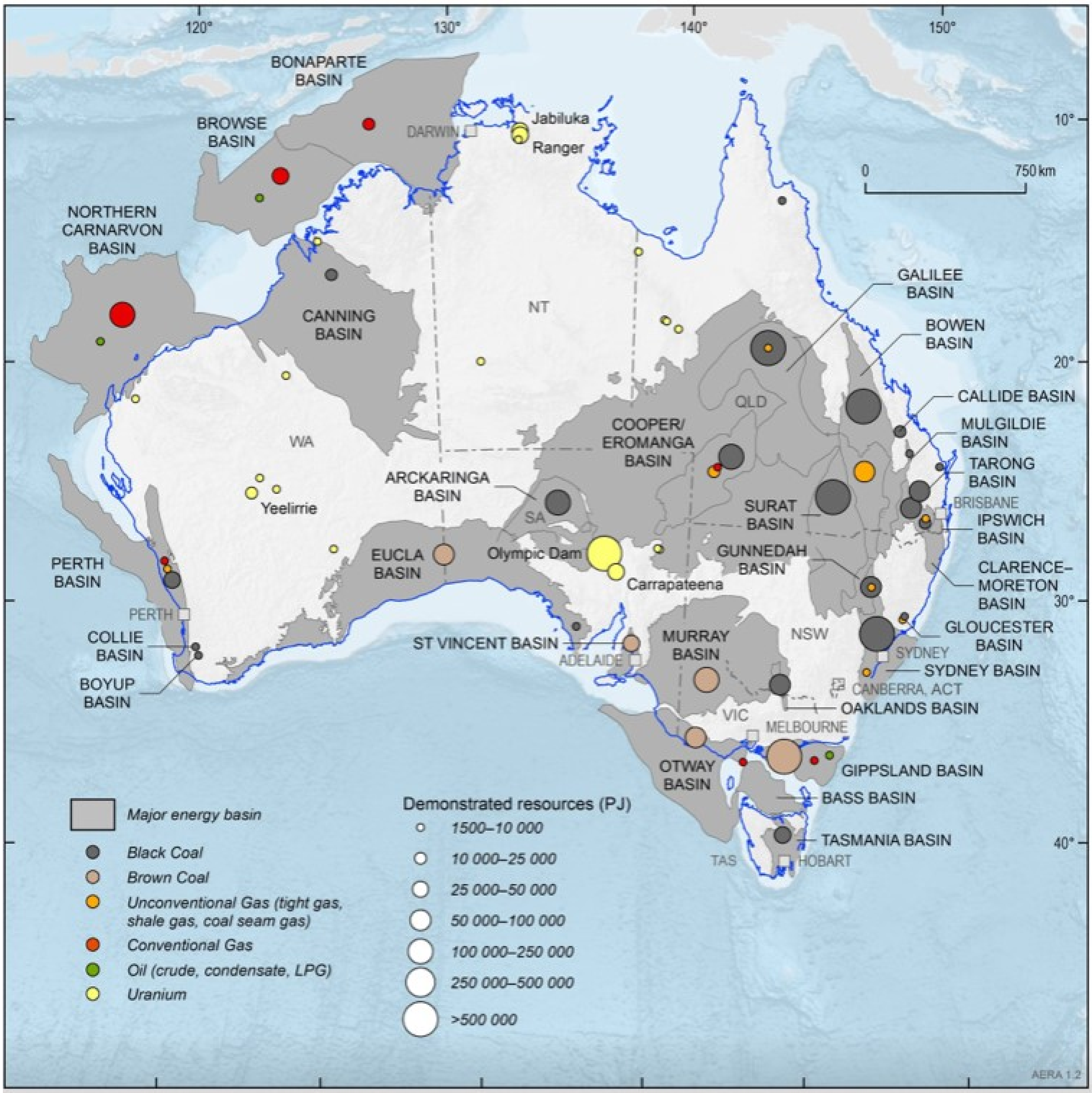
[4] For an overview of the national classification system applied to resource assessment, see: Geoscience Australia, *Australia's Identified Mineral Resources 2017*, 2017, p 8

[5] Geoscience Australia, *Australian Energy Resources Assessment: Coal*, 2019

[6] NSW Government, *Common Ground*, 2019 [website – accessed 13 September 2019]

commodities for NSW, and export volumes are projected to increase over the next two years.[7]

Figure 2: Distribution of Australia's major (containing more than 1,500 PJ) non-renewable energy sources[8]



As of 2014, NSW had approximately 2,266 PJ of gas reserves[9], which consisted solely of coal seam gas. This was equivalent to approximately 1.8% of total Australian gas reserves (conventional and coal seam gas).[10] As at September 2019, two Liquefied Natural Gas (LNG) import terminals are in the planning stage in NSW, at Port Kembla and Newcastle.

[7] Commonwealth Department of Industry, Innovation and Science, *Resources and Energy Quarterly*, June 2019

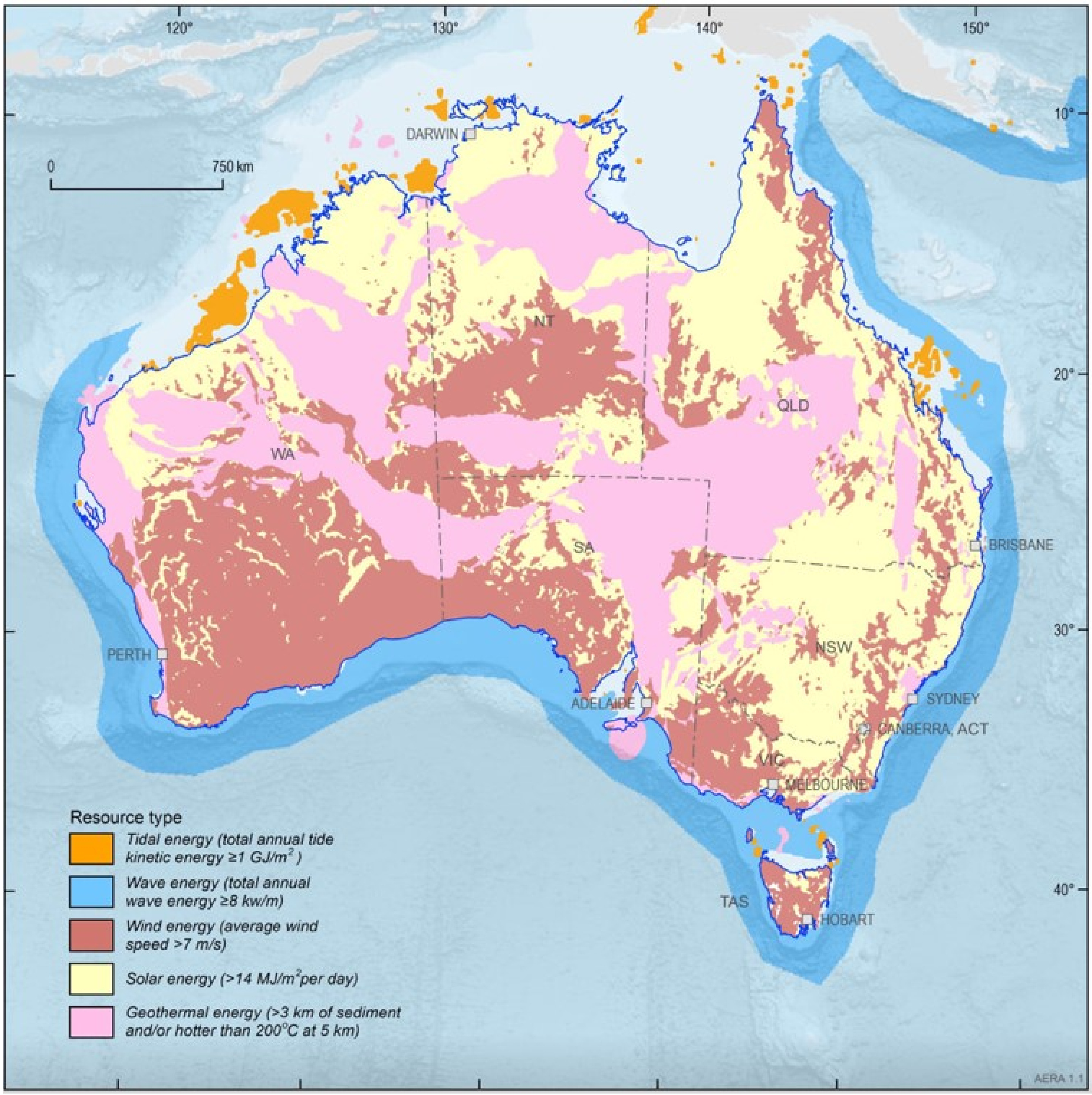
[8] Geosciences Australia, *Australian Energy Resources Assessment*, 2019

[9] This consists of reserves in the Gloucester, Gunnedah and Sydney Basins. 1,195 PJ of CSG are found in the Clarence/Moreton Basin, a small part of which lies in NSW.

[10] Geosciences Australia, *Australian Energy Resources Assessment*, 2019

As at December 2016, NSW had one known deposit of uranium at Toongi, with between 3,000 and 10,000 PJ of Identified Resources of uranium. This was equivalent to 0.2-0.8% of Australia's total Identified Resources of 1,241,091 PJ (see further chapter 9.2).[11]

Figure 3: Distribution of Australia's renewable energy resources, excluding bioenergy and hydro energy resources[12]



3.2 Renewable resources

Figure 3 shows that NSW has the potential to access large amounts of renewable energy sources, especially wind, solar and wave energy. NSW also has significant hydro resources and a small, but growing, bioenergy industry.

[11] Geosciences Australia, *Australian Energy Resources Assessment*, 2019

[12] Geosciences Australia, *Australian Energy Resources Assessment*, 2019. See also: Carter P and Gammidge L (compilers), *Renewable energy map of NSW*, NSW DPE, November 2018; Energy NSW, *Mapping resources*, 2019 [website – accessed 13 September 2019]

Most deployment of wind generation across Australia has been through large-scale wind farms. NSW has some of the best wind resources in the world, particularly along the east coast and regions of the Great Dividing Range such as New England and the Southern Highlands.[13]

Australia receives, on average, the world's highest solar energy per square metre. Solar power can be captured by a number of technologies to generate electricity, including photovoltaic (PV) and solar thermal. In NSW, solar PV systems have been deployed at both the small scale (on houses) and large scale (solar farms).[14]

The majority of Australia's current hydroelectricity generation capacity and reservoir storage is found in NSW, Victoria and Tasmania. Availability of water resources for electricity generation is subject to seasonal variability, as well as the requirements of other water users. According to Geosciences Australia, the use of dams, water storage reservoirs and off-river storage for pumped storage schemes represents a significant opportunity.[15]

4. The electricity supply chain and electricity markets

4.1 The supply chain

The traditional electricity supply chain model[16] has five components (Figure 4):

(1) Generators produce electricity from sources such as coal, gas, uranium, solar, water, wind and biomass. Large-scale generators such as coal-fired power stations are connected to customers via transmission and distribution networks. Smaller distributed energy resources (DER) connect directly to the distribution network. DER includes generation (such as solar PV rooftop panels), storage (batteries and electric vehicles) and demand response (hot water systems and smart appliances);

(2) Transmission networks provide for the bulk transfer of electricity at high voltages from generators to major demand centres;

(3) Distribution networks transport electricity from transmission networks to customers;

(4) Retailers sell bundled electricity products that include electricity purchased from wholesale markets and network costs. Markets for new energy

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[13] Geosciences Australia, *Australian Energy Resources Assessment: Wind*, 2019; Energy NSW, *Wind energy*, 2019 [website – accessed 13 September 2019]

[14] Geosciences Australia, *Australian Energy Resources Assessment: Solar*, 2019; Energy NSW, *Solar energy in NSW*, 2019

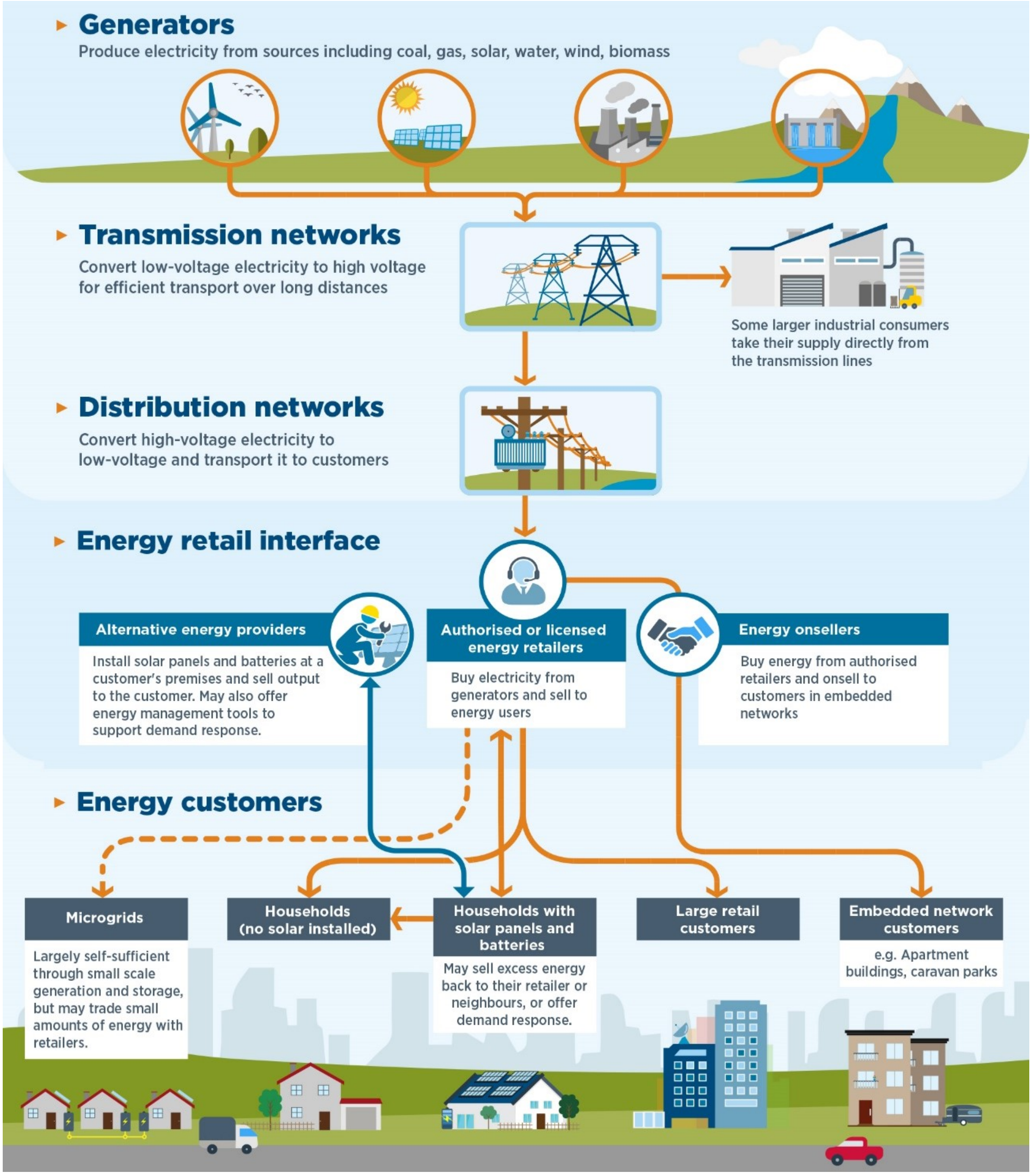
[15] Geosciences Australia, *Australian Energy Resources Assessment: Hydro*, 2019. See also: Australian National University, *ANU finds 22,000 potential pumped hydro sites in Australia*, 21 September 2017 [website – accessed 6 September 2019]; Energy NSW, *Hydro energy in NSW*, 2019 [website – accessed 13 September 2019]

[16] AEMO observes that this traditional electricity supply chain model is changing, with the integration of new technologies such as batteries and solar PV into the system (see further chapter 7). AEMO, *Emerging Generation and Energy Storage in the NEM*, Stakeholder paper, November 2018

services are opening up with the introduction of smart meters, DER and demand response contracts; and

(5) Energy customers include industry, businesses and residential customers. Some large consumers purchase electricity directly from the wholesale electricity market, rather than from retailers.[17]

Figure 4: The electricity supply chain[18]



[17] AER, *State of the Energy Market 2018*, December 2018

[18] AER, *State of the Energy Market 2018*, December 2018, p 28

4.2 Electricity markets

In Australia, three markets are integrated into the supply chain:

(1) Wholesale electricity markets;

(2) Transmission and distribution networks; and

(3) Retail electricity markets.[19]

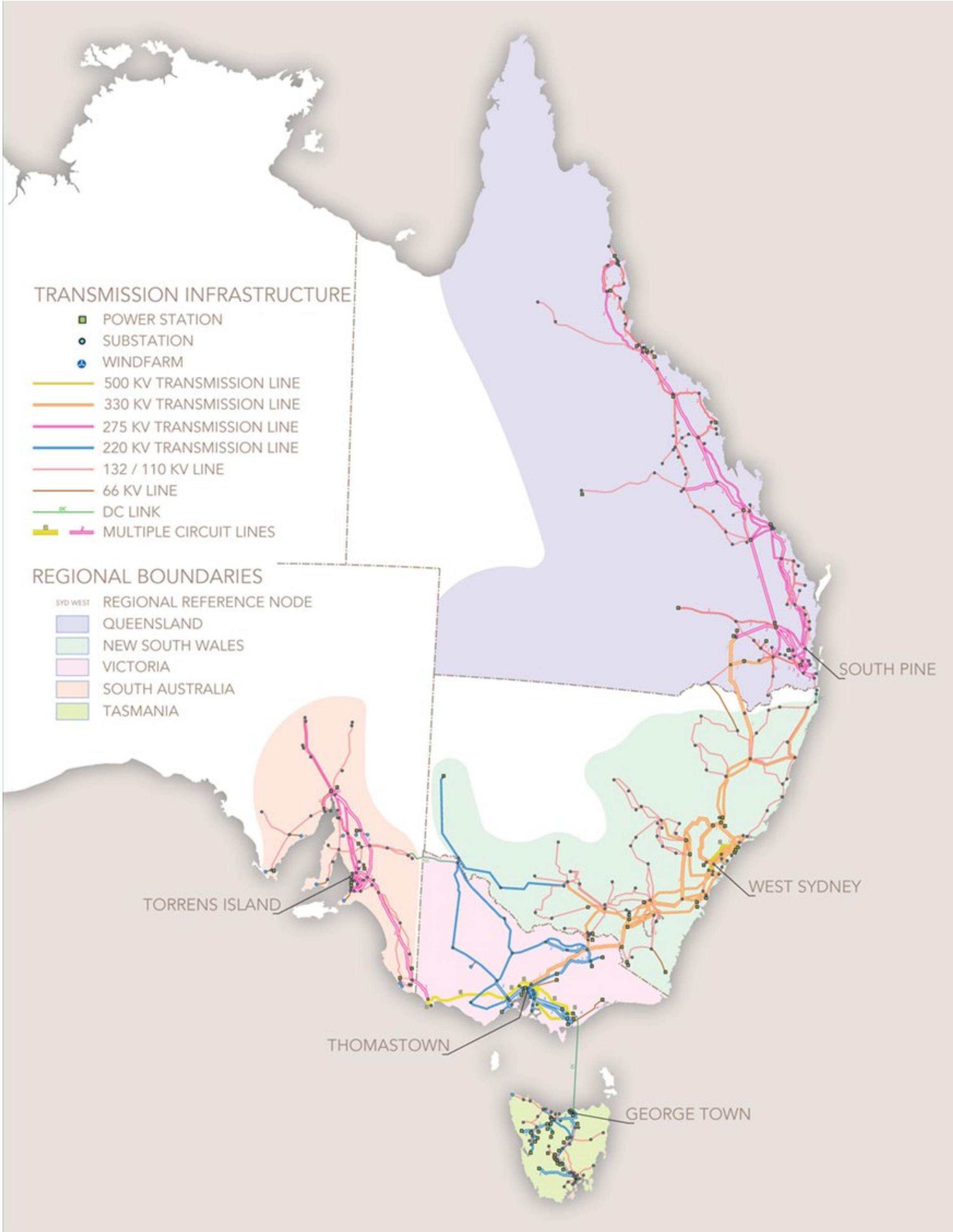
The wholesale electricity market (the National Electricity Market (NEM)) is where generators sell electricity to retailers. The NEM (Figure 5) is comprised of five interconnected States that also act as price regions: NSW (including the Australian Capital Territory); Queensland; South Australia; Tasmania; and Victoria. Electricity can be purchased in the NEM through either a spot market or a contract market. The NEM is operated by the Australian Energy Market Operator (AEMO). Western Australia (the Wholesale Electricity Market (WEM)) and the Northern Territory (the Interim Northern Territory Electricity Market) have their own wholesale markets due to their distance from the eastern States.

Transmission and distribution networks are capital intensive assets where it is cost efficient to have only a single network in an area. Because this produces a natural monopoly industry structure, network businesses are regulated to replicate the incentive properties of a competitive market. Network businesses participating in the NEM are regulated by the Australian Energy Regulator (AER).

The energy retail market enables energy retailers to sell electricity, gas and energy services to residential and business customers. It also allows customers to choose between competing retailers within a framework that includes consumer protections.

[19] AEMC, *Electricity Market*, 2019 [website – accessed 26 August 2019]

Figure 5: The National Electricity Market[20]



[20] AEMC, *National Electricity Market*, 2019 [website – accessed 26 August 2019]

5. Regulatory and operational framework

A number of key bodies in the NEM States are involved in operating and regulating the electricity supply chain and electricity markets, as well as developing energy policy.

Council of Australian Governments (COAG) Energy Council

The COAG Energy Council is a forum comprised of the Commonwealth, State, Territory and New Zealand energy and resources ministers. The Council's reform program is guided by five themes:

- Overarching responsibility and policy leadership for Australian gas and electricity markets;
- Promotion of energy efficiency and energy productivity in Australia;
- Australian electricity, gas and petroleum product energy security;
- Cooperation between Commonwealth, State and Territory governments; and
- Facilitating the economic and competitive development of Australia's mineral and energy resources.

Australian Energy Market Commission and national energy laws

The Australian Energy Market Commission (AEMC) is one of three bodies responsible for energy in Australia. It has rule making and review responsibilities under three statutes (the national energy laws):

- The National Electricity Law (NEL);
- The National Energy Retail Law (NERL); and
- The National Gas Law (NGL).

These statutes were made in South Australia (SA) under a national agreement, and apply in the other NEM jurisdictions under legislation passed in each State.[21]

The AEMC makes and amends the following rules under the three statutes:

- National Electricity Rules;
- National Energy Retail Rules; and
- National Gas Rules.

These rules:

- Govern the operation of the NEM and the electricity supply chain;

[21] In NSW, these statutes are the *National Electricity (New South Wales) Act 1997* and *National Electricity (NSW) Law*; *National Energy Retail Law (Adoption) Act 2012* and *National Energy Retail Law (NSW)*; and *National Gas (New South Wales) Act 2008* and *National Gas (NSW) Law* respectively.

- Govern the economic regulation of transmission and distribution networks;
- Govern how market participants can operate in the retail market; and
- Facilitate the provision of services to retail customers and provide rights for consumers.

Each of the national energy laws contains a national energy objective that guides the operation and regulation of each sector. As included in the NEL, the National Electricity Objective (NEO) is:

> to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:
>
> - price, quality, safety and reliability and security of supply of electricity
> - the reliability, safety and security of the national electricity system.

The National Energy Retail Objective (NERO) as stated in the NERL is:

> to promote efficient investment in, and efficient operation and use of, energy services for the long term interests of consumers of energy with respect to price, quality, safety, reliability and security of supply of energy.

Australian Energy Market Operator

The Australian Energy Market Operator (AEMO) is Australia's independent energy market and power system operator. Together with the operation of a number of gas wholesale and retail markets, AEMO operates the NEM and the Western Australian WEM. AEMO also provides critical planning, forecasting and power systems information, security advice, and services to its stakeholders.

Australian Energy Regulator

Under the national energy laws and rules, the Australian Energy Regulator (AER):

- Monitors, investigates and enforces compliance with national electricity legislation and rules in the NEM;
- Regulates transmission and distribution networks by setting the maximum amount of revenue they can earn; and
- Regulates electricity retail markets in all NEM States except for Victoria.

Energy Security Board

The Energy Security Board (ESB) has been tasked by the COAG Energy Council with coordinating implementation of the 2017 *Independent Review into the Future Security of the National Electricity Market – Blueprint for the Future* (the Finkel Report; see further chapter 7.5). Key responsibilities of the ESB include:

- Developing a Strategic Energy Plan for the NEM, and monitoring its implementation;
- Reporting on the health of the NEM; and

- Developing a post-2025 market design for the NEM.

Other key bodies

Other key Australian and NSW bodies include:

- The Australian Competition & Consumer Commission (ACCC) conducts inquiries into the electricity sector, regulates the retail market, and is developing a Consumer Data Right in relation to energy;
- Energy Consumers Australia (ECA) is the independent, national representative body for residential and small business energy consumers. It works with other consumer groups to provide evidence-based advocacy on NEM matters;
- Energy NSW, which is part of the NSW Department of Planning, Industry and Environment (DPIE), provides financial assistance to customers, administers the *NSW Transmission Infrastructure Strategy*, and supports investment in renewable energy through programs such as the Emerging Energy Program;
- The Independent Pricing and Regulatory Tribunal (IPART) monitors the performance of the retail electricity market in NSW, provides guidance on solar feed-in tariffs, administers licences and monitors the safety and reliability of the transmission and distribution networks, and administers the Energy Savings Scheme; and
- The Environment Protection Authority (EPA) regulates the operation of power stations.

6. The National Electricity Market

6.1 Operation

The NEM is a wholesale electricity market that operates across the five interconnected States as a spot market, where power supply and demand are matched instantaneously in real time through a centrally coordinated dispatch process. Generators offer to supply the market with specified amounts of electricity at specified prices for set time limits. AEMO accepts the cheapest bids first and dispatches those bids to meet demand. Generators therefore need to be able to offer their electricity at a competitive price in order to ensure selection for dispatch. In this way, the NEM is designed to meet electricity demand in the most cost-efficient way.

Electricity production is matched to demand, with spare generating capacity kept in reserve in case it is needed. Production is also limited by the capacity of the transmission network to transport electricity. When delivering electricity, AEMO determines a dispatch price every five minutes, and six dispatch prices are averaged over every half-hour to determine the spot price for each NEM region. The NER set both a maximum ($14,200 per megawatt hour (MWh) and minimum (-$1,000/MWh) spot price for the NEM. The spot price is used as the basis for settling the financial transactions for all electricity traded in the NEM. AEMO pays generators for the electricity, and recovers the cost from retailers.

AEMO also purchases frequency control ancillary services (FCAS) through a market that is co-optimised with the wholesale electricity market to minimise costs. FCAS are required to maintain the frequency of the power system within safe operating standards.[22]

Due to significant spot price volatility, NEM participants adopt various strategies to manage their financial risks.[23] Some participants ('gentailers') manage risk internally through vertical integration, operating both generation and retail arms to balance out the risks in each market. Both gentailers and stand-alone generators and retailers participate in contract markets to manage risk. Two financial markets support the wholesale electricity market in this way:

- Over the counter (OTC) markets, in which two parties contract with each other directly. These trades are confidential; and
- The exchange traded market, in which electricity futures products are traded on the Australian Securities Exchange (ASX) and publicly reported. Participants include generators, retailers, speculators such as hedge funds, banks and other financial intermediaries.[24]

As of August 2019, there were 398 participants in the NEM, including generators, network service providers (NSPs), and retailers.

6.2 Security, reliability and safety

Under the NEO, the NEM is managed, operated and regulated in a way that meets system security, reliability and safety performance standards. These standards are defined in the NER and by the AEMC's Reliability Panel. Some aspects of reliability and safety are regulated by jurisdictions within the NEM and these are addressed below.

Security

AEMO is required to keep the NEM in a secure operating state, where security is defined as occurring when the power system is operating within set technical limits, and is likely to return to meeting those technical limits after a disruptive event such as the disconnection of a major power station. AEMO ensures security through a variety of measures including dispatch constraints and intervening in the NEM to direct market participants.[25]

Reliability

A reliable power system possesses enough generation, demand-side response and network capacity to meet electricity demand with a very high degree of confidence. Reliability requires well-functioning wholesale markets, system forecasting and planning, policy certainty, reliable transmission and distribution

[22] AER, *State of the Energy Market 2018*, December 2018
[23] AER, *State of the Energy Market 2018*, December 2018
[24] AER, *State of the Energy Market 2018*, December 2018
[25] Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019

networks, and a secure system.

Reliability is measured in terms of unserved energy (USE), which is the amount of energy that is not supplied when required due to a shortage of generation or interconnection capacity. The reliability standard requires that no more than 0.002% of a region's forecast annual demand should be at risk of not being met.

It is important to note that this definition of reliability excludes other circumstances that may cause an interruption to consumer supply:

- Distribution network outages, which are by far the most frequent cause of supply interruptions;
- Outages in the transmission network other than the interconnectors; and
- Imbalances in generation and demand triggered by shortages in generation capacity due to unforeseeable events such as multiple generation unit failures.

Maintenance of transmission and distribution network reliability is the responsibility of each NEM State.[26]

Safety

Safety in the NEM has two components:

- Technical safety, where generators, the transmission and distribution networks, and other NEM facilities are safe from damage; and
- Public safety, where those same components of the NEM are not a source of injury and danger.

While both aspects of safety are important considerations under national electricity law, according to the AEMC, "in general terms, there is no national safety regulator of the NEM".[27]

State jurisdictions have responsibility for the safe operation of power stations, transmission networks and distribution networks, as well as smaller components of the system such as meters and batteries. In NSW, the EPA regulates power stations under the *Protection of the Environment Operations Act 1997*. IPART is the safety and reliability regulator for electricity networks under the *Electricity Supply Act 1995*.[28]

6.3 Power system requirements

A range of interdependent operational and technical requirements need to be met in order to maintain a safe, secure and reliable power system. These needs are satisfied by a combination of services provided by generators and networks, and

[26] Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019
[27] Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019, p x
[28] Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019

the technical performance standards that apply to market participants. Current structural changes in the system pose challenges to the ability of AEMO to continually meet the needs of the power system (see further chapter 7).[29]

Power system requirements fall into two groups: operational; and technical. AEMO and NSPs must have access to critical operational levers to manage the power system within its technical limits.

The operational prerequisites are:

- Dispatchability of the power system – the ability to manage dispatch and configure power system services to maintain system security and reliability; and
- Predictability of the power system – the ability to:
    - Acquire accurate data on energy demand, power system flows, and generation output across numerous timeframes (real time, hours/days/weeks/years ahead) as key inputs into planning and operational decision-making; and
    - Forecast upcoming power system conditions and have confidence in how the system will perform.

Using these operational levers, AEMO keeps the NEM in balance using security-constrained economic dispatch – dispatching "the 'least-cost' combination of generation (and dispatchable load) to meet demand and ancillary services, based on bids and offers, while remaining within the security and reliability parameters".[30]

Four key technical attributes together provide for the resilience of a power system, so that it can withstand unexpected disturbances such as generator or interconnector failures:

- Resource adequacy and capability – a sufficient overall portfolio of energy resources to continuously achieve the real-time balancing of supply and demand;
- Frequency management – the ability to set and maintain system frequency within acceptable limits;
- Voltage management – the ability to maintain voltages on the network within acceptable limits; and
- Ability to restore system – the ability to restart and restore the system in the unlikely event of a major supply disruption.[31]

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[29] AEMO, *Power system requirements*, Reference Paper, March 2018; AEMO, *Integrated System Plan for the National Electricity Market*, July 2018

[30] AEMO, *Power system requirements*, Reference Paper, March 2018, p 5

[31] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018

6.4 Electricity generators and network technologies

Electricity generators may be classified according to a number of parameters, many of which serve to maintain system reliability and security. Some of these parameters also determine whether or not a generator is registered to participate in the NEM.

Table 1 provides a matrix with examples of generators matched against these parameters. For some generators (such as wind and solar), it should be noted that their capacity to meet certain parameters required by the NEM is changing with technological improvements. Existing and new transmission and distribution network technologies can also be used to meet reliability and security requirements. Further, AEMO is moving towards a model where a portfolio of dispatchable energy resources are used to meet the needs of the system as the business viability of traditional baseload generation is eroded due to a number of factors.[32]

Dispatchability

The dispatchability of a generator is a measure of the extent to which the generator may be relied upon to follow a target (that is, they are load following), and "incorporates how controllable the resources are, how much they can be relied upon [how firm they are], and how flexible they are".[33] Generators which provide baseload power, such as coal-fired power stations and nuclear power plants, are reliable and controllable but relatively inflexible. This is because they have long start up and shut down times, and are unable to ramp production up or down quickly in response to demand. With high capital costs and low operating costs, these generators are economically viable when operating on a continuous basis to supply the 'base' or minimum load of a power grid.

While peaking generation plants are controllable, reliable and flexible, they are generally not used to provide baseload power due to fuel costs or storage capacity. Generators powered by relatively expensive fuels such as gas and diesel are most often used in high demand periods when wholesale electricity prices are raised.[34] Hydro-electric power stations, pumped hydro systems and batteries have capacity constraints due to factors such as rainfall levels.

There are two main groups of generators that AEMO does not include within the dispatchable capacity of the NEM. Variable renewable energy (VRE) sources – wind and utility solar – produce output that is not readily predictable. Network interconnectors between regions will play an increasing role in mitigating the impact of the intermittent electricity supply produced by VRE generators.

The second group belong to a set of resources embedded within the distribution network and behind the meter (on consumers' premises) that are collectively

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[32] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018; AER, *State of the Energy Market 2018*, December 2018

[33] AEMO, *2019 Electricity Statement of Opportunities*, August 2019, p 16

[34] AER, *State of the Energy Market 2018*, December 2018

called distributed energy resources (DER). DER can be used individually or in aggregate to help balance supply and demand or provide system services. They include residential or commercial installations of solar PV, wind turbines, energy storage, demand management systems, electric vehicles (EVs), combustion generators, variable speed motor drives, and cogeneration units.[35]

Synchronicity

The NEM has a set frequency range of around 50 Hertz (Hz) that provides for the safe, secure and reliable transmission of electricity. Power system frequency is controlled by constantly balancing electricity supply and demand. If supply exceeds demand at an instant in time, power system frequency will increase; if demand exceeds supply, power system frequency decreases.

Table 1: Electricity generation matrix[36]

Generator	Location	Synchronicity	Dispatchability			
	Distributed (D) or Centralised (C)	Synchronous (S) or non-synchronous (N)	Intermittent	Peaking	Load following	Baseload
Solar PV	D/C	N	✓	✓		
Solar thermal	C	S	✓	✓	✓	
Geothermal	C	S				✓
Biomass	C	S			✓	✓
Wind	D/C	N	✓			
Hydro	D/C	S		✓	✓	
Batteries	D/C	N		✓	✓	
Reciprocating engine*	D/C	S		✓	✓	
OCGT	C	S		✓	✓	
CCGT	C	S			✓	✓
Coal	C	S				✓
Nuclear[37]	C	S				✓

CCGT = Combined-cycle gas turbine; OCGT = Open-cycle gas turbine

* Reciprocating engines may be powered by diesel or gas

Synchronous generators (coal, gas, hydro, biomass and solar thermal[38]) have moving parts which rotate at a rate consistent with the frequency of the NEM power system. The inertia of their moving parts enables them to slow the rate at

[35] AEMO, *Power system requirements*, Reference Paper, March 2018

[36] AEMO, *Advice to Commonwealth Government on Dispatchable Capability*, September 2017; Lazard, *Lazard's Levelized Cost of Energy Analysis – Version 11.0*, November 2017; AEMO, *Power system requirements*, Reference Paper, March 2018; AEMO, *Integrated System Plan for the National Electricity Market*, July 2018; AER, *State of the Energy Market 2018*, December 2018. The dispatchability classifications in this Table are primarily based on Australian sources.

[37] See further chapter 11.2

[38] Nuclear power stations are also synchronous generators. See further chapter 11.

which system frequency changes. These generators provide stability to the power grid by meeting its frequency requirements, in addition to other system requirements. Non-synchronous or asynchronous generators (wind, solar, batteries) do not contain equipment that spins at system frequency. Instead, they are interfaced with the system via converters which replicate grid frequency.[39]

Network technologies

Well planned transmission and distribution networks, as well as network technologies such as static VAR compensators, synchronous condensers and static synchronous compensators, contribute to the provision of a secure and reliable power system.[40]

National Electricity Market classification

AEMO classifies all generators connected to the NEM in accordance with four parameters (Table 2):

- Dispatchability (scheduled, semi-scheduled and non-scheduled);
- Participation in the wholesale market;
- Consumption of output; and
- Capacity.

Table 2: Generator classification and exemption categories[41]

		Typical capability	Examples
Exempt		Less than 5 MW, all purchased by a local retailer or customer (automatic exemption)	1 MW backup diesel generator in a high-rise building
		Less than 30 MW, all purchased by a local retailer or customer, annual export less than 20 GWh (application required)	20 MW biomass generator with limited fuel supplies
Non-scheduled	Non-market	Less than 30 MW, all purchased by a local retailer or customer	10 MW solar PV installation
	Market	Between 5 MW and 30 MW, with some or all sent out energy sold in the NEM	10 MW landfill methane reciprocating engine supplying the wholesale market
Semi-scheduled	Non-market	Intermittent output, greater than 30 MW, all purchased by a local retailer or customer	150 MW wind farm, all purchased under contract by local retailer
	Market	Intermittent output, greater than 30 MW, with some or all sent out energy sold in the NEM	150 MW wind farm supplying the wholesale market
Scheduled	Non-market	Greater than 30 MW, all purchased by a local retailer or customer	40 MW hydro station, all purchased under contract to a local retailer
	Market	Greater than 30 MW, with some or all sent out energy sold in the NEM	2,000 MW coal-fired power station supplying the wholesale market

Electricity generators range in capacity from large coal-fired power stations, such as Bayswater in NSW with a capacity of 2,520 megawatts (MW), to the average

[39] AEMO, *Power system requirements*, Reference Paper, March 2018
[40] AEMO, *Power system requirements*, Reference Paper, March 2018
[41] Adapted from AEMO, *Participant categories in the National Electricity Market*, no date, p 3

5.5 kilowatt (kW) rooftop solar PV system. DER currently fall outside this classification system.[42]

7. Energy trends and policy developments

There are seven key trends that present opportunities and challenges for the electricity supply chain and electricity markets:

(1) A shift from large geographically concentrated energy generation to small geographically dispersed generation;

(2) Power system services previously provided at no cost as a by-product of power generation are now not necessarily provided by new generation;

(3) Transmission networks are playing an increasingly important role in providing system reliability and security;

(4) Customers are increasingly adopting small-scale solar and energy storage technologies;

(5) The power system and market are increasingly underpinned by digital technologies that make it easier to choose and control how, when and where power is delivered and used;

(6) Increasingly variable demand and supply factors makes forecasting a challenge and adds risk to operational and investment decisions; and

(7) Changing weather patterns and extreme weather events pose challenges to maintaining system security and reliability.[43]

In this chapter, discussion of energy trends and policy developments has been ordered around the electricity supply chain: supply and demand trends and forecasts; wholesale markets; transmission and distribution networks; and retail markets. Particular attention has been given to electricity generation and consumption trends and forecasts because of their relevance to current debate concerning introduction of new generation capacity into the NEM such as nuclear power stations. The chapter concludes with an overview of how governments are responding to these energy challenges.

7.1 Electricity supply and demand

Trends

Current trends in electricity supply and demand include:

- Existing supply sources such as coal-fired power stations are nearing the end of their operational lives;

[42] See AEMO, *Power system requirements*, Reference Paper, March 2018; and AEMO, *DER Register Implementation*, 2019 [website – accessed 30 August 2019]

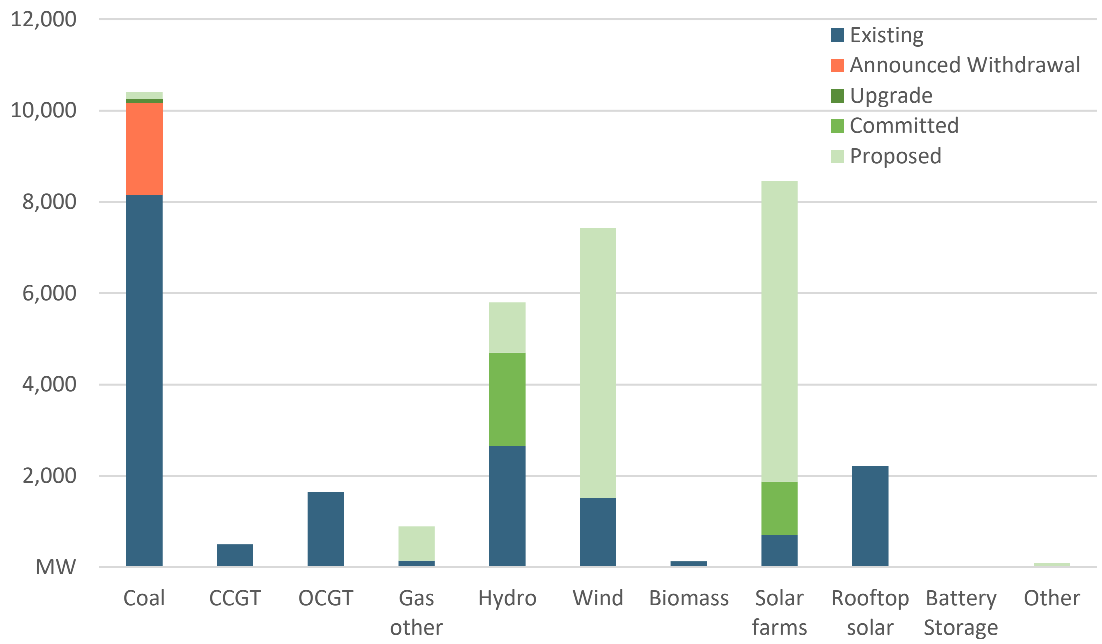
[43] AEMO, *AEMO Observations: Operational and Market Challenges to Reliability and Security in the NEM*, March 2018; AEMO, *Integrated System Plan for the National Electricity Market*, July 2018; AEMC, *Our forward looking work program*, 2019 [website – accessed 5 September 2019]; AEMO, *2019 Electricity Statement of Opportunities*, August 2019

- Increased diversity in power generation resources, including VRE and DER;
- Increasing levels of non-synchronous power generation (wind and solar);
- New security and reliability issues; and
- Changing patterns of demand.[44]

Generation capacity

As at July 2019, there was 17,479 megawatts (MW) of generation capacity in NSW registered with AEMO, with an additional 3,211 MW of committed capacity and 14,580 MW of proposed capacity (Figure 6). NSW also had 2,211 MW of installed rooftop solar which, strictly speaking, is classified in the NEM as negative demand because it is located behind the meter.[45]

Figure 6: Electricity generation capacity in NSW, July 2019[46]



CCGT = Combined-cycle gas turbine; OCGT = Open-cycle gas turbine

Fossil fuels accounted for 63.3% of generation capacity in NSW, the second highest proportion of any State in the NEM following Queensland with 69.1% (Figure 7). Tasmania had the highest renewable capacity at 87.7%, followed by SA (49.4%), Victoria (48.2%), NSW (36.7%) and Queensland (30.8%). Scheduled, or dispatchable, generation capacity accounted for 84.4% of NSW's

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[44] AEMO, Integrated System Plan for the National Electricity Market, July 2018; AER, State of the Energy Market 2018, December 2018; AEMC, Coordination of Generation and Transmission Investment, 21 December 2018; Reliability Panel AEMC, Annual Market Performance Review 2018, 4 April 2019; AEMO, 2019 Electricity Statement of Opportunities, August 2019

[45] AEMO, Power system requirements, Reference Paper, March 2018

[46] AEMO, Generation Information Page: NEM data, as of 12 July 2019, 8 August 2019; Clean Energy Regulator, Postcode data for small-scale installations – SGU-Solar, as of 31 July 2019, 20 August 2019

total generation capacity, with semi-scheduled generators accounting for a further 11.0% (Table 3).

Figure 7: Existing electricity generation capacity in NEM States, July 2019[47]

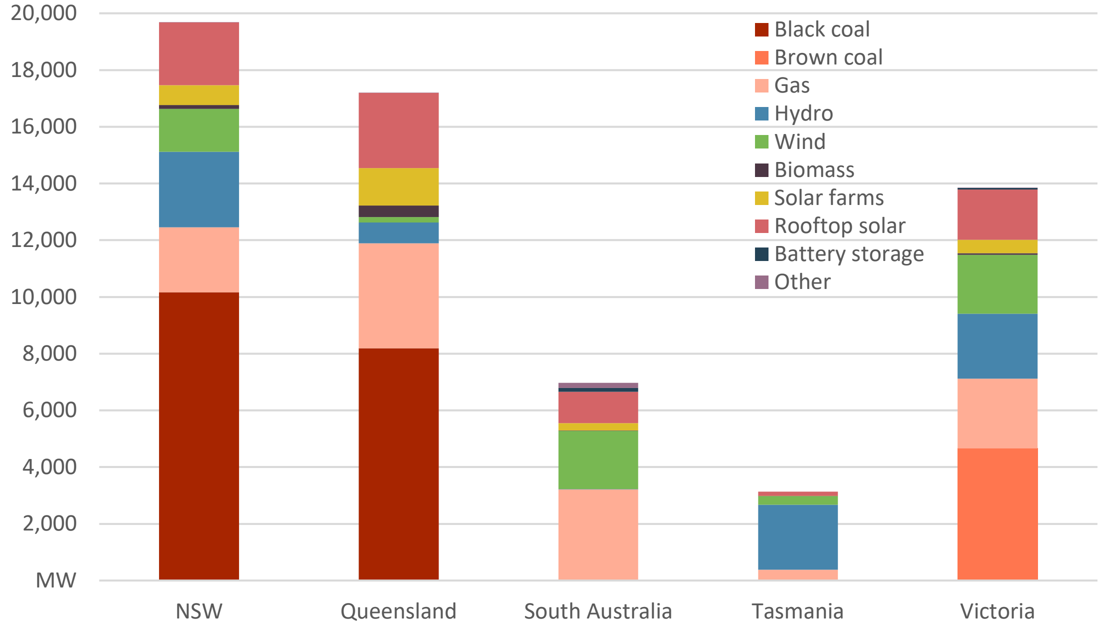

Table 3: Electricity generation capacity in NEM States, by type, July 2019[48]

	Scheduled	Semi-Scheduled	Non-Scheduled
NSW	14,748 (84.4%)	1,921 (11.0%)	810 (4.6%)
Queensland	12,205 (83.9%)	1,405 (9.7%)	942 (6.5%)
South Australia	3,173 (54.2%)	1,910 (32.6%)	775 (13.2%)
Tasmania	2,556 (85.5%)	168 (5.6%)	264 (8.8%)
Victoria	9,318 (77.2%)	1,949 (16.1%)	811 (6.7%)

Between 2012-13 and 2017-18, 11 coal-fired power stations were retired across the NEM, three of which were in NSW, with the capacity of an additional NSW power station being downgraded (Table 4). In total, 5,454 MW of capacity was lost due to these withdrawals, with approximately 2,200 MW of new generation investment (primarily wind and solar) added to the NEM over the same time period.[49] Eraring coal-fired power station (NSW) was upgraded in 2013 with 240 MW added, and an additional 100 MW of capacity is due to be added to Bayswater (NSW) by November 2022.

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47 AEMO, *Generation Information Page: NEM data, as of 12 July 2019*, 8 August 2019; Clean Energy Regulator, *Postcode data for small-scale installations – SGU-Solar, as of 31 July 2019*, 20 August 2019

48 AEMO, *Generation Information Page: NEM data, as of 12 July 2019*, 8 August 2019

49 AER, *State of the Energy Market 2018*, December 2018

Table 4: Coal and gas-fired power stations in NSW: 2012 to 2070 timeline[50]

Date	Power station	Fuel	Status	Capacity (MW)	Age at retirement/ downgrade
Jul 2012	Munmorah	Coal	Retired	600	43
2013	Eraring	Coal	Upgrade	240 (to reach 2,880)	NA
Aug 2014	Redbank	Coal	Retired	144	13
Nov 2014	Wallerawang C	Coal	Retired	1,000	38
2016	Mount Piper	Coal	Downgrade	80 (of 1,400)	23
Jun 2019	Smithfield	Gas	Upgrade	14 (to reach 185)	NA
Future developments and retirements					
Nov 2019 to Nov 2022	Bayswater	Coal	Upgrade	100 in total (to reach 2,740)	NA
Jan 2020	Redbank	Coal	Re-opening	151	NA
Apr 2022 and Apr 2023	Liddell	Coal	Retirement	450 and 1,350[51]	50
Dec 2022	Tomago	Gas	New	250	NA
2029	Vales Point	Coal	Retirement	1,320	50
2031	Eraring	Coal	Retirement	2,880	50
2035	Bayswater	Coal	Retirement	2,740	50
2042	Mount Piper	Coal	Retirement	1,320	50
2043	Tallawarra	Gas	Retirement	440	35
2044	Smithfield	Gas	Retirement	185	47
2044	Uranquinty	Gas	Retirement	640	35
2070	Colongra	Gas	Retirement	648	60

The closure of coal-fired power stations is influenced by a number of technical, commercial and financial factors. For this reason, AEMO considers the projected timing of retirements to be highly uncertain.[52] In its forward planning, it assumes a 50 year technical life for black coal-fired power stations. Liddell will have reached this lifespan by the time it is due to progressively close over April 2022 to April 2023. However, the closure of Munmorah, Redbank and Wallerawang C power stations occurred prior to this lifespan being reached. Munmorah was closed because it was no longer economically viable,[53] Redbank closed because

[50] Sources: AER, *State of the Energy Market 2015*, December 2015; AER, *State of the Energy Market 2018*, December 2018; AEMO, *Generation Information Page: NEM data, as of 12 July 2019*, 8 August 2019

[51] AEMO operates on the assumption that Liddell has total summer capacity of 1,800 MW

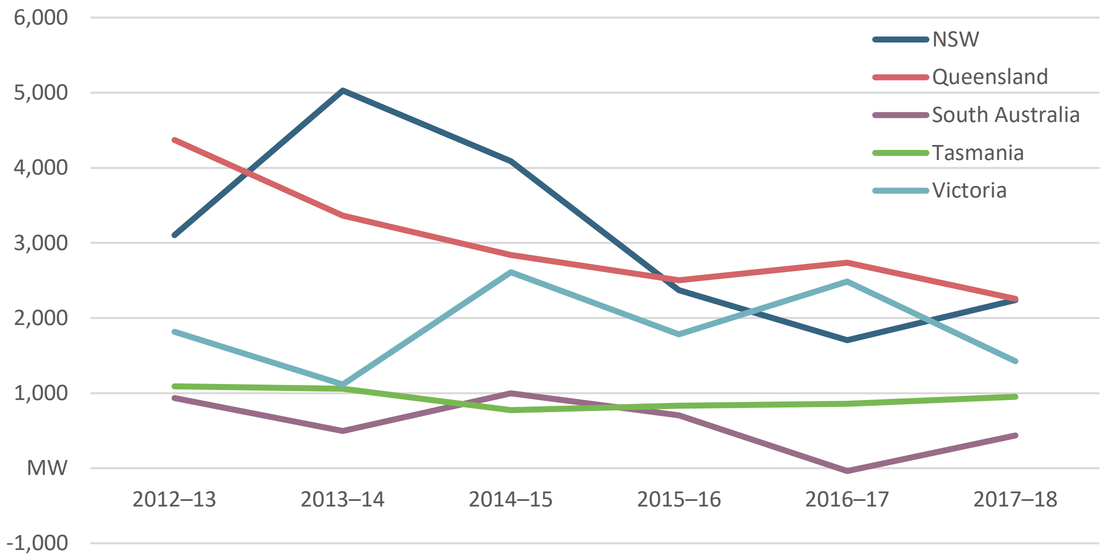
[52] AEMO, *Integrated System Plan for the National Electricity Market*, July 2018

[53] Delta Electricity, *Annual Report 2013*, 2013

its parent company went into receivership,[54] and Wallerawang was retired due to reduced energy demand, high operating costs and high coal prices.[55]

In NSW, no gas-fired power stations have either been retired or built since the Colongra, Tallawarra and Uranquinty power stations were commissioned in 2009.[56] While Smithfield was retired in July 2017, it was brought back into service in December 2017, with a capacity upgrade to 185 MW in June 2019.[57] Construction of a new gas-fired power station in the Hunter is expected to commence at the end of 2020.[58]

Figure 8: Surplus generation capacity, by region, July 2018[59]



Note: Maximum demand in financial year minus summer capacity (nameplate capacity for non-scheduled plant) at 31 January in each region. Summer capacity for 2016–17 in Victoria includes Hazelwood, with closure of the plant reflected in 2017–18 data. Wind and solar summer capacity is de-rated based on AEMO's 'firm contribution' estimates to account for generation likely to be operational during periods of maximum demand.

Investment in generation capacity across the NEM exceeded demand growth between 2009 and 2015, with surplus generation capacity peaking at 11,309 MW in 2014-15 (Figure 8). According to the AER, surplus generation capacity reached 7,309 MW in 2017-18 due to the retirement of coal-fired power stations, as well as declining investment in renewables because of uncertainty over government

[54] *Newcastle Herald*, Singleton's Redbank Power Station to close with 39 jobs lost after going into receivership, 31 October 2014

[55] EnergyAustralia, *Wallerawang power station closure*, 2019 [website – accessed 2 September 2019]

[56] AER, *State of the Energy Market 2009*, December 2009

[57] AEMO, *Generation Information Page: NEM data, as of 12 July 2019*, 8 August 2019

[58] AEMO listed another publicly announced gas-fired power station with 500 MW capacity on 12 July 2019. This has not been included in Table 4 because there was no announced full commercial use date. As of 3 September 2019, AGL is still in the process of selecting a suitable site for this project (the Dalton power project).

[59] AER, *State of the Energy Market 2018*, December 2018, p 103

policy.[60]

As at 12 July 2019, 3,211 of renewable capacity is committed to be built in NSW (Figure 6). This is comprised of eight solar projects (1,171 MW) and Snowy Hydro 2.0 (2,040 MW). An additional 13,595 MW of renewable capacity has been proposed, including three hydro (power stations and/or storage) with 1,100 MW capacity, 5,911 MW of wind capacity and 6,583 MW of solar capacity. Across the NEM, 7.2 GW of new capacity is committed to enter the market, with 4.7 GW of wind and solar capacity expected to reach full commercial use before 2021-22.[61]

The committed and proposed hydro power stations will provide dispatchable capacity for NSW, whereas wind and solar power generation will provide intermittent electricity. There are at least two ways of comparing the relative contribution of intermittent and dispatchable generation to total operational generation capacity: firm capacity; and capacity factors.

The first involves an assessment of the reliability of a generator to provide power to meet peak demand, otherwise known as its firmness. Firm capacity for thermal generators (coal and gas) is expressed below as a percentage of their total capacity. As solar and wind generators cannot be relied upon to provide during peak hours, AEMO assigns them a peak contribution factor in place of a firm capacity figure:

- NSW coal-fired power stations range from 90.0% (Liddell) to 100.0% (Mt Piper and Vales Point);
- NSW gas-fired power stations range from 66.6% (Smithfield) to 96.4% (Uranquinty);
- NSW wind generators range from 9.2% to 10.0%, depending on season and whether the generator is existing or new;
- Wind generation in all other NEM States ranges from 5.1% to 20.1%; and
- Solar has a peak contribution factor of 0.0%, as 15% of peak demand periods occur after sunset when solar generation is zero.[62]

Capacity factors mean that no generator can operate 100% of the time. The capacity factor is the amount of energy produced by a generator over a set period of time, expressed as a proportion of the maximum possible production over that same time period. In a 2018 report that assessed current incentives for new power generators to enter the market, AER calculated operational capacity factors for a selected group of technologies before adopting maximum capacity factors for modelling purposes[63] on the following assumptions (Figure 9):

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[60] AER, *State of the Energy Market 2018*, December 2018

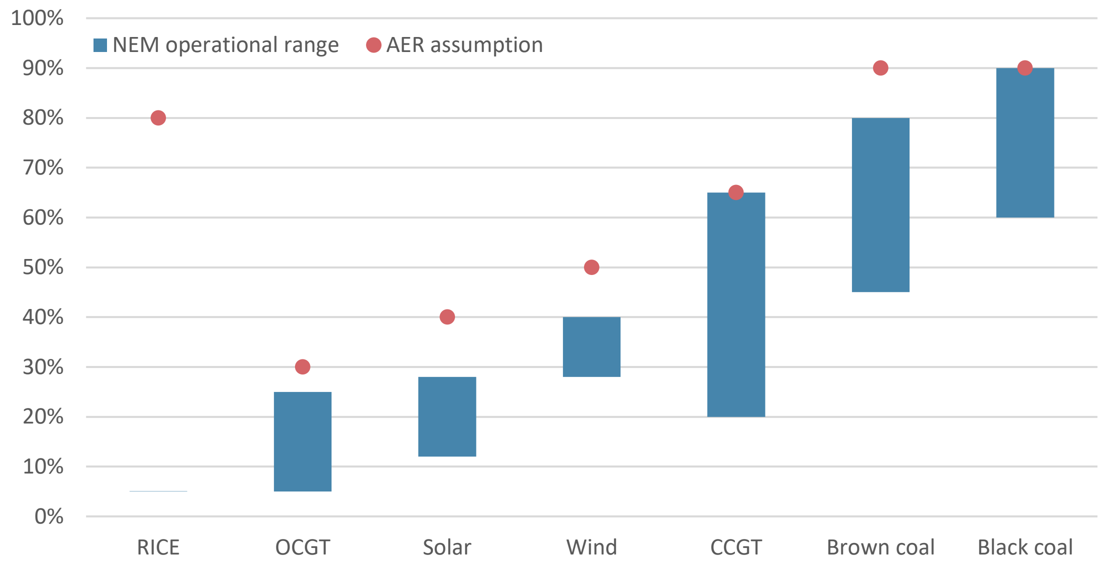
[61] AEMO, *2019 Electricity Statement of Opportunities*, August 2019

[62] AEMO, *2019 Input and Assumptions workbook*, August 2019

[63] On the adoption of these maximum capacity factors, the AER states “These capacity factors are not intended to be interpreted as the actual capacity for that technology, but rather the point at which we truncated the curves for presentation purposes”. AER, *Wholesale Electricity Market Performance Report – LCOE modelling approach, limitations and results*, December 2018, p

- Black coal, brown coal and CCGT are mature technologies;
- Solar and wind costs and efficiencies are improving;
- Open-cycle gas turbine (OCGT) may be able to operate at higher capacities due to increasing penetration of intermittent renewables; and
- While reciprocating internal combustion engines (RICE) may operate at a 50% capacity factor due to increased intermittent renewables, AER modelled up to 80% for "comparison purposes".[64]

Figure 9: Generation capacity factors for selected technologies, NEM operational range and AER assumptions[65]



RICE = Reciprocating internal combustion engine; OCGT = Open-cycle gas turbine; CCGT = Combined-cycle gas turbine

As at 31 July 2019, 7,883 MW of solar rooftop capacity is installed across the NEM, with 2,211 MW in NSW.[66] AEMO has modelled three scenarios which forecast the uptake of rooftop PV, PV non-scheduled generation (PVNSG) and aggregated embedded energy storage systems (Figure 10). Aggregated embedded energy storage systems, also called Virtual Power Plants (VPPs), refer to an aggregation of consumer DER that is coordinated using software and communications technology to deliver services traditionally supplied by power stations. Several VPP projects have recently been announced for the NEM, with targets that together add to 700 MW by 2022. Under the Central scenario

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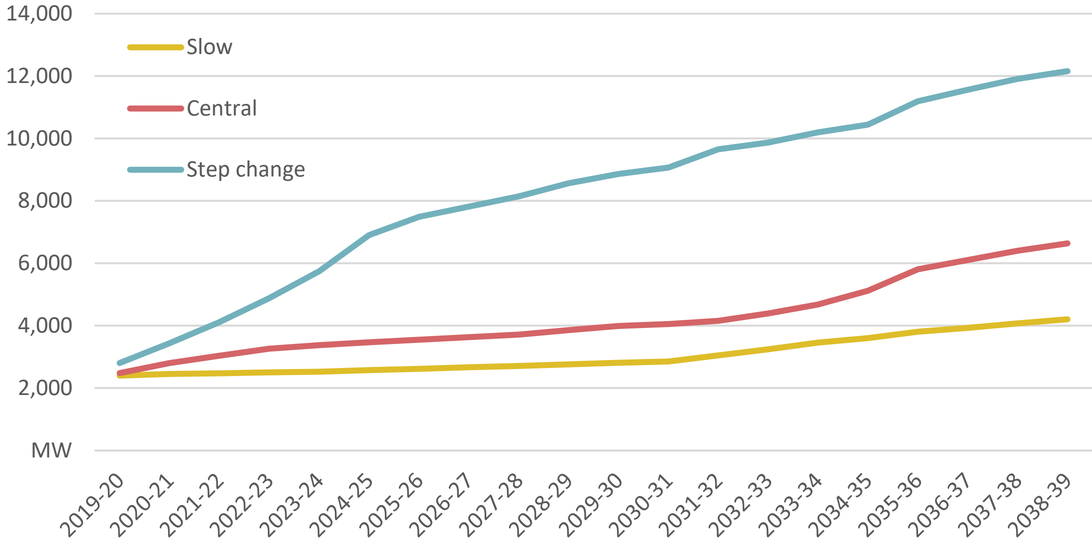
[64] AER, *Wholesale Electricity Market Performance Report – LCOE modelling approach, limitations and results*, December 2018. As part of the modelling undertaken for its 2019 Electricity Statement of Opportunities, AEMO calculated capacity factors in the NEM for wind and solar only: high wind scenario (ranged from 29% to 55%); medium wind scenario (27% to 53%); solar PV (23% to 34%); and solar thermal (23% to 50%).

[65] AER, *Wholesale Electricity Market Performance Report – LCOE modelling approach, limitations and results*, December 2018

[66] Clean Energy Regulator, *Postcode data for small-scale installations – SGU-Solar, as of 31 July 2019*, 20 August 2019

modelled by AEMO, which reflects current policy and technology trajectories, NSW's rooftop PV, PVNSG and VPP combined capacity will double in the next 16 years, reaching 5,120 MW in 2034-35. This would occur in 2042-43 under the Slow Change scenario (a general slow-down of the energy transition) and in 2022-23 under the Step Change scenario (strong action on climate change).

Figure 10: NSW forecast rooftop PV, PVNSG and VPPs[67]



PV = photovoltaic; PVNSG = photovoltaic non-scheduled generation; VPP = virtual power plant

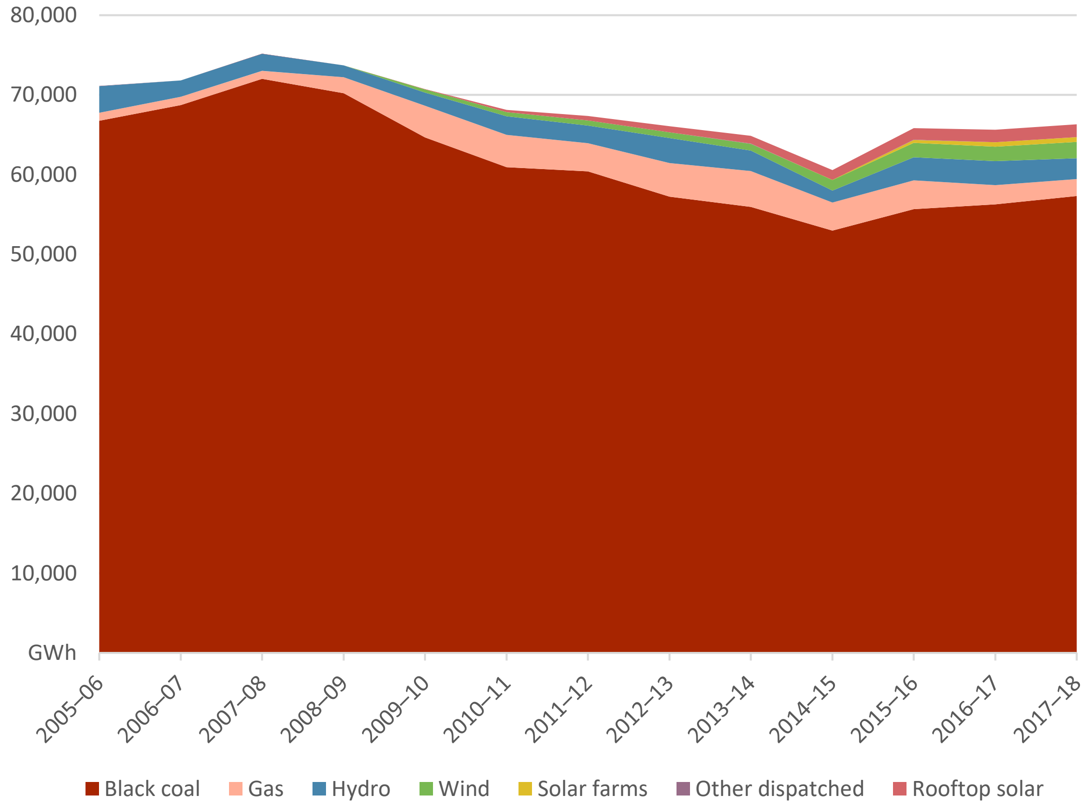
Supply trends

In 2017-18, coal-fired power stations generated 57,317 GWh (86.4%) of electricity in NSW (Figure 11). Gas-fired power stations accounted for an additional 2,121 GWh, taking the total attributable to fossil fuels to 59,439 GWh (89.6%). Hydroelectric power stations accounted for 3.9% of total electricity generated, the most of any renewable generation, followed by wind (3.1%), rooftop solar (2.4%) and solar farms (0.9%). Dispatchable generation (coal, gas and hydro) accounted for 93.6% of total electricity generated.

Fossil fuel power stations also contributed significantly to total electricity generated in Queensland (93.4%) and Victoria (83.1%) (Figure 12). SA had the largest shares of gas (52.4%) and wind power (40.1%) in their total electricity mix, and hydroelectric power dominated the Tasmanian electricity mix (81.6%).

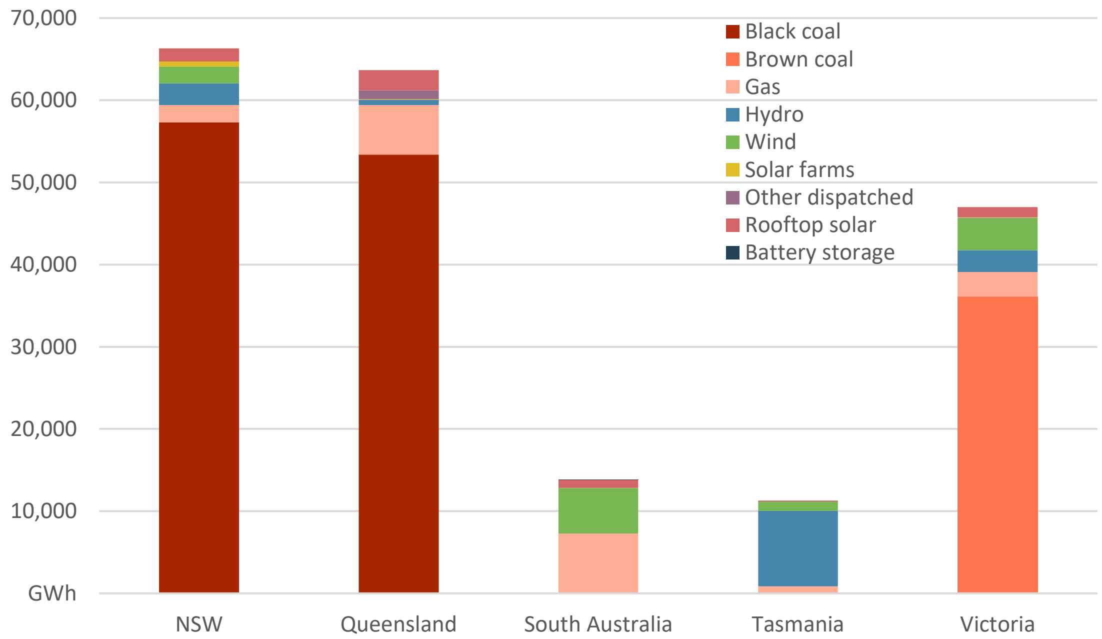
[67] AEMO, *2019 Electricity Statement of Opportunities*, August 2019

Figure 11: Electricity generation in NSW, by fuel type[68]



Other dispatched includes biomass, waste gas and liquid fuels.

Figure 12: Electricity generation in NEM States, by fuel type[69]



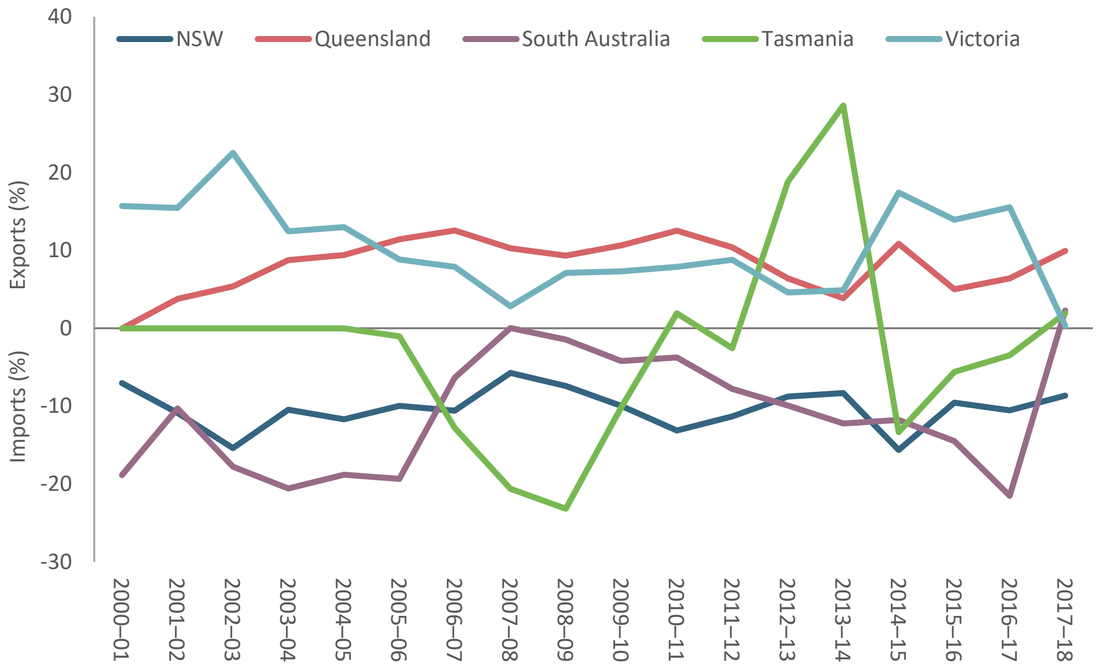
Other dispatched includes biomass, waste gas and liquid fuels.

[68] AER, *State of the Energy Market 2018*, December 2018, p 80

[69] AER, *State of the Energy Market 2018*, December 2018, p 79

Interregional trade via interconnectors enables each jurisdiction to access the lowest cost electricity. NSW has traditionally been a net importer of electricity, due primarily to high fuel costs (Figure 13). The same is true for SA. In contrast, Queensland and Victoria have generally had low fuel costs making them net exporters of electricity. NSW's trade position improved slightly in 2017-18 due to improved availability of black coal, and reduced brown coal generation in Victoria with the closure of the Hazelwood power station.[70]

Figure 13: Interregional trade as a percentage of demand[71]



Note: Net interregional trade (exports less imports) divided by regional (native) demand

Demand forecasts

According to AEMO, population growth and mining activity are expected to be the primary drivers of total electricity demand. The impact of increased adoption of electric vehicles is not projected to materially increase consumption until 2028-29. Total consumption is expected to be offset by increased energy efficiency and structural change in the economy away from energy-intensive industries. Consumption from the grid is forecast to remain flat, due primarily to the uptake of DER and increased demand-side participation (DSP), where consumers are paid for reducing their demand on the power system.[72]

Under the Central scenario modelled by AEMO (Figure 14), NSW consumption from the grid is forecast to:

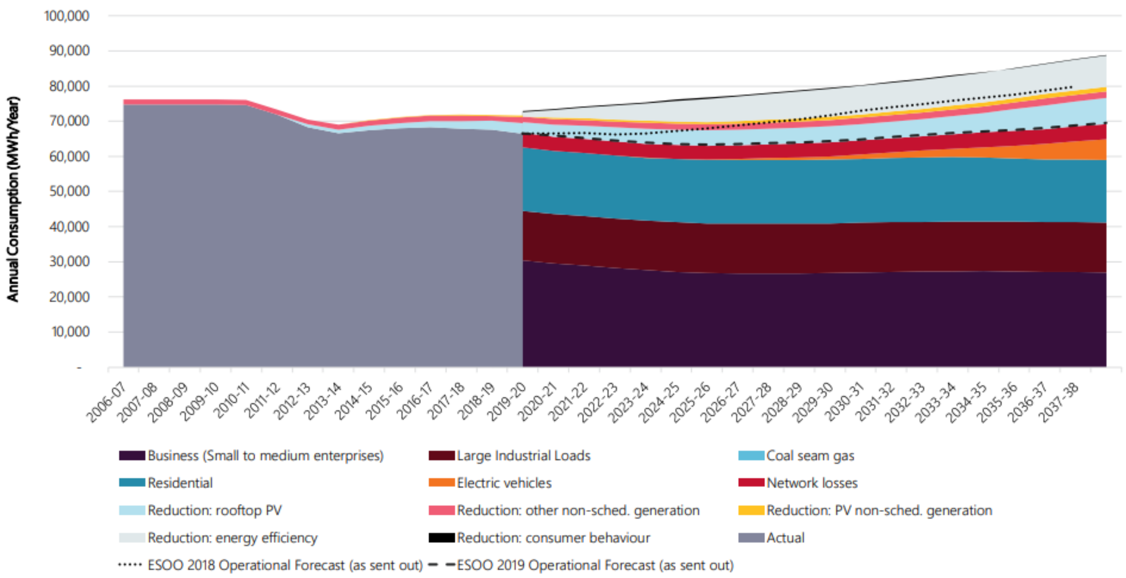
- Decrease in the short term (0-5 years) from 68 terawatt hours (TWh) to 63

[70] AER, *State of the Energy Market 2018*, December 2018
[71] AER, *State of the Energy Market 2018*, December 2018, p 91
[72] AEMO, *2019 Electricity Statement of Opportunities*, August 2019

TWh at a -1.0% average annual growth rate, due in part to energy efficiency improvements;

- Increase slightly in the medium term (5-10 years) from 63 TWh to 64 TWh at a 0.2% average annual growth rate; and
- Increase in the long term (10-20 years) from 64 TWh to 69 TWh at a 0.8% average annual growth rate.[73]

Figure 14: NSW operational consumption in MWh, actual and forecast, 2006-07 to 2038-39[74]



ESOO = Electricity Statement of Opportunities

With the advent of DER, maximum and minimum demand across the grid is changing at the daily and annual scale. In the short to medium term, maximum daily demand in NSW is expected to remain relatively flat, falling by -0.3% per annum for the first five years, then rising by 0.2% per annum for the next five. In the long term, maximum demand is expected to grow slowly at 0.7% per annum. Over the next twenty years, the maximum demand period is expected to move forwards slightly, from 15:00-18:30 to 15:30-19:30. Minimum daily demand is forecast to change more rapidly, falling by between -1.0% and -2.5% per annum in the first five years depending on the season before the decline slows over the medium to long term to between -0.7% and 0.0%.

NSW reliability outlook

The NEM reliability standard aims to ensure that there is adequate generation, demand response and interconnector capacity to meet consumer needs. It excludes network outages not associated with inter-regional flows and unforeseeable events. The reliability standard requires that no more than 0.002% of a region's forecast annual demand should be at risk of not being met. It has

[73] AEMO, 2019 Electricity Statement of Opportunities, August 2019

[74] AEMO, 2019 Electricity Statement of Opportunities, August 2019, p 96

been designed to deliver desired reliability outcomes through market mechanisms where possible.[75]

Several issues need to be taken into account when interpreting the reliability outlook. Each year, AEMO models a large number of scenarios to calculate the expected annual unserved energy (USE) for all NEM regions over a ten year period in its Electricity Statement of Opportunities (ESOO; Figure 15). The USE represents the weighted average outcome that demand will not be met. If the threshold is forecast to be exceeded, AEMO calculates the reliability gap size in terms of the amount of dispatchable generation or equivalent required to meet the standard. The modelling includes demand and supply forecasts, accounts for forecast reliability of generators and interconnectors, and excludes generation, storage and transmission projects that are not committed (i.e. projects that have been publicly announced to those in advanced stages of planning). In the case of NSW (Figure 16), this means that the impact of the following projects is not taken into account:

- The completion of Snowy 2.0 because the modelling has not included the additional transmission needed to access the project's output; and
- The completion of two interconnector projects linking NSW with Queensland and Victoria (Integrated System Plan (ISP) Stage 1[76]), which are expected to be complete in 2022 to help offset some of the impact of the retirement of Liddell.

In Victoria's case, where the reliability standard is expected to be breached in 2019-20, AEMO assumed:

- Extended unplanned outages of two major power stations, Loy Yang A2 (500 MW) and Mortlake 2 (259 MW); and
- The mothballing of two units of Torrens Island A Power Station in SA.

AEMO notes that Victoria's USE will equal the reliability standard if either the Torrens Island A remains in operation over the 2019-20 summer or, as expected, the Barker Inlet Power Station in SA commences operation in December 2018. Since publication of AEMO's ESOO, AGL has announced that the two units of Torrens Island A will now be closed in September 2020.[77]

[75] Reliability Panel AEMC, *Definition of Unserved Energy*, Final Report, 1 August 2019

[76] These projects are proposed in the AEMO Integrated System Plan for the National Electricity Market (ISP)

[77] AEMO, *2019 Electricity Statement of Opportunities*, August 2019

Figure 15: Expected unserved energy, 2019-20 to 2028-29[78]

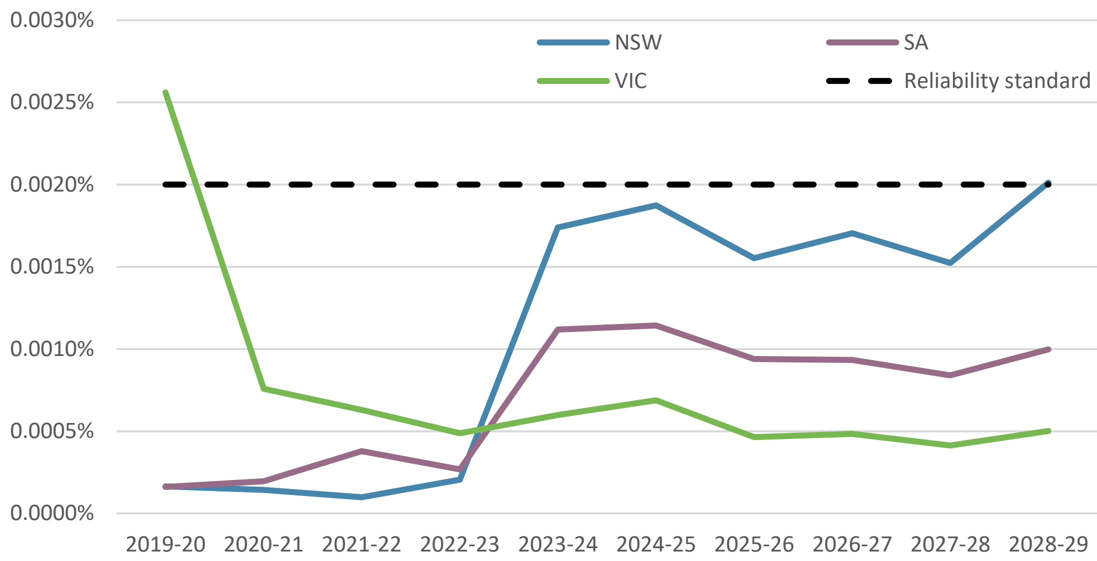
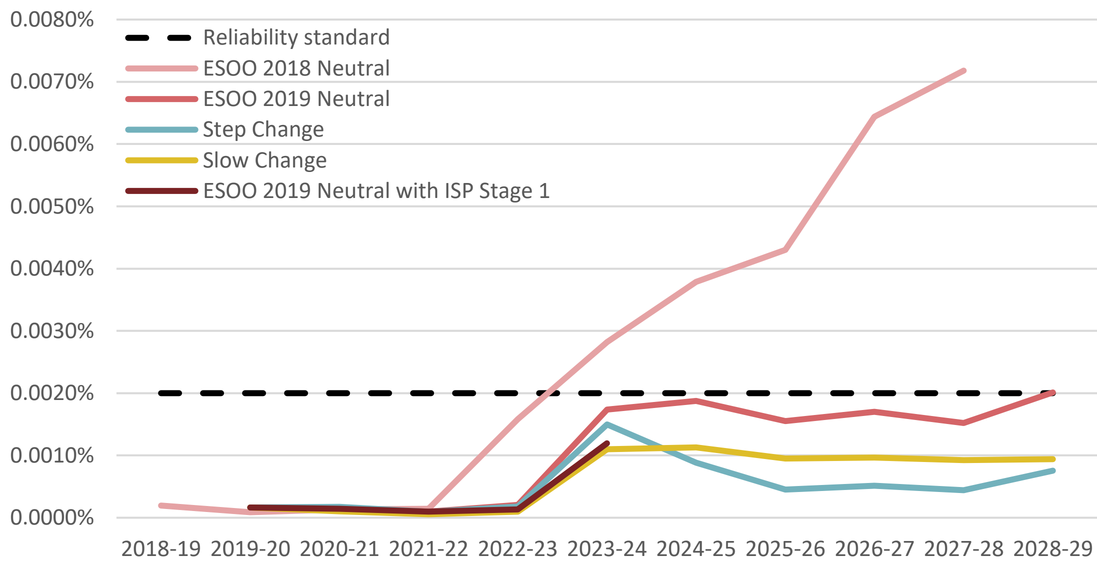


Figure 16: Forecast USE outcomes, NSW[79]



The second issue is that several trends are combining to significantly increase the risk of *actual* USE exceeding 0.002%:

- Tightening supply-demand balance due to the retirement of thermal generation;
- Increasing maximum temperatures lead to higher demand and the decreased operational capacity of generation and transmission;
- Forecast peak demand growth; and

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78 AEMO, *2019 Electricity Statement of Opportunities*, August 2019, p 10

79 AEMO, *2018 Electricity Statement of Opportunities*, August 2018; AEMO, *2019 Electricity Statement of Opportunities*, August 2019

- Increasing variability in the system due to the growing amount of renewable generation, thereby raising reliance on ageing thermal generators.

In response to these trends, AEMO reports a greater risk of load shedding (loss of customer supply) in the NEM due to uncontrollable and increasingly likely high impact events such as coincident unplanned outages. USE can be conceptualised as a tail risk with a low probability of occurrence and potentially high consequences. The use of a single 0.002% reliability standard to assess reliability is not well suited to dealing with an increasing tail risk. AEMO has therefore proposed a new reliability framework that would enable AEMO to forecast and procure sufficient dispatchable generation to avoid customer exposure to significant involuntary load shedding in approximately nine out of 10 years.

In NSW, the gap to meet the existing reliability standard is not expected to exceed zero until 2028-29 when it may reach 5 MW (Table 5). Under the proposed standard, the reliability gap remains at zero until 2023-24 where it rises to 375 MW. This calculation is based on what may be expected to happen in 2023-24 following the complete shutdown of the Liddell power station (Figure 17). For 2023-24, AEMO found that:

- While expected USE in NSW is 0.00174% (below the reliability standard), there is a significant risk (21%) that actual USE may exceed the standard; and
- Depending on the coincidence of unplanned outages and extreme weather events, load shedding could be experienced during an extreme one-in-10 year heat event, equivalent to between 135,000 and 770,000 households[80] in New South Wales being without power for three hours, potentially over multiple events.

Table 5: Reliability gap in NSW based on the current and proposed reliability standards (MW)

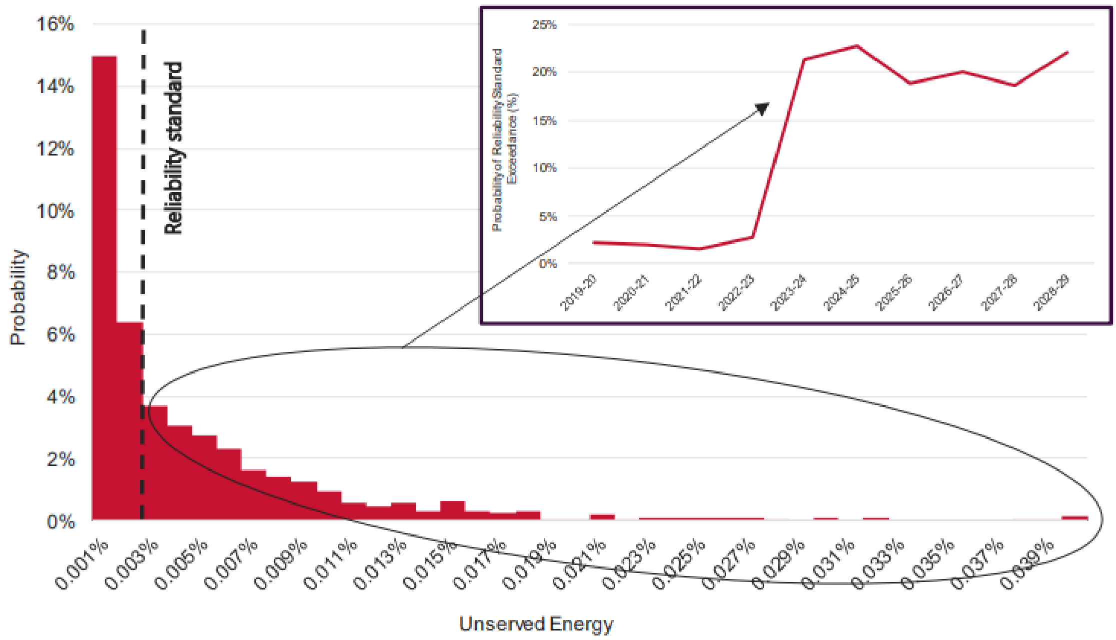
Year	Current standard	Proposed standard
2019-20	0	0
2020-21	0	0
2021-22	0	0
2022-23	0	0
2023-24	0	375
2024-25	0	375
2025-26	0	300
2026-27	0	345
2027-28	0	300
2028-29	5	480

AEMO observes that, if action is taken in NSW to meet the proposed reliability standard, the risk of load shedding events will significantly decrease.[81]

[80] This is one way of expressing the complex impact of a load shedding event. In practice, a number of levers are available to AEMO enabling it to respond to a potential load shedding event, including paying large industrial users to reduce their demand or rotational load shedding to reduce the number of households affected and the duration of time they are without power. Load shedding for the purpose of ensure reliability is relatively rare, occurring on average about once every ten years.

[81] AEMO, *2019 Electricity Statement of Opportunities*, August 2019

Figure 17: Distribution of annual unserved energy in NSW, 2023-24[82]



Security

Ongoing changes in the generation mix have implications for NEM system security. In particular, a declining ratio of synchronous to non-synchronous generators may decrease inertia in the system, reduce system strength, and make it difficult to manage voltage and stability limits. Incoming VRE generation has generally not provided these system services to date for two reasons: technical standards have not required them to do so;[83] and because they have not been separately valued, having been automatically produced as a byproduct of thermal and hydro power generation.[84] The increased uptake of DER poses additional challenges to system security because they create two-way flows on the network.[85]

Three indicators provide insight into the security of the NEM at present and emerging challenges:

(1) Frequency performance has declined, due primarily to reduced frequency control from generators;

(2) Low levels of system strength is an emerging issue for several areas within the NEM including south-west NSW, due to non-synchronous generators and DER replacing output from synchronous generators. As a result, AEMO has had to constrain output from non-synchronous generators more frequently, and

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82 AEMO, *2019 Electricity Statement of Opportunities*, August 2019, p 14. This figure excludes cases with no USE to allow for focus on the 'tail risk'

83 AEMO, *Integrated System Plan for the National Electricity Market*, July 2018

84 Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019

85 AER, *State of the Energy Market 2018*, December 2018

issue more directions to generators to maintain power system, security. This has increased wholesale electricity costs;[86] and

(3) AEMO has had to intervene in SA and Victoria to manage voltage in the system, due to both low demand and low input from synchronous generation. While this is not happening in NSW at present, increased voltages may become an issue following the closure of Liddell, in combination with increased VRE.[87]

7.2 Wholesale market

Trends

Trends in the wholesale market include:

- Increasing wholesale prices;
- Issues of opacity and illiquidity in electricity contract markets;
- Increasing market concentration; and
- A lack of investment in new generation, other than renewables, despite high prices.[88]

Wholesale prices

In 2018-19, record annual volume weighted average spot prices were reached in NSW ($92/MWh), Victoria ($124/MWh) and SA ($128/MWh) (Figure 18). Queensland ($83/MWh) and Tasmania ($88/MWh) both recorded their second highest price.

Changing wholesale prices are driven in part by the share each fuel type has in setting prices (Figure 19). Over the last year, black coal has been the most important price setter in NSW. Over the last quarter of 2018-19, black coal (58.7%), hydro (28.9%) and gas (11.5%) together set the price 99.0% of the time.[89] There are several drivers behind the increase in average wholesale spot prices that has occurred since 2014-15:

- Market concentration has recently increased due to acquisitions and closures of significant assets such as Hazelwood brown coal power station;[90]
- Black coal and gas fuel prices have generally increased. That said, despite

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86 AEMC, *Investigation into Intervention Mechanisms in the NEM*, Final Report, 15 August 2019

87 Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019

88 AEMO, *Integrated System Plan for the National Electricity Market*, July 2018; ACCC, *Restoring Electricity Affordability & Australia's Competitive Advantage*, 11 July 2018; AER, *State of the Energy Market 2018*, December 2018; AEMC, *Coordination of Generation and Transmission Investment*, 21 December 2018; Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019; AEMO, *2019 Electricity Statement of Opportunities*, August 2019

89 AEMO, *Quarterly Energy Dynamics Q2 2019: Market Insights and WA Market Operations*, 9 August 2019

90 ACCC, *Restoring Electricity Affordability & Australia's Competitive Advantage*, 11 July 2018

the steep fall in international coal prices over the past year identified by AEMO, NSW prices appear more closely aligned with gas costs (Figure 20[91]);

- While the owners of generators have cited uncertain government policy settings as a factor behind under-investment in new generation, the ACCC observes that they have had little incentive to invest in new capacity due to higher spot and futures prices.[92]

Figure 18: Annual volume weighted average spot prices in the NEM[93]

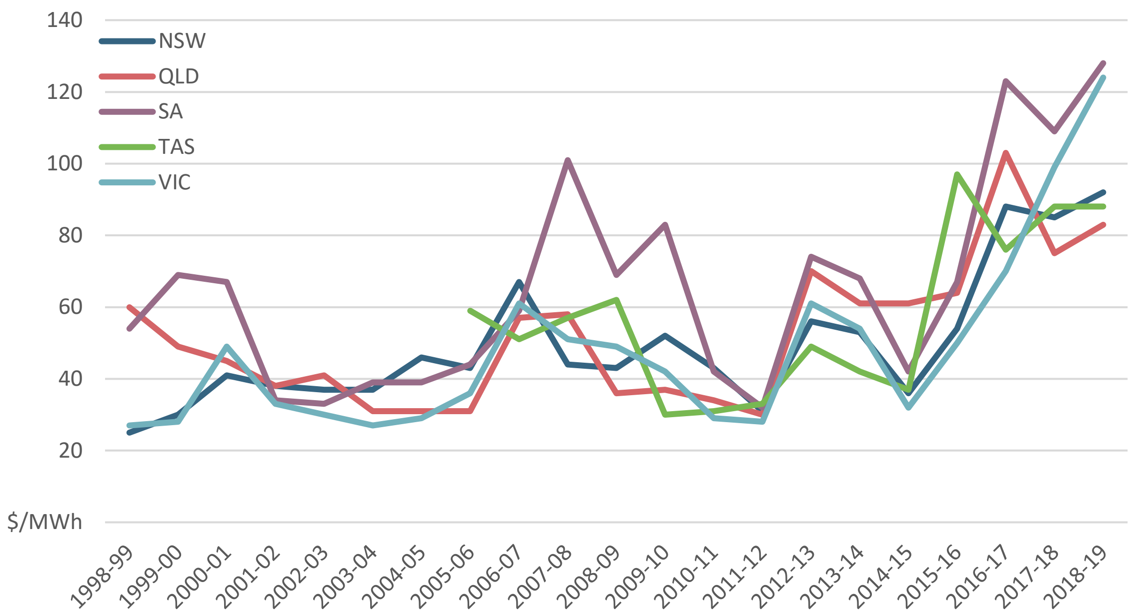
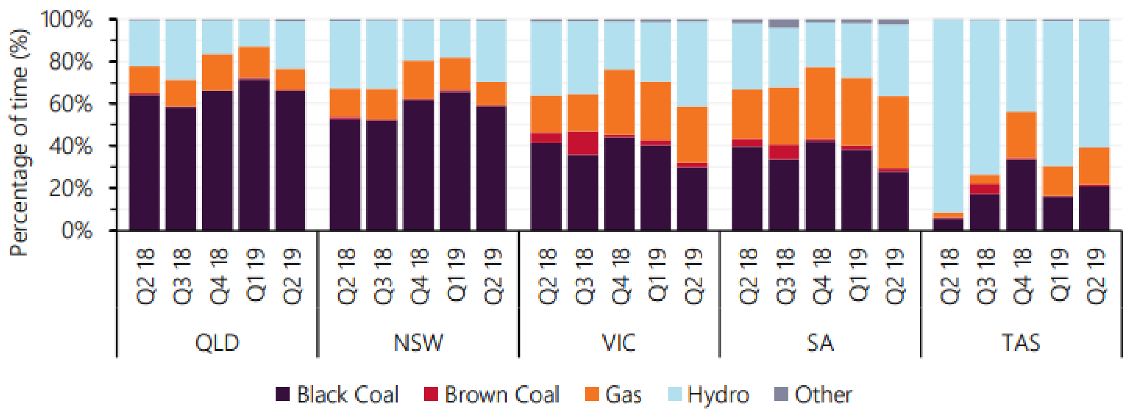


Figure 19: Wholesale price setting dynamics, by fuel type[94]



[91] AEMO, Quarterly Energy Dynamics Q2 2019: Market Insights and WA Market Operations, 9 August 2019, p 17

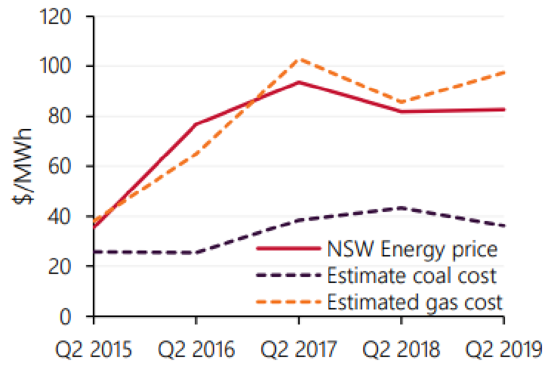
[92] ACCC, Restoring Electricity Affordability & Australia's Competitive Advantage, 11 July 2018

[93] AER, Annual volume weighted average spot prices, 2019 [website – accessed 5 September 2019]

[94] AEMO, Quarterly Energy Dynamics Q2 2019: Market Insights and WA Market Operations, 9 August 2019, p 15

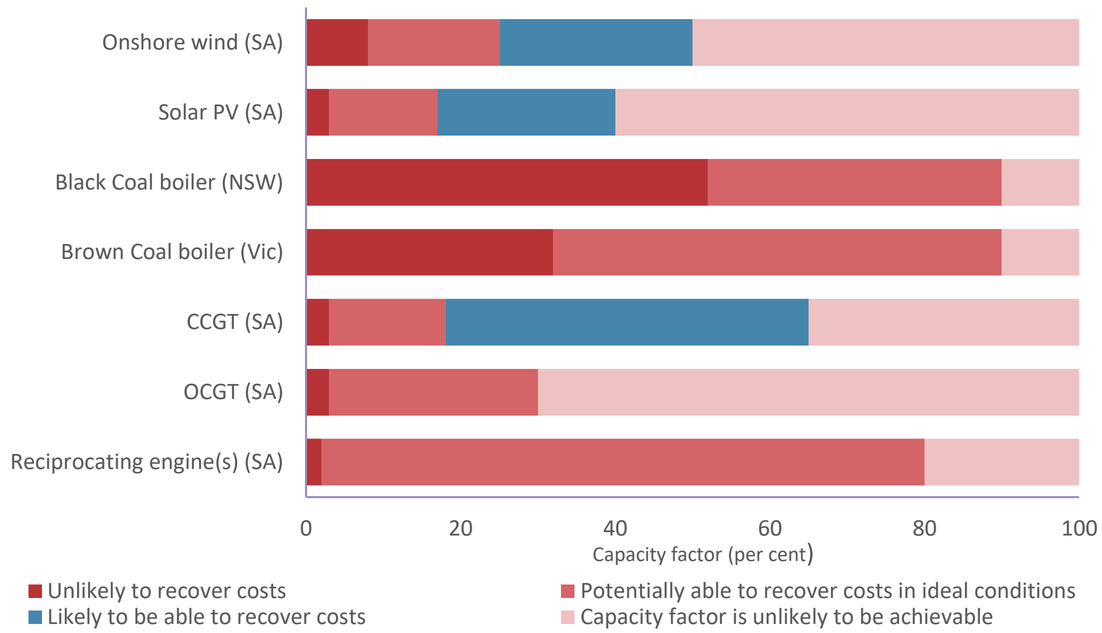
Additional contributors to recent increases in wholesale prices include higher costs of maintaining the frequency of the system,[95] the opacity of the contract market, the level of liquidity in the contract market, and advantages enjoyed by vertically integrated retailers.[96]

Figure 20: Relationship between electricity, coal and gas pricing in NSW



The ACCC and AER have both drawn attention to the potential barriers facing new generator entrants to the market. This includes those issues identified above, as well as possible price distortions due to government ownership of generation in some States and market intervention by AEMO.[97] In 2018, the AER conducted modelling comparing potential spot price revenue to the estimated costs of production for some generation technologies, taking into account the capacity factor of each technology. Figure 21 presents the likelihood of cost recovery at different capacity factors. According to AER estimates, of the technologies compared, only wind, solar PV and gas (OCGT) are likely to be able to recover costs.

Figure 21: Likelihood for new entrant cost recovery for 2017-18 by technology type[98]



[95] While relatively small, frequency control ancillary services (FCAS) costs have tripled between 2015 and 2018 to reach approximately 2% of energy costs

[96] ACCC, *Restoring Electricity Affordability & Australia's Competitive Advantage*, 11 July 2018

[97] ACCC, *Restoring Electricity Affordability & Australia's Competitive Advantage*, 11 July 2018; AER, *Wholesale Electricity Market Performance Report*, December 2018

[98] AER, *State of the Energy Market 2018*, December 2018, p 126

7.3 Transmission and distribution networks

Trends

Current trends in transmission and distribution networks include:

- The changing role of transmission networks from providing bulk energy transport from remote generation to load centres, to one that will enable competitive sharing of resources across regions and support the technological requirements needed for an increasingly diverse power system;
- Increasing need for the coordination of generation and transmission investment;
- Rising power losses across the network due to the location of new generation in remote areas;
- Recent over-investment in networks; and
- System security and reliability issues.[99]

Short-term system adequacy

As the national transmission planner, AEMO publishes a National Transmission Network Development Plan (NTNDP) which outlines a strategic plan for the development of the power system. The 2018 NTNDP identifies a number of areas that need addressing in order to ensure short-term system adequacy, including mitigating the impact of the Liddell closure in 2022. To this end, AEMO recommends:

- Timely completion of interconnector upgrades from Queensland and Victoria to NSW;
- Development of new local firm generating capacity;
- Greater use of DER; and
- Increased demand management.

7.4 Retail markets and prices

Trends

Retail market trends include:

- Rising retail prices until early 2019;
- A recent slight improvement in customer outcomes, following larger

[99] ACCC, *Restoring Electricity Affordability & Australia's Competitive Advantage*, 11 July 2018; AEMO, *National Transmission Network Development Plan (NTNDP) for the National Electricity Market*, December 2018; AER, *State of the Energy Market 2018*, December 2018; AEMC, *Coordination of Generation and Transmission Investment*, 21 December 2018; Reliability Panel AEMC, *Annual Market Performance Review 2018*, 4 April 2019

declines in previous years;

- A shift from passive to active consumers; and
- Changing demand due to increased uptake of DER.[100]

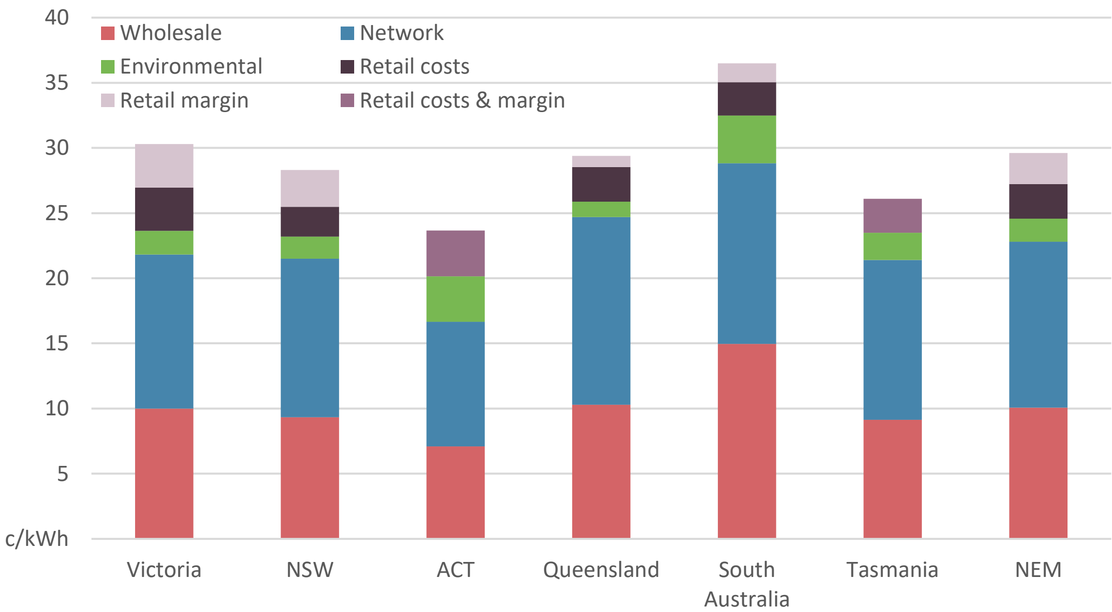
Retail prices

Residential electricity bills have five components (typical NSW proportion in brackets):

- Wholesale costs of buying electricity in spot and hedge markets (33%);
- Networks costs for transporting electricity through transmission and distribution networks (43%);
- The costs of environmental schemes that promote renewable electricity (such as renewable energy targets), energy efficiency and reduction in carbon emissions (6%);
- Retail costs of acquiring, retaining and servicing customers (8%); and
- The retailer's margin (profit) (10%).

In 2017-18, the typical cost of electricity for NSW residents was 28.3 cents per kilowatt hour (c/kWh), slightly under the NEM average of 29.6 c/kWh (Figure 22).

Figure 22: Typical composition of a residential electricity bill, 2017-18[101]

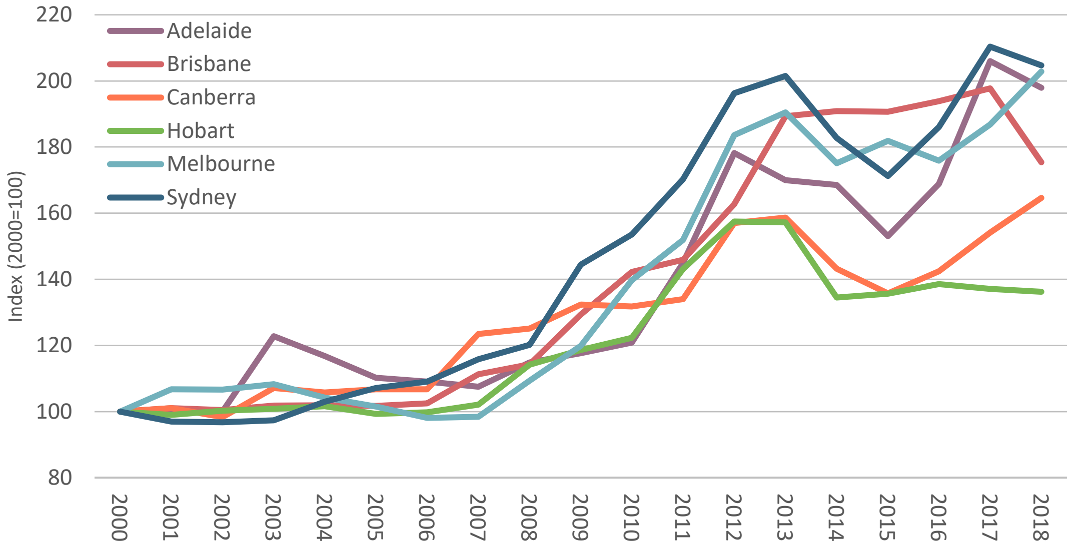


[100] ACCC, *Restoring Electricity Affordability & Australia's Competitive Advantage*, 11 July 2018; AER, *State of the Energy Market 2018*, December 2018; AEMC, *2019 Retail Energy Competition Review*, Final Report, 28 June 2019

[101] Data are estimates for 2017-18. Average residential customer prices excluding GST (real $2016–17). Retail costs and margin are combined for the ACT and Tasmania due to data availability. Source: AER, *State of the Energy Market 2018*, December 2018.

Between 2000 and 2018, NSW experienced the largest increase in electricity prices of any NEM State (Figure 23). Over the ten years to 2017-18, while prices rose by 56% in real terms across the NEM, electricity bills only rose by 35%. The difference is explained by customers achieving savings through means such as energy efficient appliances and changing their behaviour to reduce energy use.

Figure 23: Electricity retail price index (inflation adjusted)[102]



The AER and ACCC have identified a number of factors behind price rises over the decade to 2017-18, including:

- Increasing network costs (38% share of total cost increase);
- Wholesale cost increases, the largest share of which have occurred since 2016 (27%);
- Rising environmental costs due to policies such as solar feed-in tariffs (13%); and
- Increasing retail costs and margins (8% and 13% respectively), both of which are high by world standards.

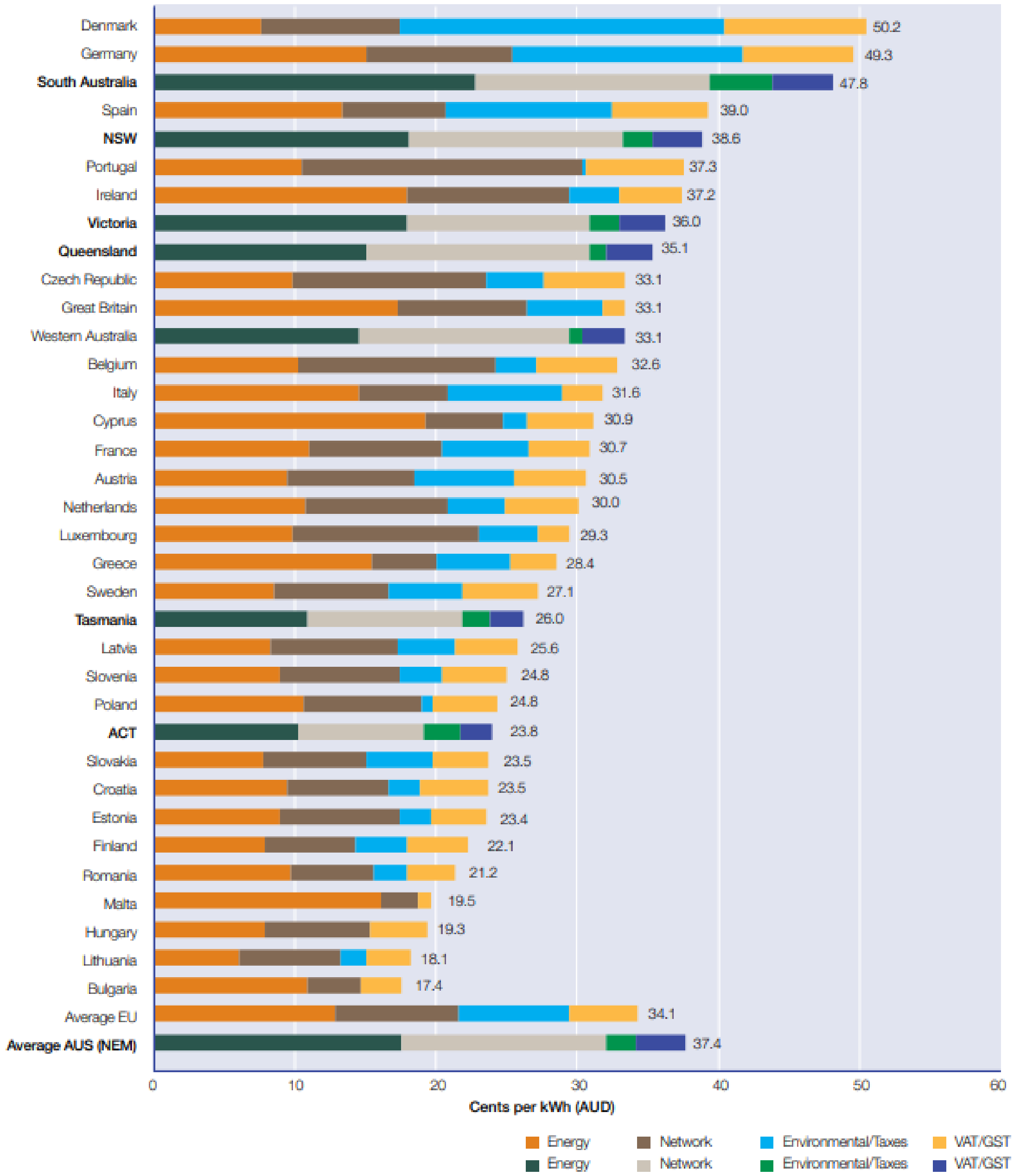
While the AER has not yet published its 2019 State of the Energy Market that will present 2018-19 figures, a June 2019 AEMC review of the retail market shows that prices fell between March 2018 and March 2019. According to the AEMC, increased competition led to decreases in prices and reduced market concentration in all States except Tasmania. AEMO expects retail prices to continue to fall over the short term, before rising again in the early 2030s as a number of coal-fired power stations are retired.

The AER has compared Australian electricity prices with prices in European countries, which historically have had some of the highest prices across the world (Figure 24). The comparison is based on purchasing power parity and adjusts for

[102] AER, *State of the Energy Market 2018*, December 2018, p 44

cost of living differences. As a result of increases over the decade to 2017-18, Australian prices are now around 10% above the European average.

Figure 24: International household electricity price comparison[103]



Note: 2018 prices, including GST.

7.5 Policy developments and reforms

Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future

At the end of 2016, Coalition of Australian Government (COAG) energy ministers

[103] AER, *State of the Energy Market 2018*, December 2018, p 45

commissioned an independent review of the NEM with a view to evaluating its security and reliability (see further chapter 13.1). The *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future* (the Finkel Review) was released in June 2017, setting out a blueprint designed to achieve four key outcomes, which together meet the energy trilemma identified in chapter 2:

(1) Increased Security: A secure electricity system is one that continues to operate across the entire region despite disruptions. A more secure power system will be resilient to the integration of new technologies and resistant to the threat of natural disasters and cyber security attacks.

(2) Future Reliability: Reliability of supply is one of the foundations of our electricity system. As ageing generators retire we must ensure that new generators enter the market to meet demand.

(3) Reward Consumers: Consumers are at the heart of our electricity system. The actions of consumers will be harnessed to improve the reliability and security of the electricity system and keep costs down. Consumers will be better informed and rewarded for managing their electricity demand. System upgrades and new generation will be achieved at lowest cost.

(4) Lower Emissions: The electricity sector will do its share to meet Australia's commitment to reduce emissions. A long-term emissions reduction trajectory will encourage investment in system capabilities.

The recommendations made in the Finkel Review initiated a series of ongoing reforms, driven by significant stakeholders such as AEMO, the AER, the AEMC, the COAG Energy Council, the ESB, the ACCC and the NSW Government. Key stages of this reform process are outlined below.[104]

Restoring electricity affordability & Australia's competitive advantage (June 2018)

In March 2017, the Commonwealth Government directed the ACCC to hold an inquiry into the retail supply of electricity and the competitiveness of retail electricity markets in the NEM. The final report, *Restoring electricity affordability & Australia's competitive advantage*, was released in June 2018. It concluded that the current situation was unacceptable and unsustainable, arguing that the NEM needs to be reset, with the report outlining a plan to do so. Fifty six recommendations were made in relation to the entire supply chain. They focused on four key areas:

(1) Boosting competition in generation and retail;

(2) Lowering costs in networks, environmental schemes and retail;

(3) Enhancing consumer experiences and outcomes; and

(4) Improving business outcomes.

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[104] See also: AEMC, *AEMC system security and reliability action plan*, 2019 [website – accessed 6 September 2019]; AER, *State of the Energy Market 2018*, December 2018

Integrated System Plan for the National Electricity Market (July 2018)

In July 2018, AEMO published its *Integrated System Plan for the National Electricity Market* (ISP) in response to the Finkel Review's recommendation for enhanced NEM planning. The ISP provides a 20-year outlook that is framed around seven key observations for the NEM's future:

(1) Changing demand from the grid: Economic growth and population growth no longer result in increased demand from the grid. For the power system to provide consumer value, the ISP needs to focus on delivering reliable power at the lowest cost;

(2) A portfolio approach: The most cost-effective replacement for the coal-fired generation that will retire over the coming years, based on current cost projections, is a portfolio of utility-scale renewable generation, energy storage, DER, flexible thermal capacity including gas-powered generation, and transmission;

(3) The crucial role of transmission: Increased investment in transmission networks will provide the flexibility, security and economic efficiency required by a power system designed to integrate existing resources, VRE, and efficient competitive alternatives for consumers;

(4) Adoption of Renewable Energy Zones (REZs): REZs provide an effective, least-cost way to integrate new generation, storage, and transmission development;

(5) Distributed Energy Resources (DER) and inter-regional development: Increased uptake of DER and improved inter-regional and intra-regional connections are expected to lower energy costs;

(6) Power system requirements: Incoming generation technologies such as wind and solar require the adoption of new technologies and approaches to provide power system services; and

(7) Timing of development plan: AEMO has modelled different transmission reinforcement options to determine optimum immediate investments and staging of future development.

Proposed NEM developments are grouped in three consecutive stages, the first of which AEMO recommends should be undertaken as soon as is practicable. This stage will involve investment in transmission to increase transfer capacity between Queensland, NSW and Victoria, and improve system reliability and security. Stage 1 has already commenced, with the NSW Government releasing its *NSW Transmission Infrastructure Strategy* in November 2018.[105]

Electricity Statement of Opportunities (August 2019)

AEMO publishes an annual Electricity Statement of Opportunities (ESOO), which forecasts electricity supply reliability in the NEM over a 10-year period to inform

[105] For additional updates, see also: AEMO, *National Transmission Network Development Plan (NTNDP) for the National Electricity Market*, December 2018

decisions by market participants, investors, and policy-makers. The 2019 ESOO found that there are possible short term shortfalls in reliability, due to a tight supply-demand balance in Victoria over the 2019-20 summer and the retirement of Liddell in NSW in 2023. It sets out nine prudent and least-cost "required actions" that should be taken to avoid consumer exposure to unreasonable level of risk of loss of supply during peak summer periods. These include:

- Developing a summer readiness plan;
- Commissioning targeted transmission augmentation – the Queensland-NSW and NSW-Victoria interconnectors;
- Introduction of new dispatchable resources, to offset the reliability gap that will ensue following the closure of Liddell; and
- Accelerating customer participation in the market via demand response mechanisms to support future reliability.[106]

AEMO develops supply forecast models as part of the process of producing the ISP and ESOO. Current energy policy settings are one of the key inputs of the models. For the 2019 ESOO, nuclear generation was excluded from the model as the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* prohibits the development of nuclear installations (see further chapter 17).[107]

Other recent developments

At the end of 2018, the Commonwealth Government launched its four-year Underwriting New Generation Investments program. The program aims to provide financial support to firm generation capacity in order to lower electricity prices and increase system reliability. Ten projects with a combined capacity of 3,818 MW have been shortlisted to receive support.

On 28 December 2018, a panel chaired by the NSW Chief Scientist & Engineer released a report which had been commissioned by the NSW Government: *Assessment of Summer Preparedness for the NSW Energy Market*. The report made a number of findings and recommendations, including that NSW was well prepared for the 2018-19 summer due to exercises conducted by the Department of Planning & Environment (DPE), other NSW Government agencies and industry stakeholders over the previous 12 months.

On 1 July 2019, the Retailer Reliability Obligation (RRO) came into effect. If AEMO identifies a material gap in supply three years and three months out, the RRO will be triggered by the AER. When triggered, retailers and some large energy users are put on notice to enter into contracts to ensure they can meet their share of demand.

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106 AEMO, *2019 Electricity Statement of Opportunities*, August 2019, p 5

107 AEMO, *2019 Forecasting and Planning Scenarios, Inputs, and Assumptions*, August 2019, p 35

On 9 August 2019, the Commonwealth and NSW Governments announced that they had established a Commonwealth-led taskforce to consider options to deal with the closure of Liddell. The taskforce is aiming to address the affordability and reliability concerns that the closure of Liddell may create, with a report due by the end of 2019.

On 2 September 2019, the ESB released an issues paper on the design of the NEM post 2025. The paper seeks feedback on:

- the possible future scenarios that will be used when assessing options for change;
- the assessment framework for evaluating market design options;
- the opportunities, challenges and risks that need to be considered as the project looks to identify market design options; and
- the implications for market design resulting from these opportunities, challenges and risk.

Submissions to the ESB issues paper close on 30 September 2019.

8. Environmental sustainability

The third component of the energy trilemma encompasses improving supply and demand-side energy efficiencies and the adoption of energy supply from renewable and other low-carbon sources. While energy efficiency was considered, where relevant in chapter 7, this chapter focuses on climate change and the decarbonisation of the electricity sector.

8.1 Climate change

Climate change is a controversial issue in modern society that generates divisive debate across the political spectrum. While there is relatively high agreement amongst climate scientists regarding climate change, there is a broader range of views amongst the general public. According to NASA, over 97% of recently published climate scientists agree that the Earth is warming and that humans are contributing to the change in climate. The 2019 Climate of the Nation survey found that 77% of Australians thought that climate change is occurring, 11% were unsure and 12% thought that climate change is not occurring (Figure 25).[108] A 2019 Lowy Institute Poll found that Australians now rate climate change as the greatest threat to the nation's "vital interests", with 64% of Australian adults viewing climate change as a "critical threat" (Figure 26). A further 26% considered it to be "an important but not critical threat" and 9% considered it to be "not an important threat at all".[109]

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[108] The poll had been run by The Climate Institute between 2007 and 2017. In 2019, The Australia Institute commissioned YouGov Galaxy to conduct the poll. YouGov Galaxy surveyed 1,960 Australians aged 18 years and older, and weighted the results by age, gender and region to reflect the latest Australian Bureau of Statistics' (ABS) population estimates.

[109] Kassam N, *Lowy Institute Poll 2019*, June 2019, p 13

Figure 25: Acceptance of climate change[110]

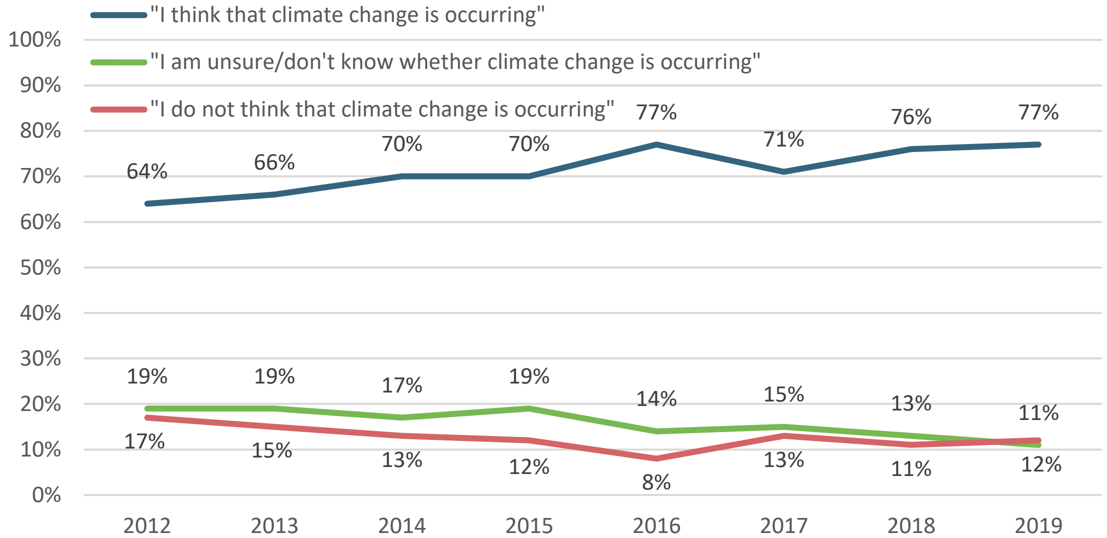
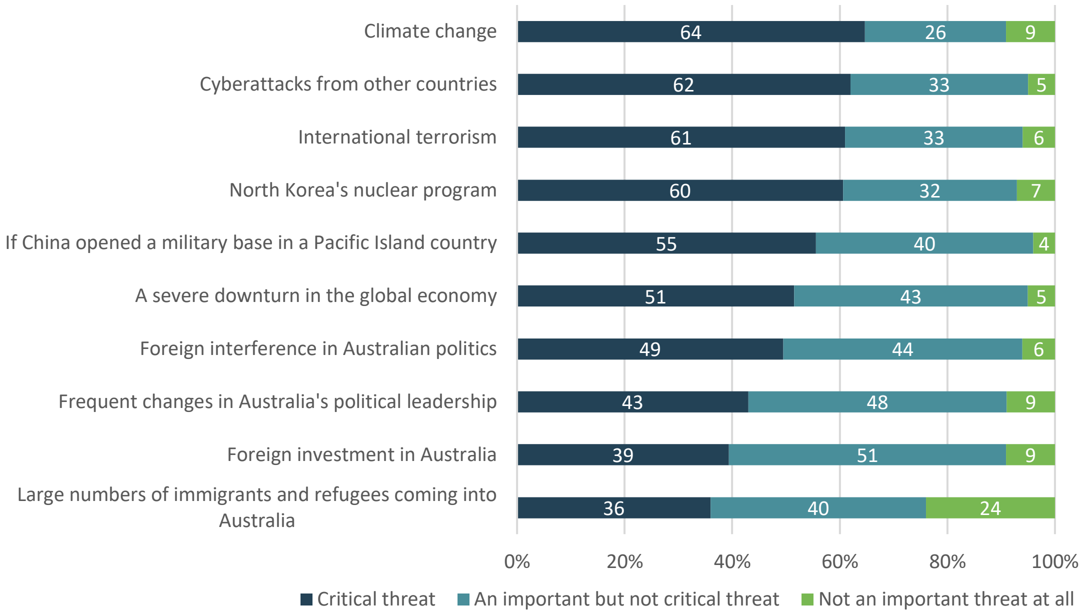


Figure 26: Threats to vital interests[111]



According to scientists, human-induced climate change is caused by rising greenhouse gas (GHG) emissions such as carbon dioxide (CO_2), which 'trap' heat in the lower atmosphere. Scientific evidence indicates that the world has already entered a period of "committed climate change"; a degree of climate change that has been locked in by past emissions and will occur regardless of future emissions.[112] According to the CSRIO and Bureau of Meteorology,

[110] The Australia Institute, *Climate of the Nation 2018: Tracking Australia's attitudes towards climate change and energy*, September 2018, p 6

[111] Kassam N, *Lowy Institute Poll 2019*, June 2019, p 13

[112] United Nations, *Global Environment Outlook — GEO 6: Healthy Planet, Healthy People*, 2019, p 43, 44

Australia is one of the most vulnerable developed countries to the possible impacts of climate change, which include physical and ecological impacts (such as heatwaves and floods), social and economic impacts (damage to infrastructure) and human health impacts (infectious diseases and poorer nutrition). Government bodies, such as the Reserve Bank of Australia, and the Commonwealth Parliament have called for the integration of climate change risks into regulatory and policy frameworks.[113]

8.2 The carbon budget

One way to conceive of efforts to address climate change is via the concept of the carbon budget, which estimates the level of GHG emission reductions required to meet a desired temperature target, such as the Paris Agreement targets of 1.5°C or 2°C.[114] Given the complexity of the climate system and the relatively long time-frames involved, carbon budget calculations contain an inherent degree of uncertainty.[115] Nevertheless, the concept of a carbon budget effectively conveys the idea that, once the carbon budget has been emitted, or spent, emissions need to be net zero in order to avoid meeting or exceeding the target temperature.[116] Net zero emissions occur where carbon emissions into the atmosphere are matched by carbon removal from the atmosphere (via “carbon sinks”, such as reforestation).[117]

Carbon budgets are affected by the “peaking year” — the year in which carbon emissions peak before declining. Earlier peaking years allow for more gradual declines in emissions. Later peaking years mean reductions will be harsher and, therefore, more economically, socially and technologically disruptive.[118] Consequently, the ability of any low emissions energy source to address climate change is dependent on the timeframe in which it can be incorporated into the NEM.[119]

8.3 Carbon emissions from Australian electricity generation

Electricity generation accounts for the largest proportion of Australia’s carbon emissions. In 2018, electricity generation accounted for 33.2% of total emissions, followed by stationary energy excluding electricity (19.1%); transport (18.9%);

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[113] NSW Parliamentary Research Service, *Key Issues for the 57th Parliament*, April 2019

[114] *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [441].

[115] The uncertainty associated with carbon budgets was discussed in *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [442]. See also: Hausfather Z, Analysis: How much “carbon budget” is left to limit global warming to 1.5C?, *CarbonBrief*, 9 April 2018; and Candela J and Carlson D, *The Annual Global Carbon Budget*, World Meteorological Organization, 2017

[116] *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [441].

[117] *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [441].

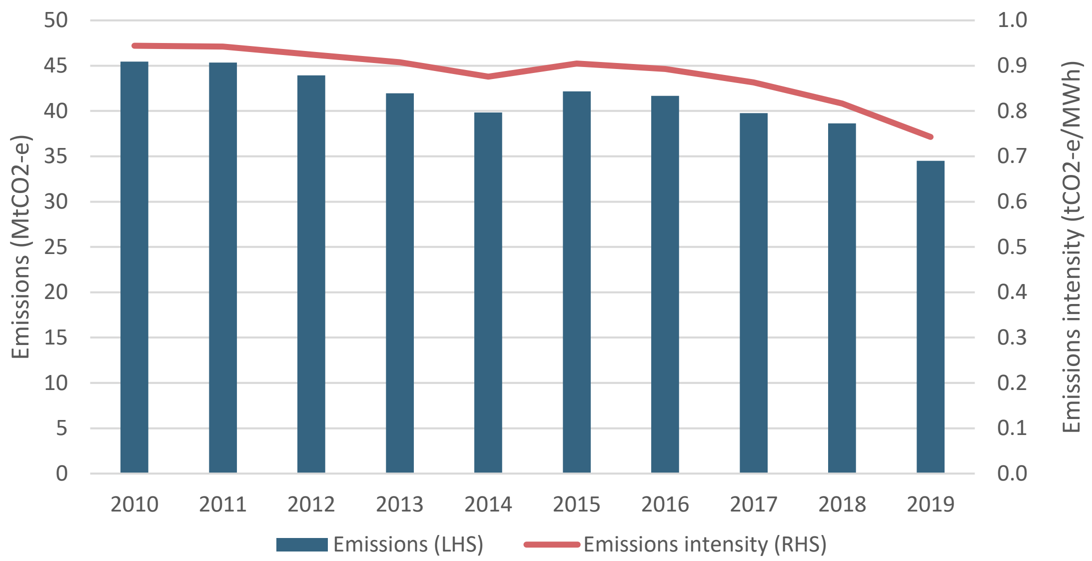
[118] *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [444]. See also: Debelle G, *Climate Change and the Economy*, Reserve Bank of Australia, 12 March 2019.

[119] For a discussion education and skills development requirements, see Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 161-163

and agriculture (12.9%).[120] Between 1995 and 2017, emissions from electricity generation in Australia fell by 4.5% to reach 189.8 Mt CO_{2-e}[121]. Over the same period, emissions from NSW electricity generation fell by 12.0%, from 58.1 Mt CO_{2-e} to 51.1 Mt CO_{2-e}.[122]

The latest available data on NEM emissions is for the 2011 to 2019 period (Figure 27). NEM emissions for the quarter fell to their lowest on record,[123] both in terms of total emissions and emissions intensity per MWh produced. Factors which have contributed to the decrease include decrease brown coal power generation, increased VRE and low NEM demand.[124]

Figure 27: Quarterly NEM emissions and emissions intensity, Q2 per year[125]



8.3 Policy

National Electricity Objective

The NEO is technology neutral and makes no reference to climate change or GHG emission reductions.[126] In its 2017 report, *Retirement of coal fired power stations*, the Senate's Environment and Communications References Committee

[120] Commonwealth Department of the Environment and Energy, *Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2018*, 2019, p 7.

[121] Greenhouse gases (GHGs) are measured in "carbon dioxide equivalent" terms. Other GHGs include methane, nitrous oxide, and hydrofluorocarbons (HFCs).

[122] Commonwealth Department of the Environment and Energy, *State and Territory Greenhouse Gas Inventories 2017*, June 2019

[123] Since 2001

[124] AEMO, *Quarterly Energy Dynamics Q2 2019: Market Insights and WA Market Operations*, 9 August 2019

[125] AEMO, *Quarterly Energy Dynamics Q2 2019: Market Insights and WA Market Operations*, 9 August 2019, p 13

[126] Commonwealth Parliament, Senate, Environment and Communications References Committee, *Retirement of coal fired power stations*, 2017, p 24, 27, 70 and 71

recommended that the NEO be amended to include a "pollution reduction objective consistent with Australia's obligations under the Paris Agreement".[127]

Climate change policy

In late 2015, under the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement was agreed to by 185 nations, entering into force on 4 November 2016.[128] Its key goal is to hold global average temperature increases to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels.[129]

If these targets are not met, global temperatures are expected to increase by approximately 4°C above pre-industrial levels by 2100, and will most likely pass the 2°C target before 2050.[130] As a signatory to the Agreement, Australia has committed to a Nationally Determined Contribution (NDC), or emissions reduction target, of 26 to 28% below 2005 levels by 2030.[131] An NDC is to be published every five years, with each successive NDC representing "a progression beyond the Party's then current nationally determined contribution and reflect[ing] its highest possible ambition".[132]

NSW climate change policy

The NSW Government, as part of its 2016 *Climate Change Policy Framework*, has endorsed the Paris Agreement and adopted an "aspirational long-term objective" of net-zero emissions by 2050.[133] The Framework's second aspirational long-term objective is to increase NSW's resilience to a "changing climate". These two objectives are to be achieved through the implementation of

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[127] Commonwealth Parliament, Senate, Environment and Communications References Committee, *Retirement of coal fired power stations*, 2017, Recommendation 3, p 71. On this point, see Box 3 of the following publication: AEMO, *Applying the Energy Market Objectives*, 8 July 2019

[128] United Nations Treaty Collection, *Paris Agreement*, no date [website—accessed 18 April 2019]

[129] United Nations, *Paris Agreement*, 2015, p 3 of English text, which commences on p 19 of the multi-language document [website—accessed 18 April 2019]. For a discussion of the climate change effects of a 1.5°C versus a 2°C temperature increase, see: Masson-Delmotte, V et al, *Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, Intergovernmental Panel On Climate Change, 2018

[130] United Nations, *Global Environment Outlook — GEO 6: Healthy Planet, Healthy People*, 2019, p 497

[131] Commonwealth Department of the Environment and Energy, *National Inventory Report 2016, Vol 1*, 2018, p xi. See also: AER, *State of the Energy Market 2018*, December 2018; Commonwealth Department of the Environment and Energy, *Australia's 2030 Emission Reduction Target*, no date, [website—accessed 6 September 2019]

[132] Article 4(3) and 4(9) of the United Nations, *Paris Agreement*, 2015, p 4 of English text, which commences on p 19 of the multi-language document [website—accessed 1 May 2019]. See also: Hanna E et al., *Climate change*, Parliamentary Library Briefing Book: Key Issues for the 46th Parliament, July 2019

[133] NSW Government, *NSW Climate Change Policy Framework*, 2016, p 1 and 4

the following policy directions:

(1) Working with the Commonwealth to create a stable investment environment in order to manage the transition to renewable energy;

(2) Increasing energy productivity in order to reduce costs in energy prices associated with the transition to a net zero emissions economy;

(3) Taking advantage of benefits associated with the transition to renewable energy, such as improvements in health from reduced air pollution, and managing unintended impacts of external policies by advocating for complementary policy reform at the national level;

(4) Taking advantage of opportunities to grow existing and new industries in NSW, such as professional services, renewable energy technology industries and financial services; and

(5) Reducing risks and damage to public and private assets in NSW arising from climate change by, for instance, including climate change considerations into asset and risk management assessments.[134]

QUESTIONS FROM ENERGY IN NSW

(1) Does the 'Energy Trilemma' framework of security, equity and environmental sustainability capture the key energy issues facing NSW? What other factors should be considered?

(2) What mix of current technologies will best meet the key energy opportunities and challenges in NSW? How might this change with future technological developments?

[134] NSW Government, *NSW Climate Change Policy Framework*, 2016, p 1 and 7. See also: NSW DPIE, *Climate change*, no date [website – accessed 10 September 2019]

C. URANIUM MINING AND NUCLEAR ENERGY

Part C of this paper discusses a range of topics related to uranium mining and nuclear energy. As with part B, the energy trilemma and the safety of power generation technologies are key themes throughout. Cross-references to related material in part B are included, where relevant.

Chapter 9 presents a summary of uranium mining in Australia. This is followed by overviews of the international nuclear energy industry and the nuclear research industry in Australia (chapter 10) and nuclear power generation technologies (chapter 11). Chapter 12 discusses selected topics of relevance to nuclear energy, including the infrastructure requirements needed to establish a nuclear power programme, the economics of nuclear energy, safety issues[135] and environmental benefits. Recent relevant Australian parliamentary inquiries and government reports on uranium mining and nuclear energy can be found in chapter 13. Chapter 14 deals with public opinion on nuclear energy, both in Australia and overseas.

9. Uranium mining

9.1 History

Uranium has been mined in Australia since the 1950s.[136] Mines have operated in the Northern Territory, SA and Queensland (Table 6). In 1984, the Commonwealth Labor Government adopted a "three mines" policy, which nominated three mines from which uranium could be exported.[137] In 1996, the Coalition Government abandoned this policy; and in 2007 the Australian Labor Party overturned its "no new mines" policy.[138]

9.2 Resources

Australia has the world's largest Economic Demonstrated Resources (EDR) of uranium – 1,270,000 tonnes (711,076 Petajoules (PJ)) – which represents around 30% of total EDR of uranium.[139] Australia has total Identified Resources[140] of uranium of 2,216,000 tonnes (1,241,091 PJ), which also includes 17,900 PJ of Subeconomic uranium resources and 512,400 PJ of Inferred uranium resources

[135] Note that chapter 20, in part D of this paper, provides an overview of the safety, security and environmental standards that would make up a regulatory framework to support a nuclear power programme. It also includes two case studies: the regulation of uranium mining in SA; and the regulation of nuclear energy in the United Kingdom (UK).

[136] Smith S, *Uranium and Nuclear Power*, NSW Parliamentary Research Service, BF 10/2006, 2006, p 12

[137] Smith S, *Uranium and Nuclear Power*, NSW Parliamentary Research Service, BF 10/2006, 2006, p 12-13.

[138] *The Age*, Labor scraps uranium policy, 29 April 2007

[139] Geoscience Australia, *Australian Energy Resources Assessment 2018 Report – Uranium and Thorium*, 2019 [website – accessed 2 September 2019]. See chapter 3 for information on all energy resources in NSW.

[140] For an overview of the national classification system applied to resource assessment, see: Geoscience Australia, *Australia's Identified Mineral Resources 2017*, 2017, p 8

(Figure 28). Although most Australian States and Territories have uranium deposits, all EDR are located in SA, the Northern Territory and Western Australia. SA's Olympic Dam is the world's largest uranium deposit, with EDR of 916,000 tonnes (512,957 PJ).[141] In NSW, the only known uranium deposit is Toongi, near Dubbo, with between 3,000 and 10,000 PJ of Identified uranium resources. This is equivalent to 0.2-0.8% of Australia's total Identified Resources. In 2012, the NSW Government lifted the longstanding ban on uranium exploration in NSW but no exploration licences have yet been issued.[142]

Table 6: Timeline of uranium mining in Australia[143]

Year opened	Mine	State/Territory	Status
1954	Rum Jungle	Northern Territory	Closed (1971)
1954	Radium Hill	South Australia	Closed (1961)
1958	Mary Kathleen	Queensland	Closed (1982)
1959	South Alligator	Northern Territory	Closed (1964)
1979	Nabarlek	Northern Territory	Closed (1988)
1981	Ranger	Northern Territory	In operation
1988	Olympic Dam	South Australia	In operation
2000	Beverley	South Australia	Ceased production (2014)
2011	Honeymoon	South Australia	Ceased production (2013)
2014	Four mile	South Australia	In operation

9.3 Production

Australia is the world's third largest uranium producer (6,517 tonnes in 2018) after Kazakhstan (21,705 tonnes) and Canada (7,001 tonnes).[144] There are three operating uranium mines: Olympic Dam (3,159 tonnes) and Four Mile (1,663 tonnes) in SA, and Ranger (1,695 tonnes) in the Northern Territory.[145] All of the uranium produced in Australia is exported.[146] Trends in uranium production and exports in Australia since 1976-77 are shown in Figure 29 (note: that the 6,654 tonnes produced in 2017-18 was equal to 3,815 PJ). In 2017-18, Australia's uranium exports (8,100 tonnes) were worth $650 million.[147] Uranium is exported

[141] Geoscience Australia, *Australian Energy Resources Assessment 2018 Report: Uranium and Thorium*, 2019 [website – accessed 2 September 2019].

[142] See further chapter 15

[143] World Nuclear Association, *Australia's Uranium*, October 2018 [website – accessed 2 September 2019]

[144] World Nuclear Association, *World Uranium Mining Production*, August 2019 [website – accessed 3 September 2019]

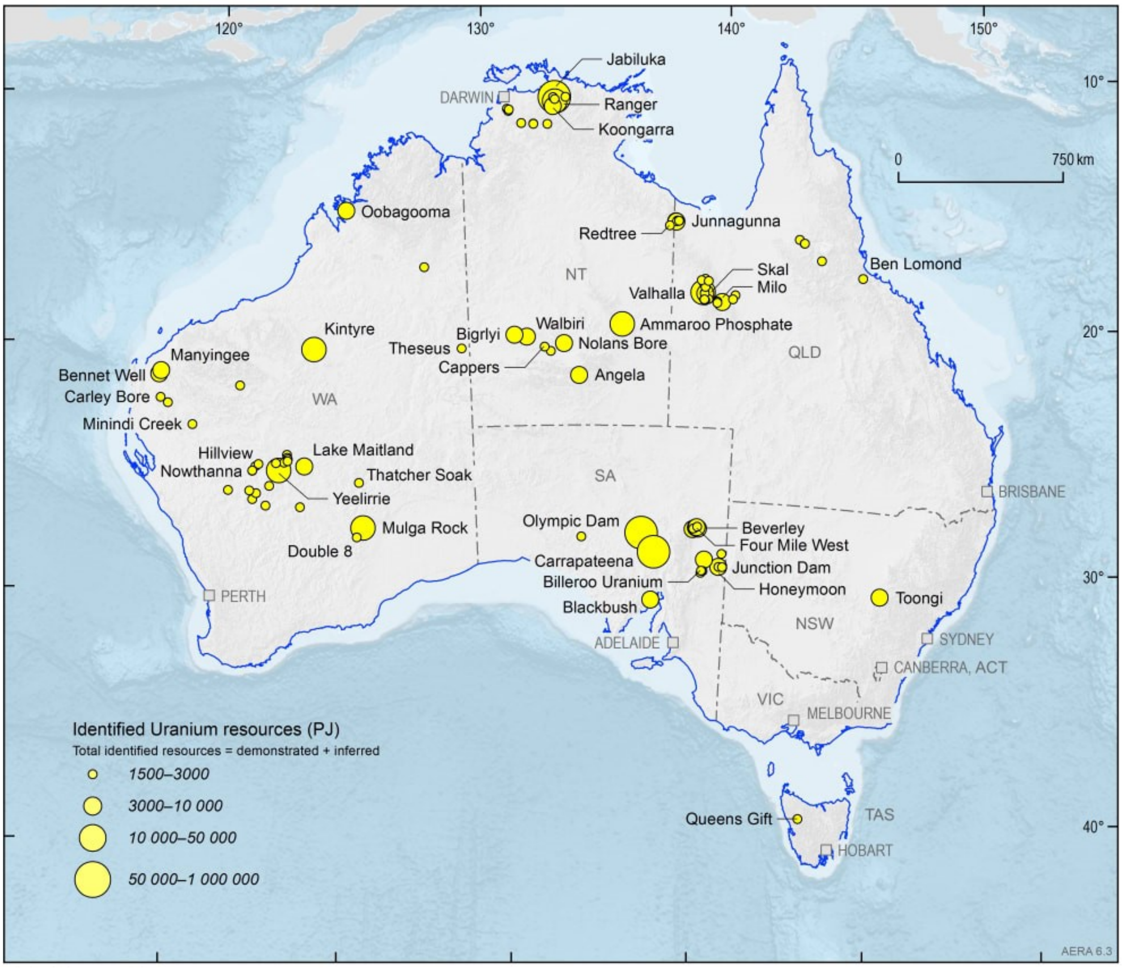
[145] World Nuclear Association, *World Uranium Mining Production*, August 2019 [website – accessed 3 September 2019]

[146] Geoscience Australia, *Australian Energy Resources Assessment 2018 Report – Uranium and Thorium*, 2019 [website – accessed 2 September 2019].

[147] Commonwealth Department of Industry, Innovation and Science, *Resources and Energy*

to Canada, China, Japan, the Republic of Korea, Taiwan and the United States (US), as well as members of the European Union including France, Germany, Sweden and Belgium.[148]

Figure 28: Australia's identified uranium resources by deposit (PJ)



According to the Nuclear Energy Agency (NEA), 3,360 people were employed at Australia's uranium mines in 2016.[149]

9.4 Potential growth

A June 2019 report by the Department of Industry, Innovation and Science stated:

> Ranger, which is owned by Energy Resources Australia, is subject to a limited lease, and is required to close in 2020. However, Four Mile has significant deposits remaining and Olympic Dam…has enough supply to last for centuries. Australia also has a further half-dozen mines under development, with most located in Western Australia. The post-Fukushima collapse in the uranium price

Quarterly, June 2019, p 76

[148] Geoscience Australia, *Australian Energy Resources Assessment 2018 Report – Uranium and Thorium*, 2019 [website – accessed 2 September 2019]

[149] NEA and IAEA, *Uranium 2018: Resources, Production and Demand*, 2018, p 138

> has pushed final decisions on prospective mines further into the future, and it is not clear that all Australian mines under consideration will ultimately commence. However, most of the crucial reviews and permissions have been received, and as the price of uranium edges up, producers are starting to look again at the future of nuclear power around the world.[150]

The report charted the potential growth in Australian uranium output having regard to existing mines and those in development (Figure 30).

Figure 29: Australian production and exports of uranium[151]

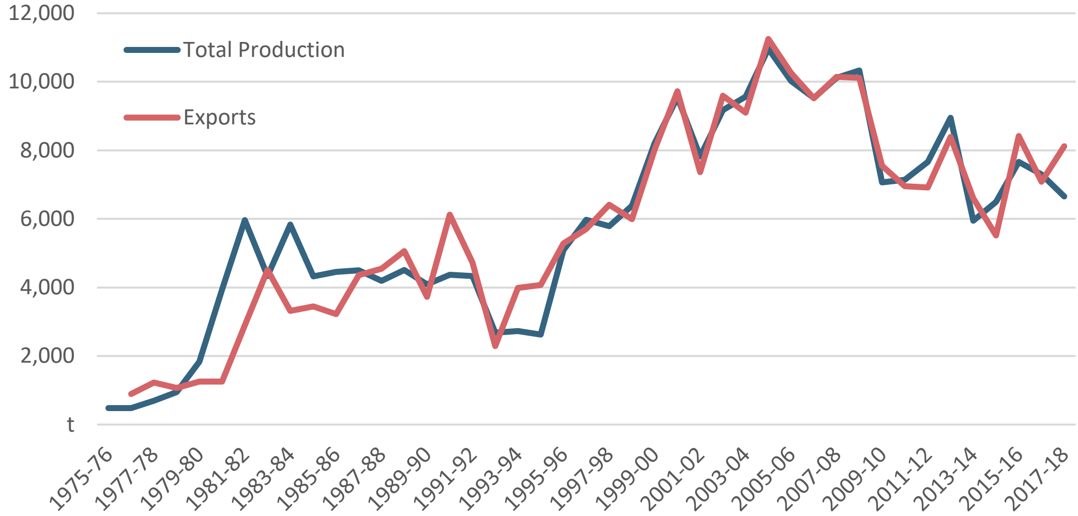
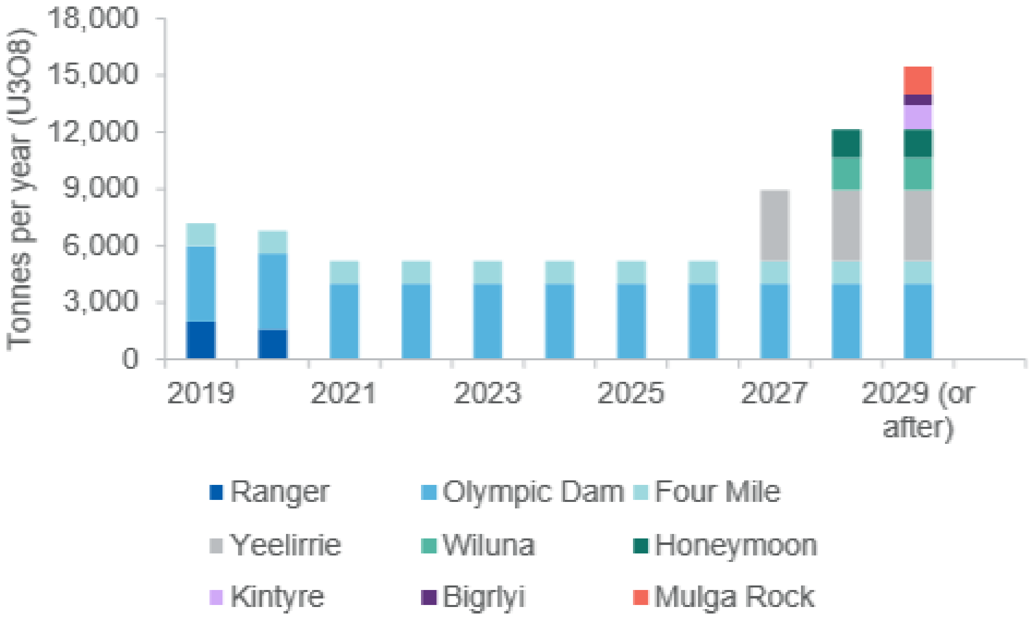


Figure 30: Potential growth of Australian uranium output[152]



[150] Commonwealth Department of Industry, Innovation and Science, *Resources and Energy Quarterly*, June 2019, p 127

[151] Commonwealth Department of the Environment and Energy, *Australian Energy Update 2019*, September 2019, Table S

[152] Commonwealth Department of Industry, Innovation and Science, *Resources and Energy*

10. International and Australian nuclear industry

10.1 International

Global energy trends

In 2018, 11.2 GW of nuclear energy were added worldwide, the largest increase since 1989 (Figure 31). Investment in coal-fired generation declined to its lowest level since 2004, investment in gas-fired generation has been decreasing since a high in 2012, and investment in renewable energy stalled for the first time since 2001, falling by 1% in 2018.[153]

Figure 31: Global power investment by technology[154]

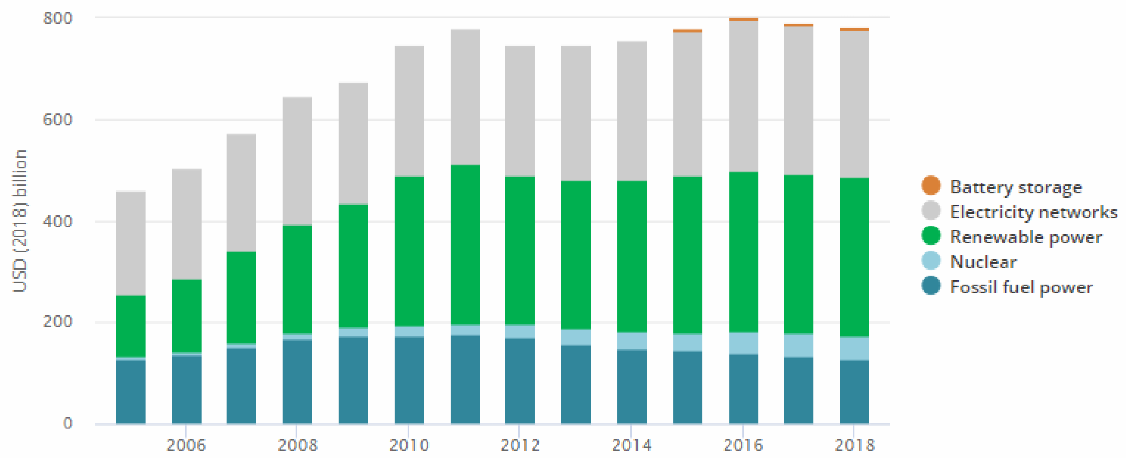
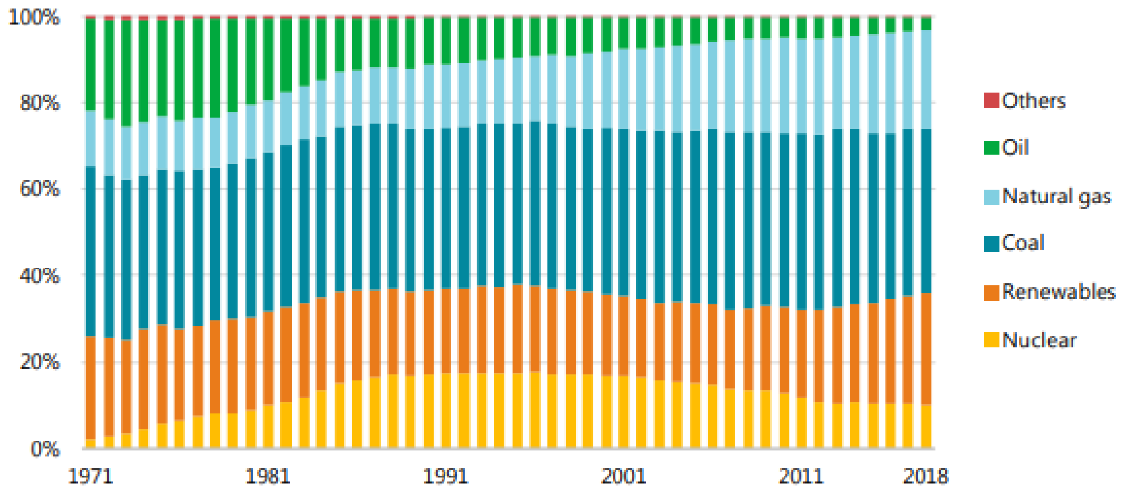


Figure 32: Share of energy sources in global electricity generation[155]



Quarterly, June 2019, p 127

[153] IEA, Power: Tracking Clean Energy Progress, 11 June 2019 [website – accessed 6 September 2019]. See chapter 7.1 for information on trends in electricity generation in NSW and the NEM.

[154] IEA, Power: Tracking Clean Energy Progress, 11 June 2019 [website – accessed 6 September 2019]

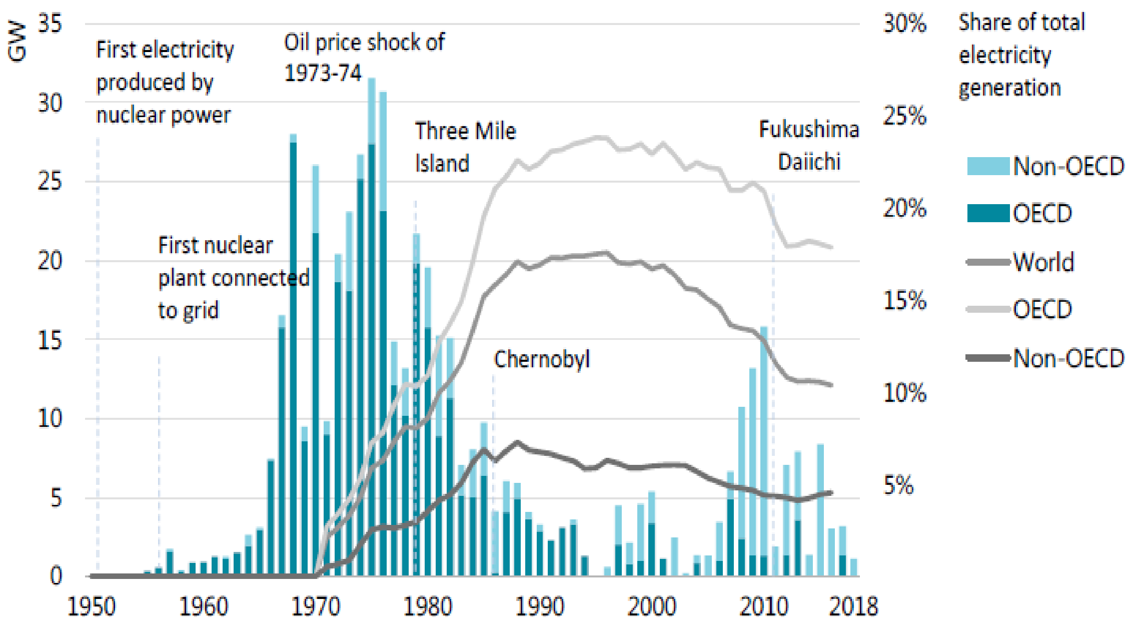
[155] IEA, Nuclear Power in a Clean Energy System, 2019, p 12

The share of nuclear power in global electricity generation has fallen over the past 20 years from a peak of around 20% in the mid-1990s to 10% in 2018 (Figure 32).

Nuclear energy trends

As at September 2019, there were 450 nuclear power stations in operation in 31 countries, with a combined capacity of about 400 GW.[156] The US (97), France (58), China (44[157]), Japan (37) and Russia (36) have the largest number of stations, together accounting for 68% of all nuclear power stations. Most nuclear power plants currently in operation in OECD (Organisation for Economic Co-operation and Development) countries were built in the 1970s and 1980s, as a means of diversifying energy production away from oil, gas and coal following the oil price shock of 1973-74 (Figure 33).[158] Since then, there have been declines in both the number of new reactors built and nuclear energy's share of total electricity generation.[159]

Figure 33: Reactor construction starts and share of nuclear power in total electricity generation[160]



Nuclear power plays a larger role in advanced economies (18% share) than developing economies (6%) (Figure 34). Of advanced economies, nuclear power contributes to over half of total electricity generation in France, Slovakia and Hungary.

156 IAEA, *Operational & Long-Term Shutdown Reactors*, 8 September 2019 [website – accessed 9 September 2019]. As at 8 September 2019, 177 nuclear power stations had been taken out of commercial operation and permanently shut down.

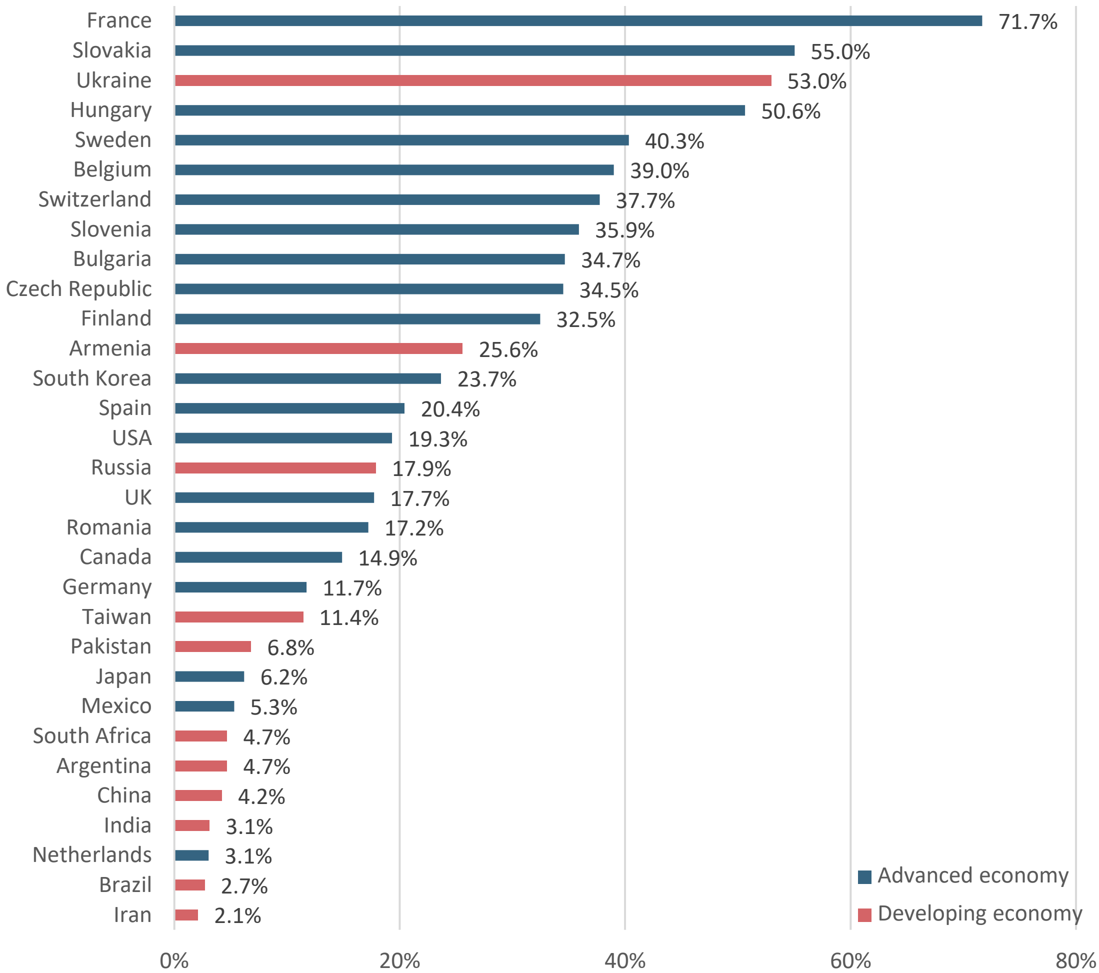
157 Excluding Taiwan, which has 4 nuclear power stations.

158 IEA, *Nuclear Power in a Clean Energy System*, 2019

159 IEA, *Nuclear Power in a Clean Energy System*, 2019

160 IEA, *Nuclear Power in a Clean Energy System*, 2019, p 10

Figure 34: Share of nuclear power in total electricity generation by country, 2018[161]



The International Energy Agency (IEA) projects that the amount of nuclear power generation capacity will fall significantly over the next 20 years without new investment (Figure 35). In advanced economies, the average age of nuclear power stations is 35 years. Most of the older nuclear power stations were designed to have an operational life of 40 years,[162] which can be extended by refurbishment.[163]

Fifty-two new reactors with a combined capacity of 53 GW are under construction, of which 37 are located in developing economies including China (7[164]), India (7) and Russia (6). New reactors have an expected operational life of at least 60

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161 IAEA, Power Reactor Information System, 24 September 2019

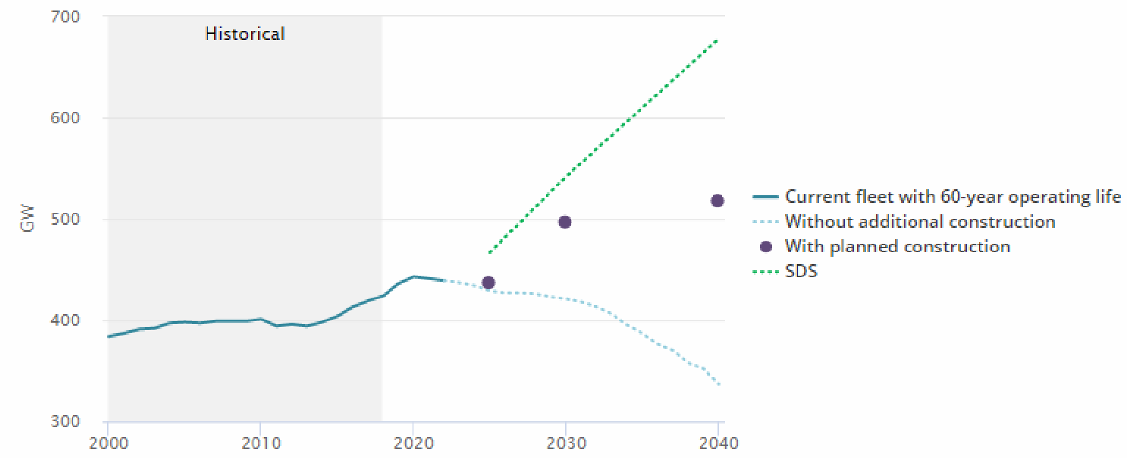
162 IEA, Nuclear Power in a Clean Energy System, 2019

163 IEA, Tracking Clean Energy Progress: Nuclear power, 2019 [website – accessed 9 September 2019]

164 Excluding Taiwan, which has 2 nuclear power stations under construction. The International Monetary Fund classifies Taiwan as an advanced economy.

years.[165] The IEA has set a carbon intensity reduction target under a Sustainable Development Scenario (SDS), with nuclear power generation expected to contribute to meeting the target.[166]

Figure 35: Current and future nuclear capacity[167]



Nuclear energy industry opportunities and challenges

In May 2019, the IEA stated in its report, *Nuclear Power in a Clean Energy System* (the Report):

> As the leading energy organisation covering all fuels and all technologies, the International Energy Agency (IEA) cannot ignore the role of nuclear power. That is why we are releasing our first report on the subject in nearly two decades in the hope of bringing it back into the global energy debate.[168]

In the Report, IEA makes a case for an increase in nuclear generation capacity across advanced economies in order to achieve the Paris Agreement CO_2 emissions reduction targets. In so doing, it "makes no recommendations to countries that have chosen not to use nuclear power in their clean energy transition and respects their choice to do so".[169] Bearing in mind that the Report applies primarily to countries with nuclear energy, key findings include:

- A range of technologies, including nuclear power, will be needed for clean energy transitions around the world. Achieving the clean energy transition with less nuclear power is possible but would require "an extraordinary effort";
- Nuclear power plants contribute to electricity security by:

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165 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016

166 IEA, *Tracking Clean Energy Progress: Power*, 11 June 2019 [website – accessed 6 September 2019]

167 IEA, *Power: Tracking Clean Energy Progress*, 11 June 2019 [website – accessed 6 September 2019]

168 IEA, *Nuclear Power in a Clean Energy System*, May 2019, p 2

169 IEA, *Nuclear Power in a Clean Energy System*, May 2019, p 6

- Helping electricity systems remain stable and flexible;
- Adjusting their operations to follow demand and supply shifts to a certain extent;
- Limiting the impacts of variable renewable generation; and
- Bolstering energy security by reducing dependence on imported fuels;

- The biggest barrier to new nuclear construction is mobilising investment (see further chapter 12.2); and
- Higher retail electricity prices are likely to occur in countries where nuclear capacity declines and new renewable capacity is introduced in its place. Without widespread lifetime extensions or new projects, IEA estimates that electricity supply costs would be close to USD 80 billion higher per year on average for advanced economies as a whole.[170]

Also writing in 2019, the Generation IV International Forum (GIF) identified the same types of challenges, together with the additional challenge of “poor social and political perception of nuclear energy safety (impact of the Fukushima Daiichi nuclear power plant accident)”.[171]

The Report argues that strong policy support is needed to secure investment in existing and new nuclear power stations, including by:

- Introducing policy reforms that ensure competition between generation technologies takes place on a level playing field;
- Addressing barriers to investment in lifetime extensions and new capacity by designing electricity markets that value clean energy and energy security;
- Securing investment in new nuclear plants through more “intrusive policy intervention”, such as long-term contracts, price guarantees and direct state investment;
- Promoting small modular reactors that are more suited to private investment through R&D funding, public-private partnerships for venture capital, and early deployment grants;
- Developing and maintaining human capital and industrial expertise.[172]

10.2 Australia

The idea of establishing a nuclear energy industry in Australia was first raised after World War II. In 1953, the Australian Atomic Energy Commission (AAEC)

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170 For a discussion of the emerging trends that present opportunities and challenges for the electricity supply chain and electricity markets in NSW, see chapter 7.

171 GIF, *GIF R&D Outlook for Generation IV Nuclear Energy Systems: 2018 Update*, 2019, p 3. See also: Buongiorno J et al., *The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary Study*, MIT Energy Initiative, September 2018

172 IEA, *Nuclear Power in a Clean Energy System*, May 2019, p 3-6

was established to be involved in all stages of the nuclear cycle. HIFAR (Hi Flux Australian Reactor) – Australia's first research reactor – was opened at Lucas Heights in Sydney in 1958, followed shortly after by the small Moata[173] research reactor in 1961. In February 1969, Prime Minister John Gorton indicated that the government intended to introduce nuclear power in Australia. In late 1969, the AAEC completed a feasibility study and recommended the establishment of a nuclear power plant at Jervis Bay. However, with a change of government in 1971, plans for an Australian nuclear energy industry were deferred indefinitely.[174]

In 1987, the AAEC became the Australian Nuclear Science and Technology Organisation (ANSTO). ANSTO closed the MOATA research reactor in May 1995 and the HIFAR research reactor in 2007. HIFAR was replaced by the Open Pool Australian Lightwater (OPAL) reactor in April 2007.[175] Currently, the Australian nuclear industry is limited to the research infrastructure operated by ANSTO, which includes OPAL and the National Research Cyclotron Facility at Camperdown in Sydney.[176]

Unlike nuclear power plants, which use the heat generated by nuclear fission to produce high-pressure steam that turns a turbine to produce electricity, OPAL (like its HIFAR predecessor) uses nuclear fission to produce and harness neutrons for scientific, industrial and medical purposes.[177] OPAL's main uses are:

- Production of radioisotopes for medical and industrial applications;
- Materials research using neutron beams;
- Analysis of minerals and samples using neutron activation techniques; and
- Irradiation of silicon used in the manufacture of semi-conductors.[178]

OPAL generates roughly 20 MW of heat using about 30 Kgs of uranium. In contrast, a typical nuclear power plant produces around 3,000 MW of heat to generate 1,000 MW of electricity and contains around 1 million Kgs of uranium.[179]

The safe operation of OPAL is overseen by the Australian Radiation Protection

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[173] Moata is an Aboriginal name meaning "gentle-fire" or "fire-stick".

[174] Holland I and James M, *Radio Active Waste*, Commonwealth Parliamentary Library, 1 January 2006 [website – accessed 24 September 2019]; Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65; ANSTO, *Our History*, 2019 [website – accessed 24 September 2019]. See also: National Academies Forum, *Understanding the Formation of Attitudes to Nuclear Power in Australia*, 2010.

[175] Holland I and James M, *Radio Active Waste*, Commonwealth Parliamentary Library, 1 January 2006 [website – accessed 24 September 2019]; Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65; ANSTO, *Our History*, 2019 [website – accessed 24 September 2019]

[176] World Nuclear Association, *Australian Research Reactors and Synchrotron*, 2017

[177] World Nuclear Association, *Australian Research Reactors and Synchrotron*, 2017

[178] ANSTO, *OPAL multi-purpose reactor*, no date [website—accessed 2 September 2019]

[179] ANSTO, *How safe is OPAL*, no date [website—accessed 2 September 2019]

and Nuclear Safety Agency (ARPANSA). According to ANSTO, in the case of an emergency, OPAL's shut down and containment systems can be activated automatically to stop a nuclear chain reaction and, if necessary, isolate the reactor building from the external environment.[180]

Four reportable incidents occurred between August 2017 and June 2018 at ANSTO's Lucas Heights facility, none of which involved the OPAL reactor.[181] This includes one Level 3 incident, as categorised on the International Nuclear Event Scale (INES). This incident was the only Level 3 (and above) incident reported worldwide in 2017. According to a 2018 independent review of the incident, Level 3 events are regarded as serious events in the nuclear industry, with any additional events of the same level likely to lead to a loss of confidence in the organisation. ARPANSA reports quarterly on a number of matters including details of any breach of licence conditions such as the four reportable incidents at Lucas Heights.

Australia's radioactive waste (which is low-level and intermediate-level waste) is managed at around 100 locations around Australia, including ANSTO, CSIRO, industrial sites and hospitals.[182] The Commonwealth Government is proposing to build a single facility in regional SA to permanently dispose of low-level waste and temporarily store intermediate-level waste.[183] Three "voluntarily nominated" sites are being considered: one near Hawker in the Flinders Ranges and two near Kimba on the Eyre Peninsula. A community ballot on the proposal will take place in the Kimba region in October 2019.[184]

11. Nuclear power generation technology

11.1 Fuel cycle

The nuclear fuel cycle main be divided into four main stages (Figure 36):

(1) Exploration, extraction and milling of minerals containing radioactive materials;

(2) Additional mineral processing and manufacture of materials containing radioactive and nuclear substances;

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[180] ANSTO, *How safe is OPAL*, no date [website—accessed 2 September 2019]. See also: World Nuclear Association, *Australian Research Reactors and Synchrotron*, 2017

[181] Hopkins A, *Independent Safety Review of the ANSTO Health Approach to Occupational Radiation Safety and Operational Procedures*, October 2018. An additional incident on 21 June 2019 has been reported in the media and noted by ARPANSA. On 8 July 2019, ARPANSA gave the accident a preliminary rating of Level 2 on the INES, with investigation into the causes and contributing factors of the accident ongoing.

[182] Department of Industry, Innovation and Science, *Managing Radioactive Waste*, [website – accessed 18 September 2019]; and Department of Industry, Innovation and Science, *Australian Radioactive Waste Management Framework*, April 2018, p 4

[183] Department of Industry, Innovation and Science, *Managing Radioactive Waste*, [website – accessed 18 September 2019]

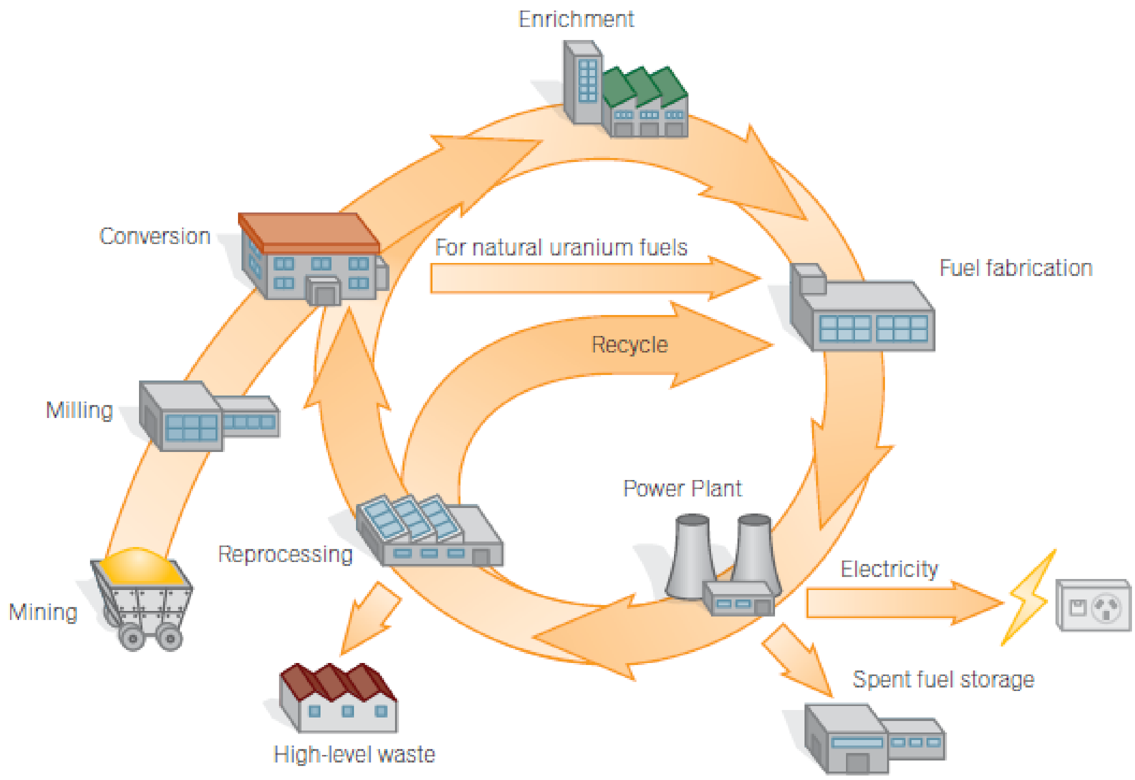
[184] Department of Industry, Innovation and Science, National Radioactive Waste Facility site: community ballot in Kimba, *National Radioactive Waste Management Facility News*, 13 September 2019

(3) The use of nuclear fuels for electricity generation; and

(4) The establishment of facilities for the storage and disposal of radioactive and nuclear waste.[185]

Each of these stages were discussed in detail the South Australian Nuclear Fuel Cycle Royal Commission's (the Royal Commission) final report.

Figure 36: The nuclear fuel cycle[186]



Uranium is the primary fuel used in the production of nuclear power. Thorium can also be used in the nuclear generation process, but commercial technologies using thorium are considered to be still some decades away. Uranium is a mildly radioactive element as found in uranium rich minerals. Once mined, it is processed into uranium oxide (U_3O_8) and exported in this form. 0.7% of uranium oxide consists of the uranium isotope U^{235}, with the remainder consisting of U^{238}.[187] Uranium oxide needs to be converted to an enriched form of uranium hexafluoride (UF_6) that contains 3-5% U^{235} in order to be used as a fuel. A nuclear reaction (fission) occurs when U^{235} is hit by a neutron and divides into smaller atoms, releasing energy in the process. Nuclear fuel has high energy density: one tonne of uranium yields the same amount of electric power as 20,000 tonnes of black coal or 8.5 million cubic metres of gas.[188] The heat from fission is

[185] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016
[186] Australian Government, *Uranium Mining, Processing and Nuclear Energy Review*, 2006, p 16
[187] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016
[188] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016

transported to an electricity-generating turbine by a gas or liquid (the coolant).

To maintain efficient reactor performance, about one-third of the spent fuel is replaced with new fuel generally every 12-18 months.[189] Used fuel may be reprocessed to recover and recycle a usable portion, or sent to long-term storage and final disposal. Wastes from the nuclear fuel cycle are categorised as low-, medium- or high-level depending on the amount of radiation they emit. Different disposal processes apply to each waste category.[190]

11.2 Reactor types

Current nuclear power stations

The majority of nuclear power stations in operation are either Pressurized Water Reactors (PWRs, 66.9%) or Boiling Water Reactors (BWRs, 15.6%). PWRs also account for the majority of power stations currently under construction (80.8%) (Table 7). Aside from two 440 MW power stations in Slovakia, all PWR and BWR power stations under construction have a capacity of over 900 MW.

Table 7: Nuclear power stations in operation or under construction, as of 8 September 2019

Type	In operation		Under construction		
	Number	Total capacity (MW)	Number	Total capacity (MW)	Capacity range (MW)
PWR	301	287,028	42	44,261	440-1,660
BWR	70	69,713	4	5,253	1,325-1,328
PHWR	49	24,557	4	2,520	630
GCR	14	7,725	0	0	NA
LWGR	13	9,283	0	0	NA
FBR	3	1,400	1	470	470
HTGR	0	0	1	200	200
Total	450	399,706	52	52,704	NA

PWR = Pressurized Water Reactor; BWR = Boiling Water Reactor; PHWR = Pressurized Heavy Water Reactor; GCR = Gas Cooled Reactor; LWGR = Light Water Cooled Graphite Moderated Reactor; FBR = Fast Breeder Reactor; HTGR = High Temperature Gas-Cooled Reactor.

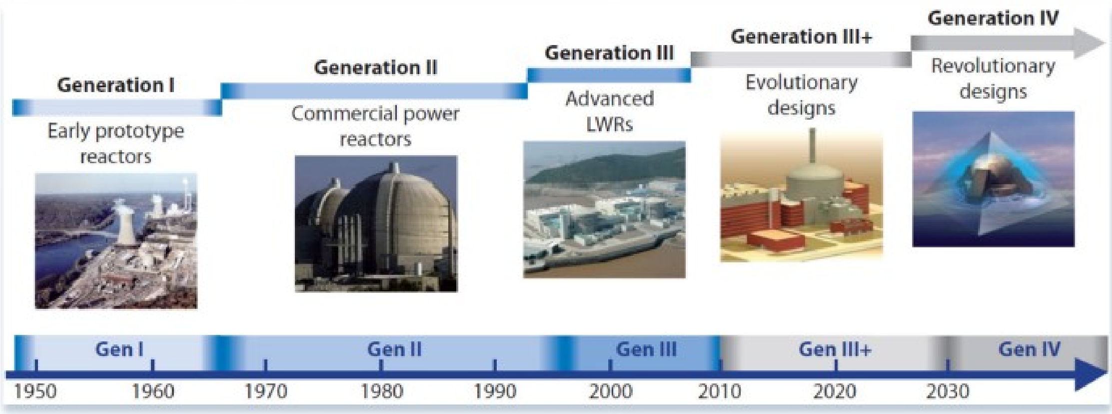
Nuclear reactors are grouped by generation of technology (Figure 37). Generation III (Gen III) systems are safer, more efficient versions of the Gen II systems. Gen III+ systems were designed to reduce construction costs, improve economic performance, and incorporate 'passive safety' features (see further chapter 12.2). Generation IV (Gen IV) systems include a range of different models that are currently under development.[191]

[189] World Nuclear Association, *The Nuclear Fuel Cycle*, March 2017

[190] World Nuclear Association, *The Nuclear Fuel Cycle*, March 2017

[191] Hicks M-L and Miller J, *Small Modular Nuclear Reactors*, UK Parliamentary Office of Science and Technology, POSTnote No 580, July 2018; Buongiorno J et al., *The Future of Nuclear*

Figure 37: The four generations of reactor designs[192]



Generation IV nuclear power stations

In 2001, the Generation IV International Forum (GIF) was founded by Canada, France, Japan, South Africa, South Korea, the US, Argentina, Brazil and the UK. Australia joined the GIF in 2016, signing the Charter and Framework Agreement that govern research and development into Gen IV technologies. In 2014, GIF published an update to their Technology Roadmap that included the four goals initially committed to in 2002:

(1) Sustainability;

(2) Safety and reliability;

(3) Economic competitiveness; and

(4) Proliferation resistance and physical protection.[193]

These goals were supplemented with four missions in 2019, the last three of which were selected to provide additional applications for nuclear power stations:

(1) The generation of electricity;

(2) The ability to produce non-electric products such as hydrogen or to process heat;

(3) The minimisation of waste; and

(4) The cost-effective integration of Gen IV systems in a global low-carbon energy system.[194]

Six Gen IV technologies are currently being investigated:

Energy in a Carbon-Constrained World: An Interdisciplinary Study, MIT Energy Initiative, September 2018; World Nuclear Association, *Advanced Nuclear Power Reactors*, May 2019 [website – accessed 9 September 2019]

[192] GIF, *GIF R&D Outlook for Generation IV Nuclear Energy Systems: 2018 Update*, June 2019, p 13

[193] GIF, *Technology Roadmap Update for Generation IV Nuclear Energy Systems*, January 2014, p 7

[194] GIF, *GIF R&D Outlook for Generation IV Nuclear Energy Systems: 2018 Update*, June 2019

Fast Reactors:

(1) Gas cooled fast reactor (GFR);

(2) Lead cooled fast reactor (LFR);

(3) Sodium cooled fast reactor (SFR);

Epithermal reactors:

(4) Molten salt reactor (MSR);

Thermal reactors:

(5) Supercritical water cooled reactor (SCWR); and

(6) Very high temperature reactor (VHTR).[195]

These systems are trialling new fuels and coolants. According to GIF, potential benefits of these technologies include:

- Reduced costs;
- Increased revenues by addressing new market opportunities such as:
  - Supplying heat to industrial applications;
  - Hybrid energy systems; and
  - Increased requirements for dispatchable electricity due to high uptake of intermittent renewable generation technologies;
- Improved thermal efficiency;
- Advanced recycling options that could enable reduction in the volume and radio-toxicity of waste stored in deep geological repositories; and
- Maintenance or improvement of current safety standards.

GIF also observes that power grids with significant levels of intermittent renewables will pose a challenge to Gen IV systems because of the associated flexible operation requirements. This could be addressed through policy options such as hybrid energy systems consisting of coupled nuclear and renewable generators, or progressive deployment of nuclear generation using small modular reactors (SMRs).[196]

[195] Fast, epithermal and thermal refers to the speed of the neutrons in the reactor that cause nuclear fission. The majority of reactors currently in use are thermal reactors, which is where the neutrons are slowed so they are more likely to cause fission. Hinson S, *New Nuclear Power*, House of Commons Library, Briefing Paper No CBP 8176, 19 August 2019

[196] For additional information on Gen IV systems, see: Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016; Buongiorno J et al., *The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary Study*, MIT Energy Initiative, September 2018; World Nuclear Association, *Generation IV Nuclear Reactors*, May 2019 [website – accessed 11 September 2019]. See chapter 6.4 and chapter 7.1 for a discussion of power generation technologies currently in use in NSW, as well as current and proposed responses to the challenges posed by intermittent renewables.

Small modular reactors

SMRs are smaller than existing reactors, with a maximum capacity of 300 MW per module, and have a shorter operational life. Designs under development include Gen III, Gen III+ and Gen IV systems, and incorporate standardised factory-manufactured parts that would be delivered ready for assembly.[197] SMRs have a number of potential applications:

- Provision of load following capabilities, bearing in mind that provision of baseload power[198] is economically optimal;
- Provision of electricity for other uses during periods of low demand or high renewable supply, such as desalination or hydrogen production;
- Provision of direct heat to customers; and
- Nuclear waste management by using the plutonium generated by conventional nuclear power stations.[199]

SMRs with a capacity less than 10 MW, otherwise known as micro modular reactors (MMRs), could be used for remote communities, mining sites and seasonal industrial complexes. Additional benefits of SMRs are said to include advantages in inherent safety features, such as simplified designs, easier deployment due to their smaller size, scalability of capacity additions, and short construction lead-times.[200] Many of these features improve the economic feasibility of SMRs when compared with conventional nuclear power generation (see further chapter 12.2).[201]

Commercial viability of Gen IV and SMRs

No Gen IV or SMR technologies are currently in commercial operation. Expectations as to when they will be ready for commercialisation have changed over the past three years, due to the significant project, technical and funding risks they face.[202]

In 2016, the Royal Commission found that the demonstration phase for the most advanced Gen IV system could commence in 2021 and last at least 10 years. It concluded that the most advanced designs "could not realistically be ready for

[197] Hicks M-L and Miller J, *Small Modular Nuclear Reactors*, UK Parliamentary Office of Science and Technology, POSTnote No 580, July 2018; IEA, *Nuclear Power in a Clean Energy System*, 2019

[198] See chapter 6.4 for a discussion of the different types of power generation technologies and an electricity generation matrix that classifies power generation technologies.

[199] Hicks M-L and Miller J, *Small Modular Nuclear Reactors*, UK Parliamentary Office of Science and Technology, POSTnote No 580, July 2018; IEA, *Nuclear Power in a Clean Energy System*, 2019

[200] Hicks M-L and Miller J, *Small Modular Nuclear Reactors*, UK Parliamentary Office of Science and Technology, POSTnote No 580, July 2018; IEA, *Nuclear Power in a Clean Energy System*, 2019

[201] For more information on SMRs, see: World Nuclear Association, *Small Nuclear Power Reactors*, May 2019 [website – accessed 11 September 2019]

[202] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 47

commercial deployment in SA or elsewhere before the late 2030s, and possibly later".[203]

In September 2018, a Massachusetts Institute of Technology (MIT) study found that more mature Gen IV technologies, such as the advanced SMR design being marketed by NuScale, an SFR, and a modular high temperature gas-cooled reactor, are technically ready for commercialisation by 2030. Less mature reactor systems were not expected to reach commercialisation before 2050. By June 2019, the outlook for Gen IV systems appears to have changed considerably. GIF found that some Gen IV systems "may enter the demonstration/deployment phase in the next decade",[204] with commercial fleet deployment for the first systems expected to commence in 2045[205].

For SMRs using Gen III or Gen III+ systems, none of the designs under development have reached commercial maturity.[206] These SMRs face considerable uncertainty around their costs, timescales and challenges, partly due to the diversity of designs.[207] According to the 2018 MIT study, the main economic question facing SMRs at present is whether they can be built at a substantially lower unit capital cost (in other words, cost per MW of capacity). An additional challenge is the likelihood that prototype and demonstration units will prove to be relatively expensive.[208]

12. Nuclear energy industry: selected economic, safety and environmental issues

12.1 Development of a nuclear power programme

As part of its Nuclear Energy Series, the International Atomic Energy Agency (IAEA) has published *Milestones in the Development of a National Infrastructure for Nuclear Power*[209] to provide guidance to countries that have decided to commence a nuclear power programme. The IAEA observes that:

> A nuclear power programme is a major undertaking requiring careful planning, preparation and investment in time, institutions and human resources. While nuclear power is not alone in this respect, it is different because of the safety, security and safeguards requirements associated with using nuclear material.
>
> A decision to start a nuclear power programme should be based on a

[203] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 47

[204] GIF, *GIF R&D Outlook for Generation IV Nuclear Energy Systems: 2018 Update*, June 2019, p 4

[205] GIF, *GIF R&D Outlook for Generation IV Nuclear Energy Systems: 2018 Update*, June 2019, p 79

[206] IEA, *Nuclear Power in a Clean Energy System*, 2019. See in particular Table 6 and Box 10 for a summary of the status of SMR research, development and deployment.

[207] Hicks M-L and Miller J, *Small Modular Nuclear Reactors*, UK Parliamentary Office of Science and Technology, POSTnote No 580, July 2018

[208] IEA, *Nuclear Power in a Clean Energy System*, 2019

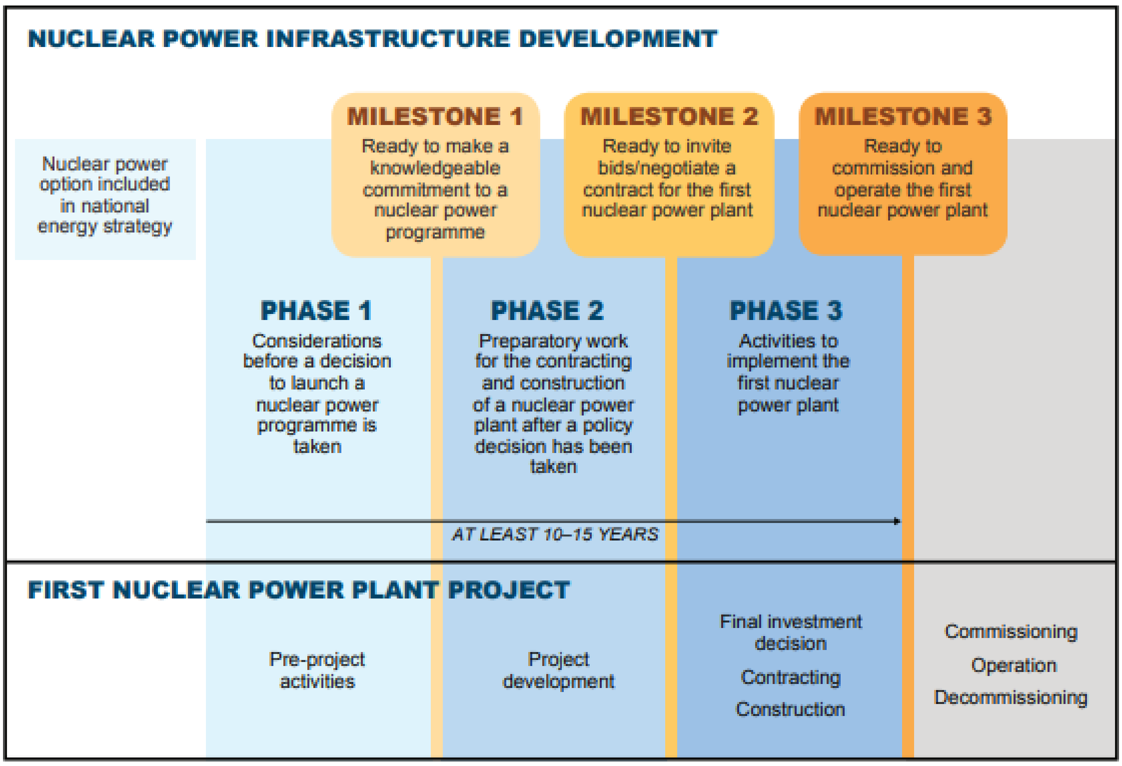
[209] See also: IAEA, *Responsibilities and Functions of a Nuclear Energy Programme Implementing Organization*, 2019

commitment to use nuclear power safely, securely and peacefully. This commitment requires establishing a sustainable national infrastructure that provides governmental, legal, regulatory, managerial, technological, human resource, industrial and stakeholder support for the nuclear power programme throughout its life cycle. The demonstration of compliance with international legal instruments, internationally accepted nuclear safety standards, nuclear security guidelines and safeguards requirements is essential in establishing a responsible nuclear power programme.

… Experience has shown that early attention to the 19 infrastructure issues presented here will facilitate a successful nuclear power programme. Insufficient attention to any of them may compromise safety or lead to costly delays or even project failure. This publication assumes that a country contemplating the introduction of nuclear power has a stable political, economic and social environment.

Timescales for nuclear power are long. Each nuclear power plant involves a commitment in the order of 100 years, through construction, operation, decommissioning and waste disposal. Experience suggests that the time from the initial consideration of the nuclear power option by a country to the operation of its first nuclear power plant is about 10–15 years. This may vary depending on the resources devoted to the programme. Depending on the circumstances in the country and the resources available, implementation could take longer.[210]

Figure 38: Development of the infrastructure for a national nuclear power programme[211]



[210] IAEA, *Milestones in the Development of a National Infrastructure for Nuclear Power*, 2015, p 1-2

[211] IAEA, *Milestones in the Development of a National Infrastructure for Nuclear Power*, 2015, p

Development of the infrastructure required for a nuclear power industry can be split into three phases, each with their own milestone (Figure 38). IAEA includes both 'hard' (for example, electrical grid and sites) and 'soft' (nuclear law, regulations and training) infrastructure within each phase. The 19 infrastructure issues listed in Table 8 need to be considered for each milestone, and are not presented in any particular order.

Table 8: National nuclear programme infrastructure issues[212]

The 19 infrastructure issues	
National position	Stakeholder involvement
Nuclear safety	Site and supporting facilities
Management	Environmental protection
Funding and financing	Emergency planning
Legal framework	Nuclear security
Safeguards	Nuclear fuel cycle
Regulatory framework	Radioactive waste management
Radiation protection	Industrial involvement
Electrical grid	Procurement
Human resource development	

12.2 Economics

Commercial viability

South Australian study

The Royal Commission commissioned modelling to assess the commercial viability of a large nuclear power plant and two SMR plants operating in SA in 2030 or 2050.[213] The modelling was based on various assumptions and inputs. Table 9 shows capital and operating cost estimates for the nuclear power plants. Three scenarios were developed of possible carbon emissions abatement targets and policies, with the "strong carbon price scenario" involving the introduction of a carbon price in 2017 to meet an emissions reduction objective of 65% of 2005 levels by 2030 and complete decarbonisation by 2050. The model assessed profitability using a commercial cost of capital of 10%.[214] The modelling also assessed two non-nuclear power generation options that could be operated with intermittent renewable technologies: CCGT; and CCGT with the "unproven" carbon capture and storage (CCS) technology.[215] The profitability analysis

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[212] IAEA, *Milestones in the Development of a National Infrastructure for Nuclear Power*, 2015, p 7

[213] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Appendix G. See also chapter 11.2 for a discussion of different reactor types. See chapter 7.2 for information on wholesale electricity market trends in NSW.

[214] As to the selection of this rate and modelling based on other rates, see DGA Consulting, *Final Report for the Quantitative Viability Analysis of Electricity Generation from Nuclear Fuels*, February 2016, p 65-66.

[215] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Appendix G

showed:

> …both the small modular reactor and large nuclear power plant options consistently deliver strongly negative outcomes under either carbon price scenario on a commercial rate of return of 10 per cent…An investment in a [CCGT] system was found to be viable under all emissions abatement scenarios irrespective of when the facility is commissioned. The viability of installing CCGT with carbon capture and storage was, in comparison, assessed using a different approach...It was found that it would not be commercially viable due to the significant costs associated with proving the stability of CO_2 in underground geological formations.[216]

Table 9: Life cycle capital and operating costs, two types of small and large nuclear reactor at brownfield and greenfield sites, 2014, $AUD[217]

Costs	Small (360 MW)	Small (285 MW)	Large (1125 MW)
Brownfield	$3,302m ($9,173/kW)	$2,942m ($10,323/kW)	$8,962m ($7,966/kW)
Greenfield	$3,692m ($10,256/kW)	$3,331m ($11,689/kW)	$9,323m ($8,287/kW)
Non-fuel operating	$61m	$48m	$190m
Fuel	$11.80/MWh	$11.80/MWh	$9.90/MWh
Used fuel disposal	$5.80/MWh	$5.80/MWh	$4.90/MWh

The Royal Commission report concluded:

> …a nuclear power plant of currently available size at current costs of construction would not be viable in the South Australian market under current market rules. The outcome of this analysis is consistent with a wide range of realistic scenarios. It does not necessarily apply to other jurisdictions in Australia. In fact, some of the modelling suggests that nuclear might well be viable elsewhere, as the challenges facing baseload generation in South Australia are not shared with other regions of the NEM.[218]

The report also stated that the commercial viability of nuclear generation as part of the NEM in SA would be improved under certain circumstances. For example, if a change to government policy resulted in a combination of:

- A higher price on emissions in the economy (including from electricity generation);
- Finance at lower costs than available on the commercial market (that is, assuming a cost of capital of 6%, which could be obtained if the government provided a form of loan guarantee); and
- Long term revenue certainty for investors (that is, if a long-term power purchase agreement could be established).[219]

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216 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Appendix G

217 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 215. Includes pre-construction, licensing, supporting infrastructure and connection costs.

218 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 55

219 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 59-63

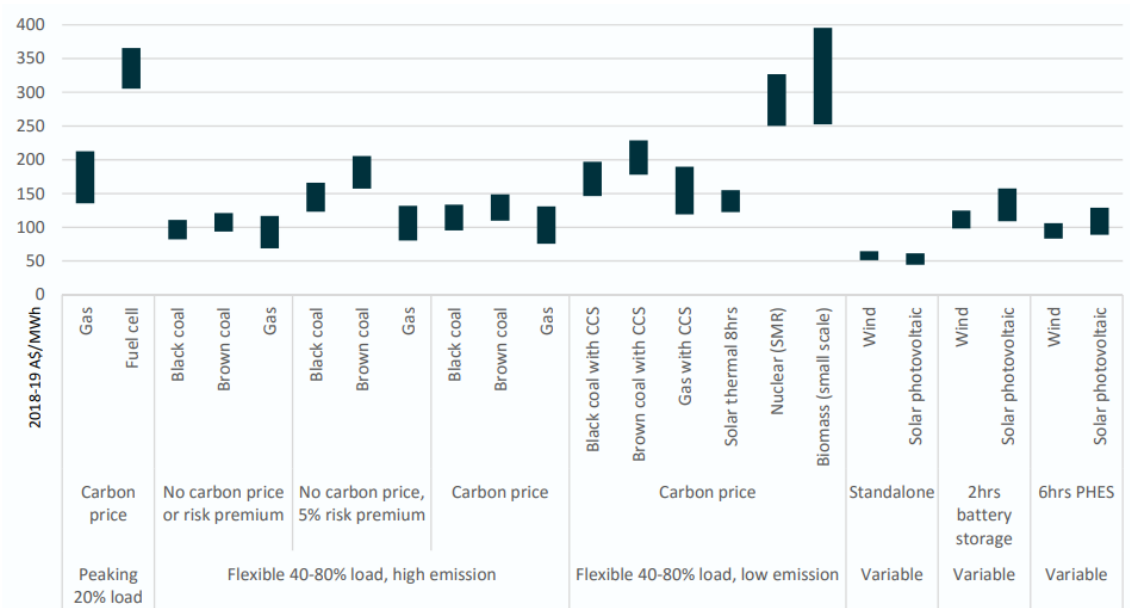
The report commented that the current viability of nuclear power "should not preclude its consideration as part of a future energy generation portfolio for the NEM".[220] In addition, it noted that there are many possible combinations of technologies that could form a low-carbon energy system, and it stated:

> Identifying which combination of technologies would be the lowest cost, including whether that mix included nuclear, would require an analysis of the future cost of the whole electricity system, that is, the total costs of electricity generation, transmission and distribution. This would require a more sophisticated analysis than that advanced in numerous submissions by proponents of particular technologies based solely on the cost per unit of energy generated (LCOE)...[221]

Recent study on Levelised Cost of Electricity (LCOE)

A 2018 study by the CSIRO and AEMO reported levelised cost of electricity (LCOE) results for different electricity generation technologies for each decade from 2020 to 2050 (see Figure 39 for 2020 results) but noted the limitations of using this measure.[222]

Figure 39: Calculated LCOE by technology and category for 2020[223]



Notes: Ranges are primarily based on differences in carbon prices, capital costs, fuel costs and capacity factors (see Apx Table B.2 in Appendix B). PHES is pumped hydro energy storage; CCS is carbon capture and storage; SMR is small scale modular reactor. The gas peaking technology is an open cycle turbine, other flexible gas refers to a combined cycle gas turbine. Flexible coal refers to a supercritical pulverised fuel plant.

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[220] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 63

[221] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 64

[222] Graham P et al., *GenCost 2018: Updated projections of electricity generation technology costs*, CSIRO and AEMO, December 2018, p 21

[223] Graham P et al., *GenCost 2018: Updated projections of electricity generation technology costs*, CSIRO and AEMO, December 2018, p 28

The report noted two important considerations when interpreting these results.[224] First, to take account of climate policy risk, the study calculated the LCOE for fossil fuel technologies in three ways: with no adjustment for climate risk, with a 5% premium added to their weighted average cost of capital (WACC) and with a normal WACC but with a carbon price. Second, to recognise differences in technology roles and abilities, the LCOE results are "divided into categories to indicate that technology cost comparisons within categories are appropriate but comparisons across categories should only be considered with caution or not at all".[225] CSIRO and AEMO are developing a more useful LCOE that will take into account balancing costs, which "are about how system demand is met from a combination of technologies with a given amount of reliability".[226]

Barriers to investment

A May 2019 report by the International Energy Agency (IEA) identified barriers to investment in new nuclear plants:

> Plans to build new nuclear plants face concerns about competitiveness with other power generation technologies and the very large size of nuclear projects that require billions of dollars in upfront investment. Those doubts are especially strong in countries that have introduced competitive wholesale markets.
>
> A number of challenges specific to the nature of nuclear power technology may prevent investment from going ahead. The main obstacles relate to the sheer scale of investment and long lead times; the risk of construction problems, delays and cost overruns; and the possibility of future changes in policy or the electricity system itself...[227]

The report also outlined the characteristics of government policies that would support the construction of new nuclear plants:

- Long-term price guarantees;
- Appropriate valuation of low-carbon production;
- Sovereign guarantees on borrowing;
- Inclusion in the regulated asset base;
- Involvement of the technology provider in equity joint ventures; and
- Direct investment by state-owned companies.[228]

The report noted that 47 of the 54 nuclear power plants under construction

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[224] Graham P et al., *GenCost 2018: Updated projections of electricity generation technology costs*, CSIRO and AEMO, December 2018, p 24-27

[225] Graham P et al., *GenCost 2018: Updated projections of electricity generation technology costs*, CSIRO and AEMO, December 2018, p 25

[226] Graham P et al., *GenCost 2018: Updated projections of electricity generation technology costs*, CSIRO and AEMO, December 2018, p 33

[227] IEA, *Nuclear Power in a Clean Energy System*, May 2019, p 4

[228] IEA, *Nuclear Power in a Clean Energy System*, May 2019, p 82-83

globally were owned by state-owned companies.[229] In advanced economies, 7 of the 14 nuclear plants under construction were owned by state-owned companies and 6 of the 7 in private ownership were subject to price regulation.

Recent UK developments

Recent developments in the UK nuclear energy industry provide additional insight into the challenges associated with the assessment of the commercial viability of nuclear power.[230] Successive UK Governments have been supporters of nuclear power based on their position that nuclear power contributes to meeting all three aspects of the energy trilemma.[231] In 2016, the UK National Audit Office (NAO) published a report on nuclear power in the UK. The NAO report identified specific challenges that need to be met to "ensure that nuclear power is on an equal footing in the market with other low-carbon technologies":[232]

- Nuclear power plants have very high upfront costs and take a long time to build, with costs having increased given extra safety considerations that need to be met following the Fukushima accident and increasing terrorist threats. While offset to some extent by low running costs, investments in nuclear power have a very long payback period;
- Nuclear power investments are exposed to external risks, including changes in government policy and market fluctuations;
- Nuclear power plants are ideal for providing baseload capacity, but are inflexible. Running them at less than full capacity generates few cost savings;
- The disposal of nuclear waste poses particular challenges and is expensive; and
- Decommissioning costs are very high relative to other low-carbon technologies. These costs are generally far in the future and remain uncertain.

Two additional challenges specific to building new nuclear power stations in the UK were also identified in the report:

- As no new nuclear power stations had been built in the UK for over 20 years, the UK lacked a proven, skilled supply chain to support the construction of a new power station; and
- At the time, the UK Government's policy was that new nuclear generation should be privately-financed. Few private companies are able to risk such large upfront investments with such a long payback period.

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[229] IEA, *Nuclear Power in a Clean Energy System*, May 2019, p 19

[230] For a discussion of the commercial viability of nuclear power in the US, see: Buongiorno J et al., *The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary Study*, MIT Energy Initiative, September 2018

[231] World Nuclear Association, *Nuclear Power in the United Kingdom*, July 2019 [website – accessed 24 September 2019]; UK NAO, *Nuclear Power in the UK*, July 2016

[232] UK NAO, *Nuclear Power in the UK*, July 2016, p 29

At the time, provision of bespoke contracts for difference (CfDs) was a key UK Government policy developed to facilitate construction of new nuclear power stations. The CfD provided for the construction of Hinkley Point C was for 35 years, longer than the typical timeframe of 15 years offered to other power generation technologies. The CfD also included a Secretary of State Investor Agreement, which means that "the government will compensate investors if the plant is shut shown for reasons that are political, or due to certain changes in insurance arrangements or certain changes in law".[233]

The NAO identified seven value-for-money risks for consumers and taxpayers associated with the Government's planning for energy infrastructure, the last three of which were specific to nuclear power:

(1) Electricity demand uncertainty;

(2) Exposure to market conditions that influence investor confidence in new power generation projects;

(3) Falls in wholesale electricity prices;

(4) Higher than expected total delivery costs;

(5) Long-term CfDs adds to price certainty for consumers but increase the risk that they do not benefit as much from any future changes such as technological advances;

(6) The greater complexity and risk of nuclear power projects could lead investors to require a higher return than for other low-carbon technologies. This would necessitate careful consideration of the allocation of risks between the government and investor; and

(7) The Government might be liable for future decommissioning costs where the total exceeds the amount set aside by the investor.[234]

Reports from the NAO and UK Public Accounts Committee found that, while there is a strategic case for nuclear, the Hinkley deal represented poor value for money for consumers. The Government has therefore proposed a new regulated asset base (RAB) model as a form of public private partnership. As summarised by the UK House of Commons Library:

> For nuclear, the proposed model would involve an independent regulator setting a price which a developer can then charge to users for the provision of the company's infrastructure, such as new nuclear power plant. Energy suppliers would be the infrastructure users who would be charged for the nuclear plant, and the suppliers could pass the charge on to their customers through their electricity bills. The charge would be applied to energy customer bills during construction of a plant and during its operational life. The exact level of the charge, and duration that it is charged, may vary over the plant's lifetime, and between projects.
>
> Because under a RAB model consumers are required to pay for the infrastructure

[233] UK NAO, Nuclear Power in the UK, July 2016, p 30
[234] UK NAO, Nuclear Power in the UK, July 2016, p 9-10

> while it is being built, consumers are at risk from cost-overruns and delays to construction, which have been common in recent examples of nuclear construction in Europe and the USA. Strike prices [under the CfD model] do not include this risk, as customers do not start paying for the plant until it is generating so the risks of increasing costs and delays during construction fall on the developer. Instead, the RAB model gives developers a guaranteed return from the start of the project. The aim of this is to lower their risk and the cost of borrowing money, making investment more attractive.[235]

Consultation on the Government's proposal is due to close on 14 October 2019.

Economic impact

The Royal Commission also commissioned modelling to assess the potential effect on the wider SA economy of investments being made in either a small or large nuclear power plant.[236] The modelling was based on a number of assumptions including that the government provided a substantial subsidy to fund development of the nuclear power plant. This analysis concluded:

> If an investment in either a large or small plant were funded such that it does not lead to reduced state government expenditure in other areas, it leads to a modest improvement to gross state product [0.05 to 0.10 per cent] and a modest reduction in gross state income [-0.03 to –0.3 per cent] in 2049–2050. This outcome arises because a significant decrease in wholesale electricity prices in the SA region of the NEM could lead to significant electricity exports through an expanded interconnector to the eastern region of the NEM: that is, SA could become a net exporter of electricity. The effect of investment in a large plant if it did lead to reduced state government expenditure in other areas, was estimated to be a substantial decrease in gross state income (–3.6 per cent) and gross state product (–3 per cent) in 2049–50.[237]

Jobs in the nuclear industry

Depending on the size of the plant, it was estimated that between 473 and 620 jobs would be created in SA by 2049-50: this included direct employment in nuclear power generation as well as indirect employment in other industries (Table 10).[238]

The Royal Commission has stated that building a sufficient level of local nuclear engineering expertise will require time, commitment and planning.[239]

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[235] Hinson S, *New Nuclear Power*, UK House of Commons Library, Briefing Paper No. CBP 8176, 19 August 2019, p 8-9

[236] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Appendix G

[237] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Appendix G

[238] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Appendix G. For an international study on jobs generated by a nuclear power industry, see OECD Nuclear Energy Agency and the IAEA, *Measuring Employment Generated by the Nuclear Power Sector*, 2018.

[239] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 161

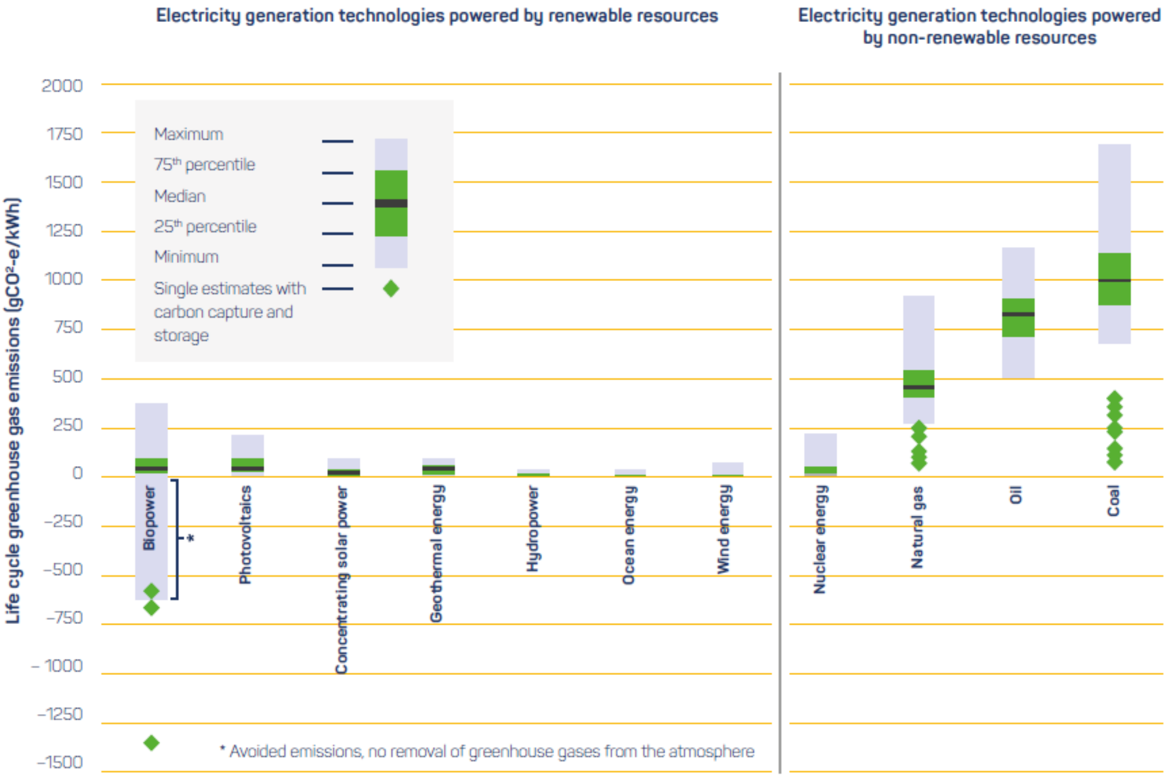
Table 10: Estimated job creation from SA nuclear power plants[240]

Type of plant	Large nuclear plant		Small nuclear plant	
Year	2029-30	2049-50	2029-30	2049-50
Total jobs	575	620	540	473
Direct jobs	330	258	167	120

12.3 Environment

An overview of the potential environmental impacts of a nuclear energy industry can be found in chapter 20.2. This section covers the contribution nuclear power may make to meeting the environmental sustainability component of the energy trilemma, namely mitigating climate change.[241]

Figure 40: Life cycle greenhouse gas emissions for electricity generation technologies[242]



Note: gCO$_2$-e/kWh = grams carbon dioxide equivalent per kilowatt hour

All power generation technologies produce carbon emissions across their life cycle. The Royal Commission included results from a "comprehensive and detailed"[243] life cycle analysis of the GHG emissions of different electricity

240 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 221

241 See chapter 8 for information on the current environmental sustainability of the electricity sector in NSW.

242 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 3

243 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 3

generation technologies that had been adopted by the Intergovernmental Panel on Climate Change (IPCC) (Figure 40). This analysis found that the median estimates for nuclear GHG emissions (12 gCO_2-e/kWh) were comparable to solar PV (18–50 gCO_2-e/kWh, depending on technology choice) and wind (12 gCO_2-e/kWh). Renewable and nuclear technologies were found to be substantially less carbon-intensive than gas and significantly less again than coal. With nuclear carbon emissions having decreased marginally in recent years, the Royal Commission concluded that nuclear will continue to be a low-carbon option for the foreseeable future.[244]

12.4 Serious nuclear plant accidents

There has long been community concern over nuclear safety, in particular the possibility of exposure to radiation from nuclear plant accidents. There have been three major accidents around the world: Three Mile Island (US) in 1979, Chernobyl (Ukraine) in 1986 and Fukushima (Japan) in 2011.[245]

Reports by the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) on the health effects of the Chernobyl and Fukushima accidents are discussed in the Royal Commission’s 2016 report.[246] For example, one finding in relation to Chernobyl was that:

> A significant increase in thyroid cancers was observed in members of the local population who were children or adolescents at the time of the accident. Doses of radiation to the thyroid were caused by the contamination of milk with radioactive iodine in the immediate days after the accident. Radiation is considered to have contributed to a large proportion of the 6,848 cases of thyroid cancer reported between 1991 and 2005. Fifteen of these proved fatal.

A more recent UNSCEAR report on this estimated that one quarter of the 20,000 cases of thyroid cancer registered between 1991 and 2015 in people who were aged under 18 in 1986 were caused by radiation exposure.[247]

12.5 Managing nuclear waste

Spent nuclear fuel assemblies are classified as high-level radioactive waste and must be securely and safely stored to prevent public exposure.[248] They need:

> …to be cooled for several years to ensure they remain below melting temperatures by a large margin of safety. This heat is managed in the short term (typically for up to 10 years) in a wet storage pool at the reactor site. During that time there is both a substantial reduction in the radiotoxicity of the used fuel and in the amount of heat generated. After removal from the wet storage pools, the used fuel assemblies are typically stored in large, dry storage casks, allowing the

[244] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 3

[245] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 33-34

[246] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 139-140

[247] UNSCEAR, *Evaluation of data on thyroid cancer in regions affected by the Chernobyl accident: A white paper to guide the Scientific Committee’s future programme of work*, 2018

[248] See chapter 10.2 for management of lower levels of waste in Australia.

> used fuel to cool further. A total of about 50 years of storage is required for used fuel to cool sufficiently before it can be permanently disposed of underground.[249]

While radiation levels decrease rapidly during the first 30 to 50 years, the most radioactive elements take around 500 years to decay, while the less radioactive but longer-lived elements require containment for at least 100,000 years.[250]

The international consensus is to use deep geological disposal for the long-term disposal of spent nuclear fuel. No such facilities exist but some are in development. The two most advanced countries are Finland and Sweden, which are building facilities that are expected to become operational in the 2020s.[251]

13. Key Australian reports

Findings from key selected Australian reports are presented here in reverse chronological order.[252]

13.1 Independent Review into the Future Security of the National Electricity Market (2017)

On 7 October 2016, COAG energy ministers approved an independent review of the NEM (the Finkel Report; see also chapter 7.5). On the topic of nuclear power, the independent review noted:

> Large, traditional nuclear power plants are limited to large-scale applications, which the Australian Nuclear Science and Technology Organisation notes makes it "*difficult to envisage [traditional nuclear power plants] being established on the NEM given current grid structure*" [emphasis in original].
>
> Small modular reactors (SMRs) are a more flexible technology, with faster construction and delivery times. SMRs have a smaller generating capacity (up to 300 MW), and are designed to allow for modular construction. SMRs are also expected to have a strong safety case based on their smaller size and factory construction. The reactors are capable of providing dispatchable and synchronous electricity, benefiting system security.[253]

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[249] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 83.

[250] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xv.

[251] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 85 and p 91.

[252] Other relevant inquiries and reports include: two NSW parliamentary inquiries, Legislative Council General Purpose Standing Committee No. 5, *The Former Uranium Smelter Site at Hunter's Hill*, September 2008, and Joint Select Committee on the Transportation and Storage of Nuclear Waste, *Inquiry into the Transportation and Storage of Nuclear Waste*, February 2004; two Commonwealth parliamentary inquiries, Senate Economics References Committee, *Selection Process for a National Radioactive Waste Management Facility in South Australia*, August 2018, and Senate Standing Committee on Environment and Communications, *Regulating the Ranger, Jabiluka, Beverly and Honeymoon Uranium Mines*, October 2003; a Queensland Government investigation, Uranium Mining Implementation Committee, *Recommencement of Uranium Mining in Queensland: A Best Practice Framework*, March 2013, together with an implementation strategy; and one Northern Territory parliamentary inquiry, Social Policy Scrutiny Committee, *Inquiry into the Nuclear Waste Transport, Storage and Disposal (Prohibition) Amendment Bill 2018*, October 2018

[253] Finkel A et al, *Independent Review into the Future Security of the National Electricity Market*,

13.2 South Australian Nuclear Fuel Cycle Royal Commission (2016)

In 2015, the South Australian Government established a Royal Commission to investigate the potential for SA to:

1. Increase its involvement in the exploration and mining of uranium and other radioactive materials;
2. Further process radioactive minerals (fuel enrichment);
3. Establish nuclear power plants for electricity generation; and
4. Establish facilities for storing and disposing radioactive and nuclear waste.[254]

The Commission found that the existing regulatory framework for mining in SA could safely support an expansion in the exploration and mining of uranium and other radioactive minerals. It recommended that the SA Government secure in advance mine decommissioning and remediation costs.[255]

Additionally, it was found that SA possessed the technical capability to provide fuel enrichment activities, although a new regulatory framework would be required to manage risks associated with these activities. However, the Commission observed that fuel enrichment markets were currently oversupplied and that fuel enrichment activities would not be commercially viable in the next 10 years.[256] Accordingly, the Commission recommended that the SA Government pursue options for fuel leasing, which involved linking fuel enrichment services with a guarantee to take back used fuel for permanent storage and disposal.[257]

While acknowledging the “severe consequences” of nuclear accidents, the Commission found “sufficient evidence of safe operations and improvements” to note that the use of nuclear power plants for electricity generation in SA should not be discounted on the basis of safety concerns.[258] Due to the characteristics of SA’s energy market, high upfront capital costs, and current NEM market rules, nuclear power plants were found not to be commercially viable in the State. Nevertheless, the Commission said nuclear power plants may be required as part of a lower-carbon electricity system. For that reason, it recommended that the SA Government pursue the removal of Commonwealth prohibitions on nuclear power generation so that nuclear power generation could contribute to a low carbon electricity system, if required.[259] The Commission noted:

> In developing Australia’s future electricity system there is a need to analyse the elements and operation of that system as a whole, and not any single element in

2017, p 189

[254] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xi.
[255] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xiv.
[256] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xiv.
[257] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xiv.
[258] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xiv.
[259] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xv.

> isolation. This will be significant in determining the role that nuclear and any other technologies should play.

It recommended that the SA Government promote the development of a comprehensive national energy policy that enables all technologies, including nuclear power, to contribute to a low-carbon, affordable and reliable NEM.[260] Ongoing monitoring of the commercialisation of new nuclear reactor designs was also recommended.[261]

The Commission found that SA has the necessary attributes and capabilities to develop, using the principles of a deep geological storage, a safe nuclear waste disposal facility that could:

> … generate $51 billion during its operation … by accumulating all operating profit in a State Wealth Fund, and annually reinvesting half the interest generated, a fund of $445 billion could be generated over 70 years (in current dollar terms).[262]

In light of these findings, the Commission recommended that the SA Government pursue opportunities to establish nuclear waste storage and disposal facilities. It also recommended the repeal of section 13 of the *Nuclear Waste Storage Facility (Prohibition) Act 2000 (SA)*, which prohibits public money being used to encourage or finance any activity associated with the construction or operation of a nuclear waste storage facility.[263]

13.3 Nuclear energy review taskforce report (2006)

In December 2006, a taskforce set up by the Prime Minister and chaired by Dr Ziggy Switkowski reported on its review of uranium mining, value-added processing and the contribution of nuclear energy in Australia in the longer term.[264] The report's key findings and conclusions included:

- *Uranium mining:* Consultations revealed support for the expansion of Australian mining and export of uranium. Skill shortages, government policies and legal prohibitions restricting the growth of the industry would need to be urgently addressed;
- *Uranium processing:* Uranium conversion, enrichment and fuel fabrication could add a further $1.8 billion of value annually if all Australian uranium was processed domestically. However, high commercial and technology barriers could make market entry difficult. Current legal and regulatory impediments would need to be removed, but there may be little real opportunity for Australian companies to extend profitably into these areas; and

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260 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xv.

261 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xv.

262 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xv.

263 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p xv–xvi

264 Switkowski Z, *Uranium Mining, Processing and Nuclear Energy — Opportunities for Australia?*, Report to the Prime Minister by the Uranium Mining, Processing and Nuclear Energy Review Taskforce, December 2006

- *Nuclear power:* Nuclear power today is a mature, safe, and clean means of generating baseload electricity. Nuclear power is an option that Australia would need to consider seriously among the range of practical options to meet its growing energy demand and to reduce its greenhouse gas signature.[265]

13.4 House of Representatives inquiry (2006)

In November 2006, the House of Representatives Standing Committee on Industry and Resources published a report on the strategic importance of Australia's uranium resources. In summary, it concluded:

> In view of the strategic importance of Australia's uranium resources, the potential benefits from the further development of these resources, and following consideration of the alleged risks…, the Committee concludes that development of new uranium deposits should be permitted and encouraged.[266]

The report noted that the Committee's terms of reference did not include:

> …the possible domestic use of nuclear power or the question of establishing domestic fuel cycle services industries. However, a number of submitters volunteered opinions and information in relation to these matters. The Committee concludes its report with an overview of this evidence.[267]

14. Public opinion

14.1 Australia

Essential polls: 2009 to 2019

The Essential Poll is a weekly Australian survey of topical issues.[268] The survey has included a question on the use of nuclear power for electricity generation seven times over the past decade (Figure 41).[269] The percentage of respondents supporting the development of nuclear power plants for the generation of electricity has generally been higher than the percentage who are opposed. This

[265] Switkowski Z, *Uranium Mining, Processing and Nuclear Energy — Opportunities for Australia?*, Report to the Prime Minister by the Uranium Mining, Processing and Nuclear Energy Review Taskforce, December 2006, p 13

[266] House of Representatives Standing Committee on Industry and Resources, *Australia's Uranium: Greenhouse Friendly Fuel for an Energy Hungry World – A Case Study into the Strategic Importance of Australia's Uranium Resources for the Inquiry into Developing Australia's Non-Fossil Fuel Energy Industry*, November 2006, p lxii

[267] House of Representatives Standing Committee on Industry and Resources, *Australia's Uranium: Greenhouse Friendly Fuel for an Energy Hungry World – A Case Study into the Strategic Importance of Australia's Uranium Resources for the Inquiry into Developing Australia's Non-Fossil Fuel Energy Industry*, November 2006, p lxvii

[268] For information relating to survey methodology, see: Essential Report, *About this poll*, no date [website – accessed 30 August 2019]

[269] For a discussion of the debates over nuclear energy that affect public opinion, see: Ho S and Kristiansen S, Environmental Debates over Nuclear Energy: Media, Communication, and the Public, *Environmental Communication*, 2019, Vol 13(4), 431-439

pattern changed significantly following the accident at the Fukushima nuclear facility on 11 March 2011. Fifty three per cent of respondents to the 21 March 2011 poll opposed nuclear power, and 35% supported nuclear power. The percentage of respondents who did not know whether or not they supported nuclear power has fluctuated around 20% over the past decade. In the latest June 2019 poll, 16% of respondents remained undecided.

Figure 41: Do you support or oppose Australia developing nuclear power plants for the generation of electricity?[270]

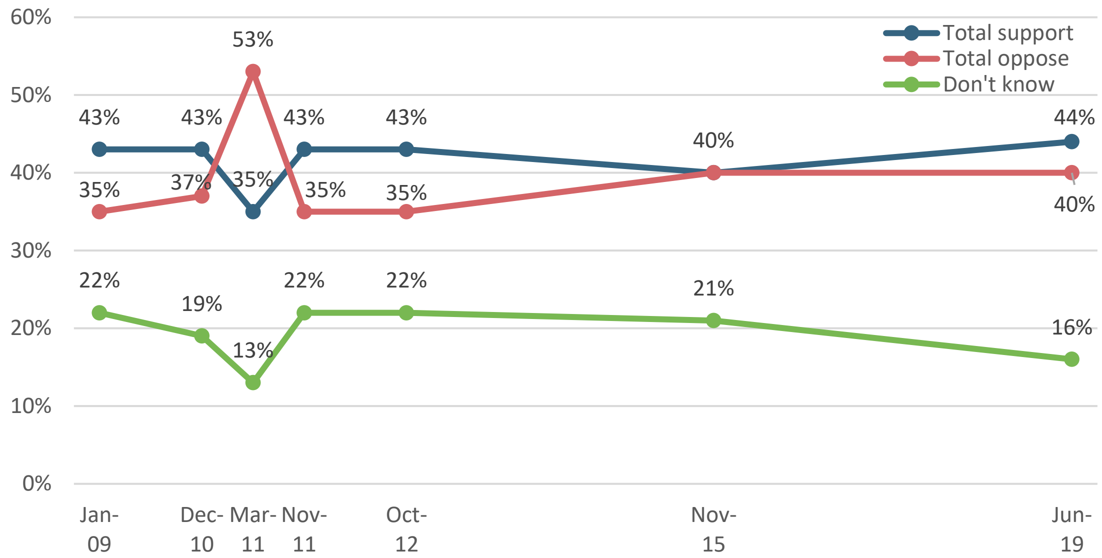

Table 11: Do you think Australia should put more emphasis, less emphasis or about the same emphasis as it does now on producing domestic energy from the following sources?[271]

	More emphasis	Same emphasis	Less emphasis	Don't know
Solar power	71%	14%	4%	11%
Wind	62%	20%	6%	12%
Hydro	55%	25%	4%	17%
Gas	22%	41%	20%	17%
Nuclear power	23%	25%	32%	21%
Coal	9%	25%	50%	16%

270 Essential Poll, Nuclear Power Plants, no date [website – accessed 30 August 2019]; Murphy K, Australians' support for nuclear plants rising – but most don't want to live near one, *The Guardian*, 18 June 2019. For a discussion of the historical, cultural, economic and political influences that have in combination shaped public opinion in Australia, see: National Academies Forum, *Understanding the Formation of Attitudes to Nuclear Power in Australia*, 2010.

271 Essential Report, *Energy Sources*, 26 May 2015 [website – accessed 19 September 2019]

On 26 May 2015, an Essential poll asked respondents about the emphasis Australia should place on different energy sources (Table 11). Twenty three per cent of respondents thought Australia should place more emphasis on nuclear power, 25% thought that the same emphasis should be placed on nuclear power, and 32% thought that Australia should place less emphasis on nuclear power. Coal received less support than nuclear, and renewables received more support than nuclear. The same question was asked in an earlier September 2014 poll. The only substantial difference observed was an increase in respondents stating that more emphasis should be placed on hydro (up to 55% from 46%).

On 7 November 2012, an Essential poll asked respondents whether they agreed or disagreed with a series of statements about nuclear power (Table 12). Seventy seven per cent supported the development of renewable energy options before nuclear, 63% agreed that nuclear power isn't worth it because of the need to manage radioactive waste, and 62% agreed that nuclear power is too risky because of the risk of serious accidents. Respondents were approximately evenly split with regards to nuclear power being a good way to reduce greenhouse emissions, and the statement that it is logical for Australia to develop nuclear power given it has its own uranium supplies.

Table 12: Do you agree or disagree with the following statements?[272]

	Strongly agree	Agree	Disagree	Strongly disagree	Don't know
Nuclear power is a good way to reduce greenhouse emissions	10%	30%	19%	16%	25%
We should develop renewable energy options before nuclear	41%	36%	8%	3%	12%
Nuclear power is too risky because of the risk of serious accidents	28%	34%	20%	7%	12%
Nuclear power isn't worth it because of the need to manage radioactive waste	32%	31%	17%	5%	15%
Establishing a nuclear industry would be too expensive	17%	25%	23%	6%	29%
We have our own uranium supplies so it's logical we should develop nuclear power	9%	28%	22%	18%	23%

Other results from Essential poll questions on nuclear power include:[273]

- In June 2019, 28% of respondents agreed, and 60% disagreed, with the statement "I would be comfortable living close to a nuclear power plant";[274] and
- In June 2015, the poll asked "Do you support or oppose Australia developing nuclear waste storage facilities?" Thirty one per cent of respondents expressed their support and 50% expressed opposition.[275]

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[272] Essential Report, *Nuclear Power*, 7 November 2012 [website – accessed 19 September 2019]

[273] These results exclude the category of respondents who answered "Don't know".

[274] Murphy K, Australians' support for nuclear plants rising – but most don't want to live near one, *The Guardian*, 18 June 2019

[275] Essential Report, *Nuclear Waste Storage*, 10 November 2015 [website – accessed 19 September 2019]

2014 study

A 2014 study reported on two nation-wide surveys that investigated the attitudes of the Australian public to nuclear power in relation to climate change (Table 13), and in comparison to other energy sources (Table 14). The first survey took place in 2010, with a follow-up survey in 2012 to see if attitudes had changed after the Fukushima accident of 11 March 2011. The surveys were administered online, with a total of 1,085 and 1,101 successful completions respectively.[276]

Table 13: Public attitudes to nuclear power in relation to climate change[277]

	Agree		Disagree		No opinion	
	2010	2012	2010	2012	2010	2012
I am willing to accept the building of nuclear power stations if it would help to tackle climate change	42.0	34.4	30.5	40.1	27.5	25.5
Promoting renewable energy sources, such as solar and wind power, is a better way of tackling climate change than nuclear power	73.9	75.9	6.1	6.5	20.0	17.5

Notes: "Agree" and "disagree" includes the responses "strongly" or "tend to". "No opinion" includes the responses "neither agree nor disagree" and "no opinion/don't know"

Table 14: Public opinion of different energy sources[278]

	Favourable		Neither		Unfavourable		Don't know	
	2010	2012	2010	2012	2010	2012	2010	2012
Biomass	40.6	40.1	28.7	28.6	18.0	13.5	12.8	17.7
Coal	22.6	27.3	30.9	28.5	40.9	39.3	5.6	4.9
Gas	50.7	49.7	30.5	28.0	14.7	18.4	4.1	3.9
Hydro	70.7	71.1	17.0	15.1	6.0	8.3	6.4	5.6
Nuclear	30.9	26.9	22.6	18.6	41.0	50.1	5.6	4.4
Oil	19.2	22.0	32.8	28.9	42.4	44.5	5.6	4.7
Sun/solar	88.9	84.8	5.9	7.5	2.8	5.5	2.4	2.2
Wind	80.1	78.1	11.3	10.4	4.6	8.6	4.0	3.0

The study also examined opinions on nuclear power (Tables 15 and 16). The following tables show that significant proportions of the public felt that they needed more information to make an informed decision about whether or not they support nuclear power. In 2010 and 2012 respectively:

- 58.5% and 49.0% of respondents felt they needed more information to form a clear opinion; and
- 30.4% and 25.6% were not sure whether they supported or opposed nuclear power.

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[276] Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65, p 648

[277] Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65, p 651

[278] Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65, p 649

Table 15: Public opinion concerning statements about nuclear power[279]

	Agree		Disagree		No opinion	
	2010	2012	2010	2012	2010	2012
There are a lot of good things about nuclear power	38.0	40.3	23.3	30.9	38.6	28.8
I need more information to form a clear opinion about nuclear power	58.5	49.0	19.5	25.4	22.0	25.7
I feel confident that the Australian government will adequately regulate the nuclear power industry to ensure public safety	40.7	34.4	31.1	40.0	28.2	25.6
I don't trust the nuclear industry to run nuclear power stations safely	40.2	50.0	23.3	20.1	36.4	30.0

Table 16: Which, if any, of the following statements most closely describes your own opinion about nuclear power discussion in Australia today?[280]

	2010	2012
Overall, I support nuclear power	29.0	24.4
Overall, I oppose nuclear power	31.7	41.4
I am not sure whether I support or oppose nuclear power	30.4	25.6
I don't care what happens with nuclear power	1.8	1.6
None of these/no opinion/don't know	8.1	7.9

14.2 International

United States

Figure 42 presents the results from Gallup surveys conducted in the US between 1994 and 2019. In 1994, the percentage of survey respondents who favoured the use of nuclear power plants was 20% greater than the percentage of respondents who opposed their use. In 2019, an equal percentage of respondents (49%) favoured and opposed the use of nuclear power plants.

United Kingdom

In 2019, the UK Department for Business, Energy and Industrial Strategy surveyed 4,224 respondents asking for their opinions on nuclear energy (Figures 43 and 44). The proportion of respondents who supported nuclear power exceeded the proportion who opposed nuclear power for all questions asked in the survey. The proportion who neither supported nor opposed nuclear power was higher than 30% for all questions.

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[279] Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65, p 650

[280] Bird DK et al, Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster, *Energy Policy*, 2014, Vol 65, p 649

Figure 42: Do you strongly favor, somewhat favor, somewhat oppose or strongly oppose the use of nuclear energy as one of the ways to provide electricity for the U.S.?[281]

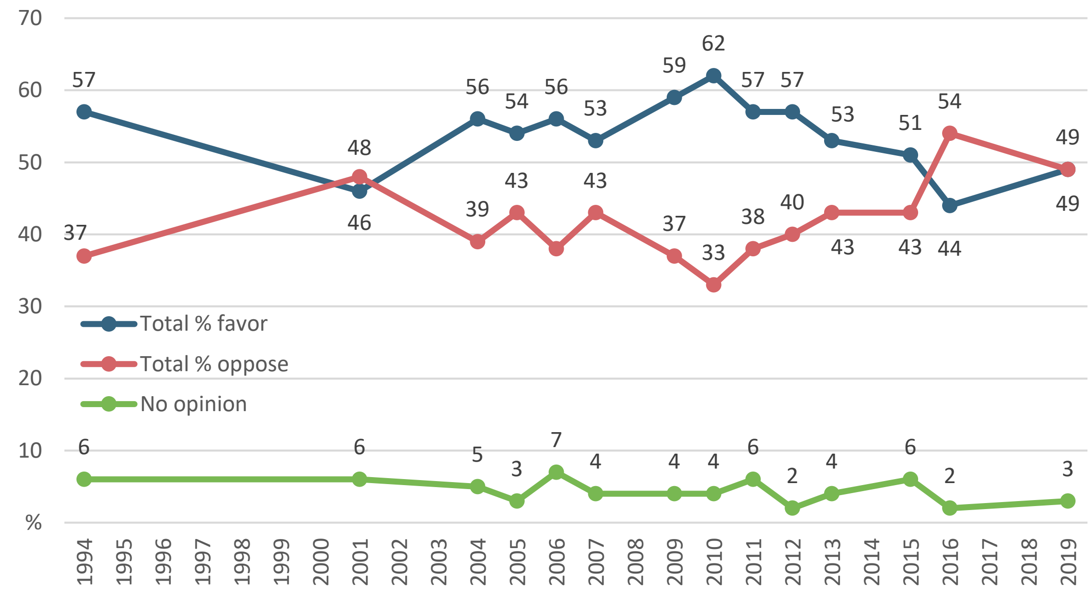
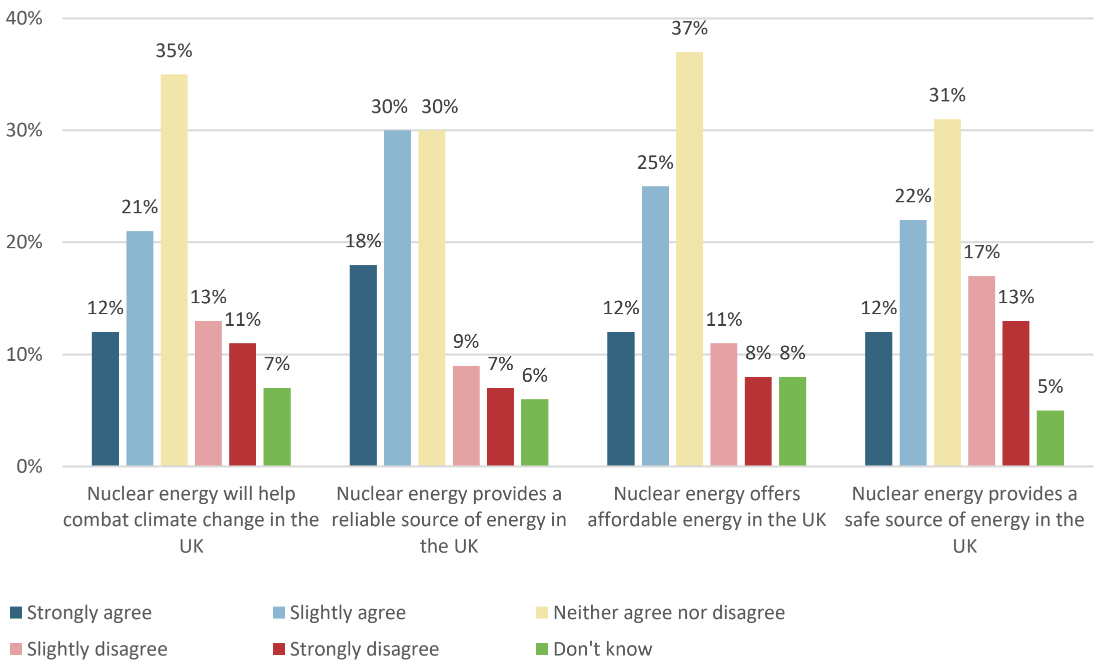


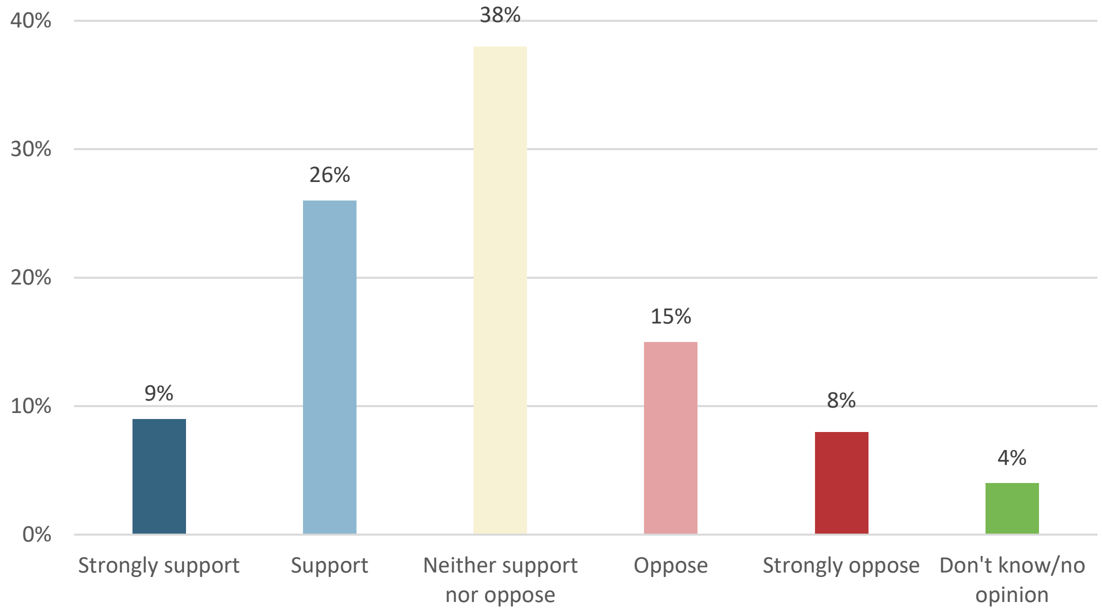
Figure 43: How much do you agree or disagree with the following statements about nuclear energy?[282]



281 Gallup, Energy, no date [website – accessed 30 August 2019]

282 UK Department for Business, Energy and Industrial Strategy, How much do you agree or disagree with the following statements about nuclear energy?, *Statista*, 17 September 2019

Figure 44: From what you know, or have heard about using nuclear energy for generating electricity in the UK, do you support or oppose its use?[283]



[283] UK Department for Business, Energy and Industrial Strategy, From what you know, or have heard about using nuclear energy for generating electricity in the UK, do you support or oppose its use?, *Statista,* 9 August 2019

QUESTIONS FROM URANIUM MINING AND NUCLEAR ENERGY

(3) What are the economic, social and environmental opportunities and risks associated with uranium mining in NSW?

(4) Under what conditions would uranium mining be viable in NSW?

(5) What are the economic, social and environmental opportunities and risks associated with nuclear energy in NSW?

(6) Under what conditions would nuclear power generation be viable in NSW?

(7) What is the optimal investment model to create a nuclear energy industry in NSW? How does the return on investment compare with other energy options?

(8) Are private sector financial organisations interested in financing nuclear power projects in NSW should current prohibitions be repealed?

(9) How would radioactive waste from nuclear power generation be managed?

(10) What is the current level of support amongst the NSW public for uranium mining and nuclear energy?

D. REGULATORY FRAMEWORKS

The object of the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019 (the Repeal Bill) is to repeal the *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986* (the 1986 Act). In order to assess the effect of the Repeal Bill, the current prohibitions on uranium mining and nuclear power plants in NSW created by the 1986 Act are discussed in detail (chapter 15), as are the effects of relevant Commonwealth laws (chapter 17).

The following discussion (chapters 17 and 18) indicates that, should the Repeal Bill be enacted, a prohibition on nuclear power plants in NSW will remain, due to the effect of the existing Commonwealth prohibitions. Uranium mining in NSW would be permitted subject to approval at the Commonwealth and State levels under, respectively, the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*, the *Environmental Planning and Assessment Act 1979 (NSW)* (EP&A Act 1979), and the *Mining Act 1992 (NSW)*.

Legislation prohibiting certain nuclear activities has also been enacted by other Australian jurisdictions (chapter 19). Ultimately, States can legislate to regulate the nuclear fuel cycle due to their ownership of uranium deposits and the power vested in State Parliaments by their respective Constitutions to enact laws for the peace, welfare and good government of their State.[284] However, as is the case with respect to NSW's 1986 Act, legislation in other States can be invalidated by validly enacted Commonwealth laws due to the operation of section 109 of the Commonwealth Constitution.

If the 1986 Act is repealed, before nuclear activities could be undertaken in NSW consideration would need to be given to updating existing regulatory frameworks, or creating new regulatory frameworks, in order to ensure that those activities could be undertaken efficiently and safely (chapter 20).

15. Current NSW legislation

15.1 Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986

Object

The Uranium Mining and Nuclear Facilities (Prohibition) Bill 1986 (the 1986 Bill) was introduced into the Legislative Assembly and read for a second time on 1 December 1986 by Peter Cox MP; then Minister for Industry and Small Business, and Minister for Energy and Technology, on behalf the Unsworth Labor Government.[285] In the Second Reading speech to 1986 Bill Mr Cox MP said:

[284] Carney G, *Constitutional Framework for Regulation of the Australian Uranium Industry* (2007) 26 *ARELJ* 235 at 237. See, for instance, section 5 of the *Constitution Act 1902* (NSW).

[285] Cox P, Uranium Mining and Nuclear Facilities (Prohibitions) Bill 1986, *NSW Hansard*, 1 December 1986, p 7362. For the Second Reading speech in the Legislative Council, see Hallam J, Uranium Mining and Nuclear Facilities (Prohibitions) Bill, *NSW Hansard*, 4 December 1986, p 7,995.

> The clear objective of this bill, which I now commend to the House, is the protection of the health, safety and welfare of the people of New South Wales and the environment in which we live. This will be achieved through the prohibition against prospecting or mining for uranium or the construction or operation of nuclear reactors and other facilities in the nuclear fuel cycle.[286]

This objective is set out in section 3 of the 1986 Act, which states that the object of the Act is:

> (a) to prohibit mining for uranium, and
>
> (b) to prohibit the construction or operation of nuclear reactors and other facilities in the nuclear fuel cycle,
>
> in order protect the health, safety and welfare of the people of New South Wales and the environment in which they live.[287]

In seeking to assure the achievement of these objectives, section 5 provides that the 1986 Act binds the Crown and section 6(1) states that the 1986 Act prevails over any other Act or law to the contrary.

Notably, the debates in the Legislative Assembly and Legislative Council both referred to the Chernobyl nuclear meltdown, which had occurred on 26 April 1986.[288]

The 1986 Act was enacted, received Royal Assent, and commenced on 9 January 1987.[289]

Key terms

Key terms used in the 1986 Act are defined in section 4 and include:

- Enrichment: which, in relation to nuclear material, is defined to mean "any process by which the proportion of an isotope is increased in relation to the natural abundance of the isotope";
- Mine: which, in relation to uranium, is defined to include producing uranium ore concentrates in a mill or other plant;
- Nuclear fuel cycle: which is defined to include "any process or step in the utilisation of material capable of undergoing nuclear fission, including its ultimate disposal";
- Nuclear material: which is defined to mean "any radioactive substance associated with the nuclear fuel cycle, including radioactive waste

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[286] Cox P, Uranium Mining and Nuclear Facilities (Prohibitions) Bill 1986, *NSW Hansard*, 1 December 1986, p 7,362-7,363

[287] Section 3 of the *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986*

[288] World Nuclear Association, *Chernobyl Accident 1986*, June 2019 [website—accessed 22 July 2019]

[289] Except for sections 1 and 2, which commenced on the date of assent of 18 December 1986, section 2(2) and Government Gazette No 6 of 9.1.1987, p 66.

material".

- Nuclear reactor: which is defined to mean "a device designed to produce controlled nuclear fission".

Additionally, the term "nuclear facility" is defined in section 4 to have the meaning provided in section 8, namely:

> (a) a facility for the conversion of uranium ore into uranium hexafluoride or any other chemical in order to enable its enrichment,
>
> (b) an isotope separation plant or other facility for the enrichment of nuclear material,
>
> (c) a fabrication plant or other facility for transforming nuclear material into a form suitable for use as fuel in a nuclear reactor,
>
> (d) a nuclear reactor, whether or not designed for the purpose of generating electricity,
>
> (e) a reprocessing plant or other facility for the chemical separation of fuel that has been irradiated in a nuclear reactor, or
>
> (f) a separate storage installation for the storage or disposal of any nuclear material (including radioactive waste material) in the nuclear fuel cycle, being nuclear material used in or resulting from any of the facilities described in paragraphs (a)–(e).

The prohibitions

Prohibition on uranium mining

Section 7(1) of the 1986 Act states that "a person shall not mine for uranium".[290] A maximum penalty of 1,000 penalty units ($110,000) applies to an offence against section 7.[291]

Section 7(2) clarifies that an authority, mineral claim or opal prospecting licence under the *Mining Act 1992* does not authorise the holder of the authority, claim or licence to mine for uranium in contravention of section 7(1). It is further clarified by section 7(3) that a person who mines uranium in the course of mining for some other mineral is not guilty of an offence under this section if:

> (a) the person establishes that there are reasonable grounds for believing that the amount of uranium in the total amount of material that has at that stage been removed from the land being mined does not exceed .02 per cent by weight; and
>
> (b) the person complies with such conditions (if any) as may be prescribed by the regulations with respect to the mining and the treatment, handling and disposal

[290] "Person" is defined in section 21 of the *Interpretation Act 1987* to include "an individual, a corporation and a body corporate or politic".

[291] Section 17 of the *Crimes (Sentencing Procedure) Act 1999* provides that one penalty unit equals $110.

of the material containing uranium.

Prospecting or exploration originally prohibited but now permitted

The original objects of the 1986 Act, as set out in section 3, also extended to prohibiting "prospecting" for uranium. The term "prospecting" was defined in section 4 to mean:

> search for uranium ore bodies by any means, and includes to carry out works or remove samples to test the uranium-bearing qualities of land for the purpose of mining.[292]

Reflecting that object, section 7 of the 1986 Act originally stated "a person shall not prospect or mine for uranium".[293]

On 4 April 2012, the words "prospect" and "prospecting" were omitted from sections 3, 4 and 7 of the 1986 Act by Schedule 3 of the *Mining Legislation Amendment (Uranium Exploration) Act 2012*.[294] The policy change underlying the removal of the prohibition on uranium exploration was discussed in the Second Reading speech to the Mining Legislation Amendment (Uranium Exploration) Bill 2012 by Chris Hartcher MP, former Minister for Resources and Energy, Special Minister of State, and Minister for the Central Coast, in the O'Farrell Liberal Government:

> While the amendments themselves are straightforward, they reflect the significant change in government policy in this State. For the first time in 26 years the policy on uranium exploration has been re-examined and revised to allow exploration for uranium. This policy change follows a request from the Commonwealth Government for New South Wales and Victoria to review their prohibition on uranium exploration and mining. New South Wales and Victoria are the only two mainland States to still have a prohibition on uranium exploration and mining. South Australia, Western Australia and the Northern Territory have uranium exploration and mining industries that make Australia the world's third largest exporter of uranium. Queensland's uranium legislation provides for both exploration and mining, but currently only exploration is permitted. In 2010-2011 exploration expenditure for uranium in Queensland was $18 million. Internationally, many countries are turning to uranium as a low-carbon source of energy that can provide for their rapidly growing energy needs...[295]

Although the prohibition on prospecting for uranium in section 7 of the 1986 Act has been removed, prospecting without an exploration licence remains an offence under section 5 of the *Mining Act 1992*. Applications for an exploration

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[292] Historical version of the *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986*, 8 December 2000 to 31 December 2011.

[293] *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986* (as originally enacted)

[294] The *Mining Legislation Amendment (Uranium Exploration) Act 2012* also made related amendments to the *Mining Act 1992*, *Mining Regulation 2010*, *Radiation Control Act 1990*, *Aboriginal Land Rights Act 1983* and the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*.

[295] Hartcher C, Mining Legislation Amendment (Uranium Exploration) Bill 2012, *NSW Hansard*, 16 February 2012, p 8,465-8,467

licence may be made under section 13 of the *Mining Act 1992*.[296] Section 24 of the *Mining Act 1992* states that exploration licences may be granted over any "group of minerals". "Group of minerals" is defined by section 6(1) and Schedule 2 of the *Mining Regulation 2016* to include uranium and thorium. Section 14 of the *Mining Act 1992* provides that the Minister may, by notice published, invite tenders for exploration licences.

Section 28 provides that an exploration licence must include a description of the land over which it is granted; a list of the groups of minerals over which it is granted; the conditions to which it is subject; and the period for which it is to have effect. Pursuant to section 29(1), the holder of an exploration licence may, in accordance with the conditions of the licence, prospect on the land specified in the licence for the specified group of minerals. Following the repeal of the uranium exploration ban, six companies were invited by the NSW Government to apply for uranium exploration licences.[297] One company submitted an application but this was withdrawn in April 2016.[298]

Prohibition on constructing or operating certain nuclear facilities

Section 8(2) of the 1986 Act states that "a person shall not construct or operate a nuclear facility".[299] A maximum penalty of 1,000 penalty units ($110,000) applies to that offence.[300] Section 8(3)(a) of the 1986 Act states that the prohibition created by section 8(2) does not prevent the construction or operation, under an Act of the Commonwealth, of a nuclear facility by the Australian Atomic Energy Commission (or by any authority of the Commonwealth that replaces that Commission).

The Australian Atomic Energy Commission was established in 1952 and operated under the *Atomic Energy Act 1953 (Cth)*.[301] It was replaced in 1987 by the Australian Nuclear Science and Technology Organisation (ANSTO), which principally operates under the *Australian Nuclear Science and Technology Organisation Act 1987 (Cth)*. ANSTO's functions include conducting research and development in relation to nuclear science and technology; producing and using radioisotopes, isotopic techniques and nuclear radiation for medicine, science, industry, commerce and agriculture; and managing radioactive materials and waste arising from various prescribed activities. ANSTO operates a number of facilities, including the Open Pool Australian Lightwater (OPAL) nuclear reactor at Lucas Heights and the Australian Synchrotron in Melbourne.

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296 See: Form EL1: Application for an Exploration Licence, February 2018 (v4.13)

297 Breen J, Slow uptake of NSW uranium exploration licenses, *ABC News*, 18 March 2015

298 Nuclear Energy Agency, International Atomic Energy Agency, *Uranium 2018: Resources, Production and Demand*, 2018, p 133; Nicholls S, NSW uranium push a failure as sole exploration candidate withdraws, *Sydney Morning Herald*, 13 May 2016

299 "Person" is defined in section 21 of the *Interpretation Act 1987* to include "an individual, a corporation and a body corporate or politic".

300 Section 17 of the *Crimes (Sentencing Procedure) Act 1999* provides that one penalty unit equals $110.

301 National Archives of Australia, *Australian Atomic Energy Commission — Fact Sheet 253*, no date [website—accessed 25 July 2019]

Section 8(3)(b) of the 1986 Act states that the prohibition created by section 8(2) does not prevent the construction or operation of a facility for the storage or disposal of any radioactive waste material resulting from the use of nuclear materials for research or medical purposes, or for any other purpose authorised under the *Radioactive Substances Act 1957*. (On 1 September 1993, the *Radioactive Substances Act 1957* was repealed by section 43(1) of the *Radiation Control Act 1990*).[302]

Section 9 clarifies that an authority of the State is not authorised by any other Act to approve or operate a nuclear reactor for the purpose of generating electricity.

15.2 Radiation Control Act 1990

The *Radiation Control Act 1990* and *Radiation Control Regulation 2013* regulate the existing use of radiation for medical, research and industrial purposes. These statutes are administered by the EPA. The EPA has powers to regulate:

> the use, sale, giving away, disposal, storage, possession, transport, installation, maintenance or repair, remediation or clean-up of regulated material (radioactive substances, ionising radiation apparatus, non-ionising radiation apparatus of a kind prescribed by the Regulations and sealed source devices) in NSW.[303]

16. The Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019

The Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019 (the Repeal Bill) was introduced as a Private Members Bill into the NSW Legislative Council on 6 June 2019 by Mark Latham MLC.[304]

16.1 Object

The underlying policy objective of the Repeal Bill was articulated by Mr Latham MLC in its Second Reading speech as:

> to liberate a significant part of the New South Wales power and resource sector to create jobs, investment and, most of all, to undertake the long-term planning needed to keep the lights on in New South Wales. …
>
> The best insurance for keeping the lights on and doing something positive about emission reduction is nuclear. Renewables have a place but they must be supplementary to base load power. If the sun is not shining and the wind is not blowing, there is nothing to despatch. There is no dispatchable base load power. That is the key element. …[305]

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[302] Section 2 and Government Gazette No 94 of 27.8.1993, p 4,867. Section 6(2) of the 1986 Act clarifies that nothing in the 1986 Act affects the operation of the *Radiation Control Act 1990* or the *Work Health and Safety Act 2011*.

[303] NSW Environmental Protection Authority, *Managing radiation in NSW*, no date [website—accessed 31 July 2019]

[304] This discussion relates to the Repeal Bill at the First Proof stage.

[305] Latham M, Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019, *NSW*

16.2 Provisions

The key provision of the Repeal Bill is clause 3, which repeals the 1986 Act in its entirety.

Clause 4 of the Repeal Bill amends the *Mining Act 1992* by omitting section 10A of that Act. Section 10A states that an authorisation (other than an exploration licence or an environmental assessment permit relating to an exploration licence) may not be granted in respect of uranium. An authorisation includes a mining lease granted under Part 5 of the *Mining Act 1992*. Section 73 entitles the holder of a mining lease to mine on specified land for specified minerals.

Clause 5 of the Repeal Bill amends the *Land and Environment Court Act 1979* in order to omit sections 20(1)(ba), 20(3)(a) and 21(fa); which provide the court with its Class 4 and Class 5 jurisdiction to hear and dispose of matters arising under sections 10(1) and 12 of the 1986 Act.

17. Commonwealth laws

Unlike the States, the Commonwealth cannot directly regulate the nuclear fuel cycle because its legislative powers in section 51 of the Constitution do not expressly include mining or energy.[306] Instead, it must rely on a sufficient connection with any of the listed heads of legislative power in section 51. Commenting on this issue, Professor Gerard Carney noted:

> Potential heads of power are the powers in s 51 to make laws with respect to: para (i) interstate and overseas trade and commerce; para (vi) defence; para (xx) foreign, trading and financial corporations; and para (xxix) external affairs. The Commonwealth may also indirectly regulate uranium exploration, mining and processing through its taxation regime (s 51(ii)). There is, however, greater scope for direct Commonwealth regulation of the sale and transportation of uranium products from the States pursuant to the interstate and overseas trade and commerce power in s 51(i).[307]

Commonwealth laws prohibit the use of nuclear energy for electricity generation across Australia. Commonwealth laws regulate the use of nuclear energy for medical and research purposes, and permit uranium mining subject to Ministerial approval.

The repeal of the 1986 Act by the Repeal Bill would not affect the existing Commonwealth prohibitions on the use of nuclear energy for electricity generation. Those Commonwealth prohibitions and regulations would continue to apply in NSW. This outcome was commented upon by Mark Latham MLC in the Second Reading speech to the Repeal Bill:

Hansard, 6 June 2019, p 56 and 57

[306] Carney G, Constitutional Framework for Regulation of the Australian Uranium Industry (2007) 26 *ARELJ* 235 at 237

[307] Carney G, Constitutional Framework for Regulation of the Australian Uranium Industry (2007) 26 *ARELJ* 235 at 238

> Some might say, "What about the Federal ban on nuclear?" The adoption of this legislation is only the first step to lift the New South Wales ban but it would send a positive message to the Federal Government that it should do the same. I welcome the statement of two Coalition MPs in the weekend media that they would move for a Senate inquiry into nuclear and possibly lifting the Federal ban. There is work to be done in that regard. The *Australian Radiation Protection and Nuclear Safety Act 1998* and the *Environmental Protection and Biodiversity Conservation Act 1999* in Canberra prohibit the approval, licensing, construction or operation of a nuclear fuel fabrication plant, nuclear power plant or enrichment. These Acts should be amended to enable nuclear energy to develop in Australia.
>
> Lifting the bans would not mean that changes overnight. Lifting the bans is the first step. The next step is testing the market to find out what private investment capacity there is for this new form of power generation in Australia. If we do not take the first step there will be no second, third or fourth step and there will be no boost in dispatchable base-load power in our State.[308]

17.1 Environment Protection and Biodiversity Conservation Act 1999

Objects

The objects of the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (the EPBC Act 1999 (Cth)) are set out in section 3(1). Those objects include protecting the environment; promoting ecologically sustainable development; promoting the conservation of biodiversity; and promoting a co-operative approach to the protection and management of the environment (one that involves governments, the community, land-holders and Indigenous peoples).

Section 10 states that the Act is not intended to exclude or limit the concurrent operation of any law of a State or Territory, except so far as the contrary intention appears.

As discussed below, under the EPBC Act 1999 (Cth) actions that have, will have, or are likely to have a significant impact on the environment are generally either prohibited or require Ministerial approval to occur.

Prohibition on nuclear actions

Part 3 Division 1 Subdivision E of the EPBC Act 1999 (Cth) is entitled “Protection of the environment from nuclear actions”. Subdivision E is comprised of sections 21–22.

Section 21(1) of the EPBC Act 1999 (Cth) prohibits a constitutional corporation, the Commonwealth or a Commonwealth agency from taking a nuclear action that has, will have or likely to have a significant impact on the environment. A constitutional corporation includes foreign corporations and trading or financial

[308] Latham M, Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019, *NSW Hansard*, 6 June 2019, p 59

corporations formed within Australia.[309]

Section 21(2) of the EPBC Act 1999 (Cth) prohibits a person from taking a nuclear action that has, will have or is likely to have a significant impact on the environment, for the purposes of trade or commerce between Australia and another country or between two Australian States and Territories.

A prohibition against taking a nuclear action in a Territory that has, will have or is likely to have a significant impact on the environment is created by section 21(3) of the EPBC Act 1999 (Cth).

In respect of each of these three prohibitions, a civil penalty of 5,000 penalty units ($1,050,000) applies for an individual and 50,000 penalty units for a body corporate ($105,000,000).[310]

A “nuclear action” is defined in section 22 of the EPBC Act 1999 (Cth) to mean:

> (a) establishing or significantly modifying a nuclear installation;
>
> (b) transporting spent nuclear fuel or radioactive waste products arising from reprocessing
>
> (c) establishing or significantly modifying a facility for storing radioactive waste products arising from reprocessing;
>
> (d) mining or milling uranium ore;
>
> (e) establishing or significantly modifying a large-scale disposal facility for radioactive waste;
>
> (f) de-commissioning or rehabilitating any facility or area in which an activity described in paragraph (a), (b), (c), (d) or (e) has been undertaken;
>
> (g) any other action prescribed by the regulations.

“Nuclear installation” is defined in section 22 to mean:

> (a) a nuclear reactor for research or production of nuclear materials for industrial or medical use (including critical and sub-critical assemblies);
>
> (b) a plant for preparing or storing fuel for use in a nuclear reactor as described in paragraph (a);
>
> (c) a nuclear waste storage or disposal facility with an activity that is greater than the activity level prescribed by regulations made for the purposes of this section;
>
> (d) a facility for production of radioisotopes with an activity that is greater than the activity level prescribed by regulations made for the purposes of this section.

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[309] Section 51(xx) of the Commonwealth Constitution and section 528 of the *EPBC Act (Cth)*
[310] Section 4AA of the *Crimes Act 1914 (Cth)* states that “penalty unit” means the amount of $210

Uranium mining permitted subject to approval

Section 21(4) of the EPBC Act 1999 (Cth) provides that the prohibitions created by sections 21(1), 21(2) and 21(3) do not apply to an action if:

(a) An approval has been granted under Part 9; or

(b) Part 4 allows the action to be taken without an approval under Part 9.

Neither subsections (a) nor (b) create an exemption for nuclear power plants but they do create an exemption with respect to uranium mining. Section 140A (in Part 9) states that the Minister must not approve actions relating to the construction or operation of nuclear fuel fabrication plants, nuclear power plants, a nuclear enrichment plant, and a nuclear reprocessing facility. Section 37J (in Part 4) states that the Minister must not make a declaration in relation to the construction or operation of the same nuclear plants or facility. As these sections do not refer to uranium mining, it is permitted subject to Ministerial approval.[311]

17.2 Australian Radiation Protection and Nuclear Safety Act 1998

Objects

The object of the *Australian Radiation Protection and Nuclear Safety Act 1998 (Cth)* (the ARPNSA Act (Cth)), as set out in section 3, is to "protect the health and safety of people, and to protect the environment, from the harmful effects of radiation". It seeks to achieve that aim through the work of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and the Radiation Health and Safety Advisory Council,[312] and by regulating the use of controlled material, facilities and apparatus through a system of licences, enforcement and inspection provisions.

Prohibitions

Constructing, operating, possessing, or decommissioning a controlled facility without a licence, as well as preparing a site for a controlled facility or remediating a legacy site, is an offence against section 30(1) of the ARPNSA Act 1988 (Cth), which carries a penalty of 2,000 penalty units ($420,000).[313] A "controlled facility" is defined to mean a nuclear installation, a prescribed radiation facility, or a prescribed legacy site.[314] This offence applies only to a "controlled person". A "controlled person" is a Commonwealth entity; a Commonwealth contractor; a person in the capacity of an employee of a Commonwealth contractor; and a person in a prescribed Commonwealth place.[315] Note that under section 10(2) a licence must not be issued in respect of a nuclear fuel fabrication plant, a nuclear power plant, an enrichment plant or a reprocessing facility.

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311 See also sections 29(1) (in Part 4) and section 55, which relate to bilateral agreements between the Commonwealth and a State.

312 See Parts 3 and 4, respectively, of the *ARPNSA Act 1988 (Cth)*

313 Under section 4AA of the *Crimes Act 1914 (Cth)* a "penalty unit" equals $210

314 Section 13 of the *ARPNSA Act 1988 (Cth)*

315 Section 13 of the *ARPNSA Act 1988 (Cth)*

17.3 Nuclear Non-Proliferation (Safeguards) Act 1987

Objects

Section 3 of the *Nuclear Non-Proliferation (Safeguards) Act 1987 (Cth)* (the NNPS Act 1987 (Cth)) states that the objects of the Act are to give effect to obligations that Australia has as a party under:

- The Treaty on the Non-Proliferation of Nuclear Weapons;
- The Agreement between Australia and the International Atomic Energy Agency on the Application of Safeguards in connection with the Treaty on the Non-Proliferation of Nuclear Weapons;
- Supplementary Agreements with the International Atomic Energy Agency;
- Prescribed international agreements;
- The Convention on the Physical Protection of Nuclear Material; and
- The International Convention for the Suppression of Acts of Nuclear Terrorism.

The Director General of the Australian Safeguards and Non-Proliferation Office (ASNO) has a number of functions under the Act.

Prohibitions

Under Part II of the NNPS Act 1987 (Cth), permits are required to possess nuclear material (section 13), transport nuclear material (section 16), establish a nuclear facility (section 16A) and decommission a nuclear facility (section 16B). Under section 21, those permits do not make it lawful for the permit holder to do anything that is unlawful under another Commonwealth, State or Territory law.

Prohibitions exist for possessing nuclear material without a permit (section 23), transporting nuclear material without a permit (section 24), breaching conditions of a permit (section 25), establishing a facility without a permit (section 28A) and decommissioning a facility without a permit (section 29A).[316]

17.4 Customs (Prohibited Exports) Regulations 1958

Clause 9 of the *Customs (Prohibited Exports) Regulations 1958* applies to the materials set out in Schedule 7 of that Regulation, including uranium (in various isotopic forms) and thorium. Clause 9(3) prohibits the exportation of those goods from Australia unless the Minister has granted permission.

18. Interaction of Commonwealth and State laws

For the purposes of this issues paper, the interaction of Commonwealth and State laws involves two distinct issues:

[316] Offences have also been created relating to the Convention on the Physical Protection of Nuclear Material (sections 33–38) and in respect of nuclear terrorism (sections 38C–38E).

1. The effect of enacting the Repeal Bill given existing Commonwealth laws.
2. The scope for Commonwealth laws to override State prohibitions on nuclear activities.

18.1 The effect of enacting the Repeal Bill given existing Commonwealth laws

Enacting the Repeal Bill to repeal of the 1986 Act would have no effect on existing Commonwealth prohibitions on nuclear power plants. With respect to uranium mining, however, the situation differs. Repeal of the 1986 Act by the Repeal Bill would enable Ministerial approval of uranium mining in NSW. Approval for uranium mining would be required at both the Commonwealth and State level under, respectively, Part 9 of the EPBC Act 1999 (Cth) and Part 4 of the EP&A Act 1979.[317] An authority (mining lease) would also be required under section 5 of the *Mining Act 1992*.

18.2 The scope for Commonwealth laws to override State prohibitions on nuclear activities.

The interaction of Commonwealth and State laws was considered in a 2003 Parliamentary Inquiry into the storage and transportation of nuclear waste. The inquiry was established in light of Commonwealth Government plans to increase nuclear waste transportation and storage in NSW.[318] The Joint Select Committee on the Storage and Transportation of Nuclear Waste considered the interaction of Commonwealth and State laws, commenting that:

> As with so many issues in a federal system such as Australia's, commonwealth-state relations can be a tangle. This certainly seems to be the case with the regulation of radioactive waste. The *Uranium Mining and Nuclear Facilities (Prohibition) Act* is a practical means for the state government to formally express its and the public's opposition to all or part of the proposals.[319]

The Joint Select Committee on the Storage and Transportation of Nuclear Waste recommended that the NSW Government should obtain legal advice on the Commonwealth Government's *constitutional* power relating to nuclear technology.[320] The Government's response to the Committee's report stated:

> The NSW Government has previously sought legal advice on the

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[317] Also of relevance is clause 8A of the *State Environmental Planning Policy (State and Regional Development) 2011*, which sets out the circumstances in which the Independent Planning Commission becomes the designated consent authority for State significant development. Under Schedule 1[5] of the *State Environmental Planning Policy (State and Regional Development) 2011*, State significant development relevantly includes proposed mines in environmentally sensitive areas of State significance and mines with capital investment of more than $30 million.

[318] NSW Parliament, *Joint Select Committee on the Storage and Transportation of Nuclear Waste*, 2004, p 1

[319] NSW Parliament, *Joint Select Committee on the Storage and Transportation of Nuclear Waste*, 2004, p 45

[320] NSW Government, *NSW Government Response to the Inquiry into the Transportation and Storage of Nuclear Waste*, 10 November 2004, Recommendation 21, p 7

> Commonwealth's powers in this area which indicated that State law cannot override Commonwealth law. The NSW Government believes there is no reason to seek further legal advice at this time.[321]

This legal position is ultimately due to section 109 of the Commonwealth Constitution, which provides that Commonwealth laws prevail over State laws and that State laws are invalid to the extent of the inconsistency. Professor Carney has said:

> The States may prohibit or permit any stage of the nuclear fuel cycle on such terms and conditions as they fit. The only constraints on their power derive from valid inconsistent Commonwealth legislation … and restrictions on their power from the Commonwealth Constitution, principally, the freedom of interstate trade, commerce and intercourse under s 92, and the prohibition on the imposition of customs and excise duties under s 90.[322]

If the Repeal Bill is not enacted and there was a change in Commonwealth policy in favour of establishing in NSW uranium mining or nuclear power plants, the Commonwealth Government would be required to enact constitutionally valid legislation that, via section 109 of the Commonwealth Constitution, invalidates the 1986 Act.

19. Other State and Territory legislation prohibiting nuclear activities

Other States and Territories have enacted legislation similar to NSW's 1986 Act (Table 17). The scope of the legislation in each jurisdiction varies as to the extent to which it covers the areas of uranium mining, nuclear energy and nuclear waste. Victoria is the only other State that has enacted a prohibition on uranium mining, while Victoria and Queensland are the only other States that have enacted a prohibition on nuclear energy. The Queensland Act is distinctive in that it provides that if the Commonwealth is taking any step allowing the construction of a nuclear facility in Queensland, the Minister administering the Act is required to conduct a plebiscite to ascertain the views of the Queensland people.

Table 17: Legislation in other Australian jurisdictions

Legislation prohibiting uranium mining, nuclear energy and nuclear waste	
Victoria	*Nuclear Activities (Prohibitions) Act 1983*
Legislation prohibiting nuclear energy and nuclear waste	
Queensland	*Nuclear Facilities Prohibition Act 2007*
Legislation prohibiting nuclear waste, storage and transport	
South Australia	*Nuclear Waste Storage Facility (Prohibition) Act 2000*
Western Australia	*Nuclear Waste Storage and Transportation (Prohibition) Act 1999*
Northern Territory	*Nuclear Waste Transport, Storage and Disposal (Prohibition) Act 2004*

[321] NSW Government, *NSW Government Response to the Inquiry into the Transportation and Storage of Nuclear Waste*, 10 November 2004, p 7

[322] See: Carney G, *Constitutional Framework for Regulation of the Australian Uranium Industry* (2007) 26 *ARELJ* 235 at 237

20. The need for a new regulatory framework

If the 2019 Repeal Bill is enacted, before nuclear activities could be undertaken in NSW consideration would need to be given to updating existing regulatory frameworks, or creating new regulatory frameworks, in order to ensure that those activities could be undertaken efficiently and safely.

The regulation of uranium mining in SA is outlined in Case Study 1 below. With respect to nuclear power plants and nuclear waste storage and disposal activities, the Royal Commission into the nuclear fuel cycle noted that this "would require changes to the existing regulatory frameworks to address specific hazards".[323] The Royal Commission commented:

> Different regulatory approaches affect the requirements placed on potential proponents. Outcomes-based approaches establish specific performance goals or outcomes for proponents to attain, but do not specify how they must be attained. In contrast, prescriptive approaches establish specific requirements for proponents and their activities, including proposed technical and other processes for meeting those requirements. Each approach has benefits and difficulties. In practice, and consistent with IAEA requirements, nuclear industry regulators around the world employ a graded range of adapted processes appropriate to the relevant activity and the nature of the associated safety or security risk.
>
> The preferred regulatory approach to creating and enforcing safety requirements would need to be determined following consultation and agreement between relevant state and federal government agencies, to ensure a coordinated approach. Irrespective of the approach chosen, it would need to be established in, or be clearly implicit from, the regulator's founding legislation. This would support consistent and coherent regulatory decision making, creating an environment in which potential proponents, the public and the international community have confidence in the process. This would be essential for any proposed new nuclear facility, both in encouraging investment and maintaining social consent.[324]

The regulation of nuclear power in the UK is summarised in Case Study 2, following an overview of international nuclear safety, security and environmental best practice standards.

20.1 Case Study 1: Regulation of uranium mining in South Australia

The SA Government states that it "openly and actively supports" exploration for uranium SA.[325] It further states that it has streamlined the project approval process in order to improve industry and community confidence, promote efficiency in mining operations, and protect the community and environment.[326]

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[323] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 157

[324] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 158-159

[325] SA Government, Department for Energy and Mining, *Uranium*, no date [website accessed 26 August 2019]. The relevant legislation in SA is the *Mining Act 1971 (SA)* and the *Radiation Protection and Control Act 1982 (SA)*.

[326] SA Government, Department for Energy and Mining, *Uranium*, no date [website accessed 26 August 2019].

The Royal Commission found that current regulatory practices in SA have been informed by the mistakes of the past.[327] For instance, at the Radium Hill uranium mine, which was operated by the SA Government from 1954 to 1961:

> …crushed waste rock containing traces of radioactive ore was used to construct roads and other infrastructure. Closure of the site simply involved the removal and sale of plant. The tailings dam, which was not an engineered structure but was built using uncompacted tailings, was not capped when the mine closed. As a result the wind dispersed tailings into the surrounding landscape.
>
> In the 1980s the government capped the tailings dam at Radium Hill; however, this was only a short-term solution to the problem of dispersion … subsequent erosion is occurring and the tailings are being exposed, although to a lesser extent than before they were capped. In future, it will be necessary to increase the capping thickness and reduce the angle of the dam walls to stem erosion.[328]

Likewise, at the Port Pirie treatment plant, which was operated by the SA Government from 1954 to 1962:

> …the tailings dams were built on tidal mud flats, a sensitive marine environment, and are uncapped. Although mitigated by levees, the risk remains for further dispersion of radioactive materials and metallic elements during flooding caused by king tides. [329]

At the State level, the current regulatory framework is administered jointly by the Mineral Resources Division (MRD) of the SA Government's Department for Energy and Mining, and the SA Environmental Protection Authority (EPA).[330] As noted above (at 3.1), the EPBC Act 1999 (Cth) also applies to uranium mining. The Royal Commission found that uranium mining in SA requires:

- An Environmental Impact Statement (EIS) to ensure the accurate identification and effective management of risks;
- A Program for Environment Protection and Rehabilitation (PEPR), which must be approved by regulators prior to the commencement of operations;
- Mines and related processing facilities be kept separate from sensitive environments; and
- An independent regulator to monitor and enforce compliance with regulatory requirements.[331]

SA's mining regulatory framework employs a graduated compliance and enforcement model, which incorporates assessments, compliance plans, audits,

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[327] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 14

[328] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 14-15

[329] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 15

[330] The EPA administers the *Environment Protection Act 1993 (SA)* and the *Radiation Protection and Control Act 1982 (SA)*; while the Acts administered by the MRD include the *Mining Act 1971 (SA)*, *Mines and Works Inspection Act 1920 (SA)*, *Roxby Downs (Indenture Ratification) Act 1982 (SA)* and *Broken Hill Proprietary Company's Indenture Act 1937 (SA)*. See further, Memorandum of Understanding between the Environment Protection Authority and Mineral Resources Division, 17 August 2012

[331] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 15-26

bonds, reviews, informal warnings, show cause obligations, directions, administrative penalties, prosecutions and licence disqualification.[332]

SA's uranium mines are required to provide State and Commonwealth regulators with a compliance report every 6 months.[333] In recent times, a number of incidents have been reported at the Honeymoon, Beverley North, Beverley and Olympic Dam uranium mines. In general, as detailed in the relevant incident reports, those incidents involved the spillage of relatively small quantities of material, and were found not to have caused harm to the environment or to persons.[334]

20.2 Regulating the nuclear energy industry

In overseas jurisdictions with a nuclear industry, the hazards and risks associated with each stage in the life cycle of a nuclear power plant are subject to regulation. These stages include:

- Design;
- Site selection;
- Construction;
- Operation;
- Decommissioning; and
- Decontamination.[335]

The summaries of international safety, security and environmental best practice standards below provide some indication of the range of matters that need to be considered at each stage of the life cycle. Note that the IAEA also publishes a set of technical measures, or Safeguards, through which it seeks to independently verify that nuclear facilities are not misused and nuclear material is not diverted from peaceful uses.[336]

International safety standards

In accordance with Article III of the *Statute of the International Atomic Energy Agency*, the IAEA develops and publishes Nuclear Safety Standards in order to

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[332] SA Government, *Mining Act compliance and enforcement in South Australia*, 2016, p 7 and 21-30

[333] SA Department for Energy and Mining, *South Australia Mineral Resources regulation report 2017*, 2018, p 27

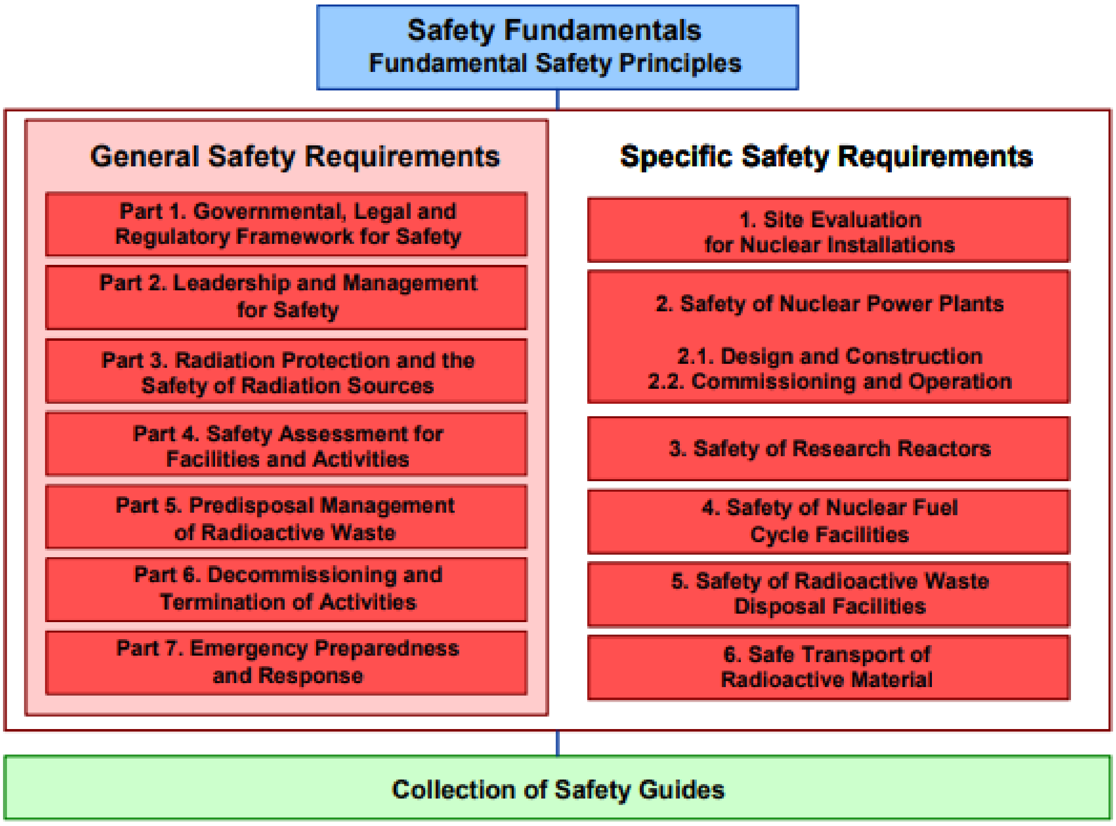
[334] See: SA Government, *Honeymoon uranium mine incident report summary*, *Beverley North uranium mine incident report summary*, *Beverley uranium mine incident summary report*, *Olympic Dam uranium incident summary report since 2003*, [websites – accessed 26 August 2019]

[335] See for example: US Nuclear Regulatory Commission, *New Reactors*, 8 January 2019 [website – accessed 12 September 2019]; US Nuclear Regulatory Commission, *Decommissioning of Nuclear Facilities*, 23 August 2019 [website – accessed 12 September 2019]

[336] IAEA, *Basics of IAEA Safeguards*, 2019 [website – accessed 12 September 2019]

protect the health of persons and minimise danger to life and property.[337] The structure of the safety standards are shown in Figure 45.

Figure 45: Structure of IAEA safety standards[338]



The 10 fundamental safety principles are outlined in Table 18.

Table 18: IAEA fundamental safety principles[339]

	Safety principle
1	Prime responsibility for safety rests with the person or organisation responsible for facilities and activities giving rise to a radiation risk
2	An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained
3	Effective leadership and management for safety must be established and sustained in organisations concerned with radiation risks
4	Facilities and activities that give rise to radiation risks must yield an overall benefit in order to be justified
5	Protection must be optimised and provide the highest level of safety than can be reasonably achieved

[337] International Atomic Energy Agency, *Safety Standards*, no date [website – accessed 5 September 2019]

[338] IAEA, *Long term structure of the IAEA Safety Standards and current status*, 5 September 2019, p 5. For more information on nuclear safety, see the following publications: IAEA, Nuclear Safety Annual Reviews 2001 to 2018

[339] International Atomic Energy Agency, *Fundamental Safety Principles*, 2006

	Safety principle
6	No individual must bear an unacceptable risk of harm
7	People and the environment, present and future, must be protected against radiation risk
8	All practical efforts must be made to prevent and mitigate nuclear or radiation accidents
9	Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents
10	Protective actions to reduce existing or unregulated radiation risks must be justified and optimised

International security standards

The IAEA defines nuclear security to be a focus on:

> … the prevention of, detection of, and response to, criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities.[340]

Nuclear security and nuclear safety share common objectives of protecting persons, property, society and the environment. Since 2006, the IAEA has been publishing a Nuclear Security Series to provide international consensus guidance on all aspects of nuclear security. IAEA is continuously updating its publications in order to respond to emerging issues such as cyber-threats and other new technologies. The series comprises four sets of publications:

- Nuclear Security Fundamentals, which establish the fundamental objective and essential elements of a State's national nuclear security regime;
- Recommendations, which set out measures that States should take in order to achieve and maintain an effective regime;
- Implementing Guides, which provide guidance on how States can implement the Recommendations; and
- Technical Guidance, which provide more detailed guidance on specific methodologies and techniques for implementing security measures.

According to the IAEA, the objective of a State's nuclear security regime is:

> …to protect persons, property, society, and the environment from harmful consequences of a nuclear security event.[341]

IAEA outlines 12 essential elements of an effective and appropriate nuclear security regime, which it considers should be applied insofar as is reasonable and practicable (Table 19).

[340] IAEA, *Objective and Essential Elements of a State's Nuclear Security Regime*, IAEA Nuclear Security Series No. 20, 2013, p 1

[341] IAEA, *Objective and Essential Elements of a State's Nuclear Security Regime*, IAEA Nuclear Security Series No. 20, 2013, p 3

Table 19: Essential elements of a State's nuclear security regime[342]

	Essential element
1	State responsibility, for meeting the nuclear security objective
2	Identification and definition of nuclear security responsibilities
3	Legislative and regulatory framework
4	International transport of nuclear material and other radioactive material
5	Offences and penalties including criminalization
6	International cooperation and assistance
7	Identification and assessment of nuclear security threats
8	Identification and assessment of targets and potential consequences
9	Use of risk informed approaches
10	Detection of nuclear security events
11	Planning for, preparedness for, and response to, a nuclear security event
12	Sustaining a nuclear security regime

International environmental standards

The IAEA publishes a Nuclear Energy Series that provides information on nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning. The series includes two publications that provides guidance on the environmental assessment of proposed nuclear power projects: *Strategic Environmental Assessment for Nuclear Power Programmes: Guidelines* (SEA Guidelines; 2018); and *Managing Environmental Impact Assessment for Construction and Operation in New Nuclear Power Programmes* (2014).

Strategic environmental assessment (SEA) is a decision support tool designed to facilitate transparent, accountable and environmentally sustainable decision making at the program level. It exists on a continuum with environmental impact assessment (EIA), which is generally more focussed at the project level. The SEA Guidelines identify eight environmental impact themes:

(1) Air, water, soil;

(2) Emissions (radiological and non-radiological), noise and vibration;

(3) Land, landscape, cultural heritage;

(4) Ecosystems;

(5) Climate change;

(6) Public health, well-being and safety;

(7) Economy (in connection with environmental implications) and society; and

(8) Natural hazards.[343]

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[342] IAEA, *Objective and Essential Elements of a State's Nuclear Security Regime*, IAEA Nuclear Security Series No. 20, 2013

[343] IAEA, *Strategic Environmental Assessment for Nuclear Power Programmes: Guidelines*, 2018,

These themes interact with the nuclear power life cycle in different ways. In many cases, they involve assessing the impact of a nuclear power plant on a theme; for example, water quality. In other cases, environmental themes may impact the operation of a nuclear power plant; for example, natural hazards such as seismic activities. Impacts from environmental themes on the nuclear power programme are generally assessed in accordance with safety standards. The SEA Guidelines also identify principles for adequate stakeholder engagement and public participation (see further chapter 21).

20.3 Case Study 2: Regulation of nuclear energy in the United Kingdom

The UK's Office for Nuclear Regulation (ONR) is responsible for independently regulating 37 currently licensed sites in the UK; including 15 nuclear reactors, fuel cycle facilities, waste management facilities, and defence nuclear facilities.[344] ONR also regulates the transport of civil nuclear material, the design and construction of new nuclear facilities, the decommissioning of sites, and liaises with international inspectorates and regulators to ensure the UK's compliance with its international legal obligations.[345] It is also responsible for assessing and approving security arrangements across the civil nuclear industry and promoting emergency preparedness.[346]

ONR's regulatory tools include licence conditions, inspections, assessments, improvement notices, enforcement letters, directions and prosecutions.[347] Additionally, a whole of life-cycle approach to regulation is taken, with plant operators required to submit a Funded Decommissioning Programme (FDP) before approval can be granted for the construction of a new nuclear power station.[348] The object of the regulatory framework administered by ONR is to ensure industry accountability and facilitate a culture of ongoing excellence and improvement:

> The responsibility for delivering a safe and secure nuclear industry rests with the nuclear industry itself. Our role, captured in our mission statement, is to provide efficient and effective regulation of the nuclear industry, holding it to account on behalf of the public. We use a wide range of regulatory tools to influence positively those we regulate, and to encourage the achievement of sustained

p 23

[344] Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 3; and World Nuclear Association, *Nuclear Power in the United Kingdom*, July 2019. ONR was established under and administers the *Energy Act 2013*. Other legislation that forms part of the regulatory framework for the nuclear industry in the UK is discussed at: ONR, *Legal Framework and regulations*, no date [website—accessed 29 August 2019]. See also the following infographic: UK Environment Agency, *New nuclear power stations: role of regulators*, 31 March 2017

[345] Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 3

[346] Office for Nuclear Regulation, *Annual Report and Accounts 2018/19*, p 17 and 54

[347] Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 18 and Office for Nuclear Regulation, *Annual Report and Accounts 2018/19*, p 33-34

[348] World Nuclear Association, *Nuclear Power in the United Kingdom*, July 2019. See also, UK Department of Energy & Climate Change, *The Energy Act 2008: Funded Decommissioning Programme Guidance for New Nuclear Power Stations*, 2011.

> excellence and continuous improvement in safety and security performance across the nuclear sector. [349]

The UK uses the IAEA's International Nuclear and Radiological Event Scale (INES) to rate reported events. ONR notes that it employs a nuclear safety inspector as the UK INES National Officer to verify the ratings given by the site.[350]

The Fukushima accident in 2011 and Chernobyl accident in 1986 were classified as Level 7 major accidents (the highest level).[351] The UK experienced a Level 5 accident in 1957, with the ONR stating:

> In the UK there has only been one event that was rated as a nuclear accident, i.e. Level 4 or above; this was the Windscale fire in 1957, which was retrospectively classified as a Level 5 event. This event was instrumental in the Government setting up the Nuclear Installations Inspectorate, since incorporated into ONR, to provide independent regulation of the civil nuclear power programme which was then being embarked upon.[352]

In 2018–19, ONR issued nine improvement notices, 35 enforcement letters and one direction, and commenced three prosecutions in relation to three incidents.[353]

The UK's Environment Agency is responsible for regulating the environmental performance of the nuclear industry, in accordance with the *Nuclear Sector Plan*. This Plan sets eight environmental performance objectives for the nuclear sector:

(1) Minimise the amount of natural resources used;

(2) Recognise the impact of climate change;

(3) Minimise discharges to air and water;

(4) Minimise and manage solid waste;

(5) Demonstrate sound environmental management and leadership;

(6) Manage land quality and biodiversity;

(7) Improve or maintain a very high level of regulatory compliance; and

(8) Achieve better regulation.

The UK's Nuclear Decommissioning Authority is responsible for decommissioning and cleaning up the UK's 17 earliest nuclear facilities, and ensuring radioactive and non-radioactive waste from those facilities is safely managed.[354]

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349 Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 3

350 Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 21

351 Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 21

352 Office for Nuclear Regulation, *A guide to Nuclear Regulation in the United Kingdom*, 2016, p 21

353 Office for Nuclear Regulation, *Annual Report and Accounts 2018/19*, p 39-40

354 UK Nuclear Decommissioning Authority, *About us*, no date [website – accessed 21 August

QUESTIONS FROM REGULATORY FRAMEWORKS

(11) If a nuclear energy industry were to be allowed in NSW, what are the optimal regulatory settings to ensure the safe and secure operation of:

a. Uranium mining;
b. Nuclear power generation; and
c. Nuclear waste disposal.

(12) Should uranium mining continue to be prohibited in NSW?

(13) Should nuclear power generation continue to be prohibited in NSW?

2019]

E. COMMUNITY ENGAGEMENT

21. Community engagement

The question of how the community is included in all stages of the decision-making process is an important consideration for proponents of uranium mining, nuclear energy and nuclear waste storage projects. This chapter discusses the concept of community engagement; a process which can take various forms but which ultimately seeks to address the issues of social impact, distributive justice, intragenerational and intergenerational equity, and social licence. Some of these terms have a legislative basis and most are used in policy guidelines. As discussed below, they are interpreted and applied by the courts in relation to a variety of development proposals.

21.1 Social impact

International guidelines define social impact as:

> …something that is experienced or felt in either a perceptual (cognitive) or a corporeal (bodily, physical) sense, at any level, for example at the level of an individual person, an economic unit (family/household), a social group (circle of friends), a workplace (a company or government agency), or by community/society generally.[355]

In short, social impacts associated with a project include all the issues that affect or concern people, whether directly or indirectly.[356] Environmental impacts can also be social impacts "because people depend on the environment for their livelihoods and because people may have place attachment to the places where projects are being sited".[357]

The Social Impact Assessment Guideline issued by DPE in 2017 for State significant mining and other resource projects defines social impact in that context as "a consequence experienced by people due to changes associated with a State significant resource project".[358] The word "social" is defined to mean "[o]f, or relating to, the lives, activities, relationships and networks of people and communities".[359]

The guideline outlines nine categories of change involving social impact:

- Way of life: including housing, employment, recreation, and interaction;
- Community: including character, cohesion and sense of place;

[355] Vanclay F et al, *Social impact assessment: Guidance for assessing and managing the social impacts of projects*, International Association for Impact Assessment, 2015, p 2

[356] Vanclay F et al, *Social impact assessment: Guidance for assessing and managing the social impacts of projects*, International Association for Impact Assessment, 2015, p 2

[357] Vanclay F et al, *Social impact assessment: Guidance for assessing and managing the social impacts of projects*, International Association for Impact Assessment, 2015, p 2

[358] NSW DPE, *Social Impact Assessment Guideline*, 2017, p 5

[359] NSW DPE, *Social Impact Assessment Guideline*, 2017, p 31

- Infrastructure services and facilities: including access and use;
- Culture: including customs and connections to places;
- Health and wellbeing: including physical and psychological;
- Surroundings: including access to and use of the natural and built environment, public safety and aesthetic value/amenity;
- Personal and property rights: including economic livelihood and civil liberties;
- Decision-making systems: including access to complaint and remedy mechanisms; and
- Fears and aspirations: related to any of the above or about the future of the community.[360]

Social impacts can be: positive (such as job opportunities) or negative (health detriments); tangible (affordable housing) or intangible (social cohesion); directly caused by the project, indirectly caused by a change that is caused by the project, or cumulative (vehicles from multiple operations may produce a cumulative noise impact). Social impacts can also be experienced differently by different communities, or different people within a community, or at different stages of the project.[361]

Also relevant in assessing social impact are the following characteristics:

- Extent: geographical area or population affected by the impact;
- Duration: timeframe over which the impact occurs;
- Severity: scale or degree of change as a result of impact; and
- Sensitivity: susceptibility or vulnerability of people or environments to adverse changes caused by the impact.[362]

The principles of the State guideline were recently applied by the NSW Land and Environment Court in *Gloucester Resources Limited v Minister for Planning*.[363] The case involved a proposal by Gloucester Resources Limited (GRL) to develop an open cut coal mine near Rocky Hill, in the Gloucester Valley. The mine would have produced 21 million tonnes of coal over a period of 16 years.[364] As the proposal for the Rocky Hill Coal Project was a State Significant Development, within the meaning of section 4.36(1) of the EP&A Act 1979, the Minister for Planning was the appropriate consent authority. The Minister for Planning, by way of his delegate, the Planning Assessment Commission (now the

360 NSW DPE, *Social Impact Assessment Guideline*, 2017, p 5

361 NSW DPE, *Social Impact Assessment Guideline*, 2017, p 6

362 NSW DPE, *Social Impact Assessment Guideline*, 2017, p 36

363 *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7

364 *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [4]

Independent Planning Commission (IPC)),[365] refused the application.[366] GRL appealed to the Land and Environment Court, which exercised the function of the Minister as the consent authority, to determine the development application for the Rocky Hill Coal Project.[367] The court refused the development application.[368] In so doing, Chief Judge Brian Preston said that the project should be refused on its unacceptable planning, visual and social impacts alone; with "a further reason for refusal" being the cumulative greenhouse gas emissions arising from the project and their contribution to climate change.[369]

Preston CJ made findings under the nine categories of social impact relating to the proposal:

- Way of life: the scale of improvement or benefit to local employment or the local economy was moderate. This moderate positive social impact could be undermined by negative social impacts on tourism, affecting employment and the economy.[370]
- Community: the mine was likely to cause divisions in the community and would negatively impact on the community's composition, cohesion and character, and local people's sense of place.[371] The consequence of this potential negative social impact was major, with a resultant social risk rating of "extreme" under the guideline.[372]
- Infrastructure: some adverse social impact was associated with road infrastructure by reason of traffic-related noise and the likelihood of increased road accidents. The consequences were moderate with a social risk rating of "high" under the guideline.[373]
- Culture: the project would have a significant negative social impact on culture, including "heritage-scenic quality", and would adversely affect Aboriginal people of the area, resulting in an "extreme" social risk rating.[374]
- Health and wellbeing: dust and particulate emissions, noise emissions and night lighting impacts had the potential to affect people's health and wellbeing, both directly and indirectly. The consequence of the impact was major and resulted in an "extreme" risk rating.[375]

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365 NSW DPIE, *Part 2–Independent Planning Commission*, 13 March 2018 [website – accessed 1 May 2019]

366 *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [7]

367 *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [7]

368 *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [8] and [700]

369 *Gloucester Resources Limited v Minister for Planning* [2019] NSW LEC 7 at [556]

370 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [280]-[281]

371 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [289], [320]

372 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [322]; NSW DPE, *Social Impact Assessment Guideline*, 2017, p 42

373 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [338]

374 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [341], [351]

375 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [354], [368]

- Surroundings: residents' concerns regarding adverse effects on amenity were reasonable and supported by the expert evidence. The impact on amenity was likely to be major, resulting in an "extreme" risk rating.[376]
- Personal and property rights and decision-making: social impacts under these categories were not as negative as the other categories.[377]
- Fears and aspirations: most of the articulated fears and aspirations of people who opposed the project were reasonable and justified on the evidence.[378]

In summary, Preston CJ found that, although the project had the potential to generate some positive social benefits, these would be outweighed by the significant negative social impacts the project would cause. As noted above, the significant net negative social impacts were a justification for refusing consent to the project.[379]

21.2 Distributive justice

Distributive justice is a type of social impact which involves the just distribution or allocation of the benefits and burdens of economic activity. Principles of distributive justice vary according to:

- The subject matter of distribution (such as resources, income, wealth, opportunities, jobs, welfare and utility);
- The entities to which a distribution is to be made (such as natural persons, corporations, groups of persons, and non-human living organisms or ecological communities); and
- The basis on which a distribution is to be made (such as equality, wealth maximisation, or according to individual characteristics or free transactions).[380]

In environmental terms, distributive justice is promoted by giving substantive rights to members of the community that enable them to:

- Share in environmental benefits (such as clean air, water and land, a quiet acoustic environment, scenic landscapes and a healthy ecology); and
- Prevent, mitigate, remediate or be compensated for environmental burdens (such as pollution and loss of amenity, scenic landscapes, biological diversity or ecological integrity).[381]

Issues of distributive justice apply within generations (intragenerational equity)

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376 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [379]

377 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [388], [392]

378 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [395]

379 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [421]

380 *Bulga Milbrodale Progress Association Inc v Minister for Planning and Infrastructure and Warkworth Mining Limited* (2013) 194 LGERA 347; [2013] NSWLEC 48 at [486]

381 *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 at [398]

and also extend across generations (intergenerational equity).[382]

21.3 Intragenerational equity

Intragenerational equity provides that people within the present generation have equal rights to benefit from the exploitation of natural resources as well as from the enjoyment of a clean and healthy environment.[383]

In *Gloucester Resources*[384] Preston CJ acknowledged expert reports that showed "distinct inequity" in the negative environmental, economic and social impacts of the mine. Greater burdens would be distributed to people in geographical proximity to the project and the physical impacts would in turn trigger social impacts on those people. Preston CJ also found other specific groups in the community would be disadvantaged by negative social impacts; including Aboriginal people who have "strong cultural and spiritual connections to Country, which will be severely damaged". Also, disadvantaged people in age brackets with vulnerability to health issues, such as those over 55 years and young children who suffer asthma.[385] Consequently, there was a real risk that the project might disproportionately affect disadvantaged groups in the community, causing inequity in the distribution of burdens and benefits of the project within the current generation.[386]

21.4 Intergenerational equity

Intergenerational equity provides that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations. This principle is highlighted in legislation, including: section 6(2)(b) of the *Protection of the Environment Administration Act 1991* *(NSW)* in relation to ecologically sustainable development; and section 3A(c) of the EPBC Act 1999 (Cth). The principle also appears at section 3.5.2 of the *Intergovernmental Agreement on the Environment 1992* between the Commonwealth, States and Territories.

Three factors form the basis of intergenerational equity:

- Conservation of options: requires each generation to conserve the diversity of the natural and cultural resource base in order to ensure that options are available to future generations in solving their problems and satisfying their needs;

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382 *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 at [398]

383 *Telstra v Hornsby Shire Council* [2006] NSWLEC 133 at [117]. See also: Preston B, "What's equity got to do with the environment?", Sir Frank Kitto Lecture, 1 September 2017, University of New England, Armidale, p 3-5 and 15-16.

384 *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 at [406]

385 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [407]-[409]

386 *Gloucester Resources Ltd v Minister for Planning* [2019] NSWLEC 7 at [410], [414]

- Conservation of quality: each generation must maintain the quality of the natural and cultural environments such that they are passed on in no worse condition than they are received; and
- Conservation of access: each generation should give its members equitable rights of access to the legacy of past generations and should conserve this access for future generations.[387]

The third factor (conservation of access) means that the principle of intergenerational equity encompasses the principle of intragenerational equity. Assuming the present generation upholds its duties to future generations, each member of the present generation ought to be entitled to the resources that could improve their own economic and social wellbeing.[388]

21.5 Social and community consent

The report of the Royal Commission defines "social consent" as the ongoing public support that is necessary for an activity to be undertaken in a society.[389] It is a broader concept than "community consent"; which is measured on a localised basis, referring to the informed agreement of an affected community in a project's location.[390]

Social consent

Social consent is not ongoing or given for the life of an activity; rather, it may be lost because attitudes, standards or expectations shifted, or confidence in the activity weakened. On the other hand, a negative opinion can be reversed due to technological advances. Social consent for a nuclear project therefore needs to be gained and sustained through decades of development and the life of the project. Major projects are by nature transgenerational and require bipartisan, continuing political support that exceeds election cycles.[391]

Community consent

In order to measure and obtain community consent, the membership of the community would need to be defined. The more far-reaching the proposal, the broader the extent of the community whose consent must be measured. Project proponents should adopt a consultative approach to defining "community" and "consent", and encourage early community agreement on who has the right to

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[387] Brown Weiss E, Intergenerational Equity: a legal framework for global environmental change in Brown Weiss E (ed), *Environmental Change and International Law: New Challenges and Dimensions*, 1992, p 385; as discussed by Justice Brian Preston (Chief Judge, Land and Environment Court of NSW) in Preston B, "What's equity got to do with the environment?", Sir Frank Kitto Lecture, 1 September 2017, University of New England, Armidale, p 4.

[388] Brown Weiss E, Intergenerational Equity: a legal framework for global environmental change in Brown Weiss E (ed), *Environmental Change and International Law: New Challenges and Dimensions*, 1992, p 405

[389] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 121

[390] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 121

[391] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 121

make and communicate decisions in relation to a proposed development. This might involve developing a “consent plan”.[392]

The Royal Commission report heeded international lessons from the 1970s to 1990s on the importance of obtaining community consent. Developments failed when plans to site new nuclear facilities considered only technical characteristics or communities were not consulted, or governments pushed ahead without consent. Since the mid-1990s, most governments and proponents of nuclear developments adopted a new approach that involved communities in decisions relating to nuclear sites.[393]

The Royal Commission found that successful processes for engaging with a community to seek consent for a nuclear facility involved:

- Transparency of the decision-making framework and flexibility to adapt the framework to meet unforeseen developments;
- Willingness to accept longer community engagement than usual for industrial developments and avoidance of arbitrary deadlines or setting deadlines primarily for commercial or technical reasons;
- Early, deep engagement with local communities using a partnership model to create a stakeholder forum to share information and build understanding, using methods such as site tours, community meetings, visitor centres, newsletters, websites and shopfronts;
- Capacity for local communities to learn about hosting a facility without committing to it;
- Resourcing a community organisation to deliberate on the proposal and to engage independent scientific advisors to review information;
- Presence of an experienced, independent regulator which is accessible and accountable to the community;
- Availability of scientific evidence, potentially from multiple bodies, to address risks;
- Provision of benefits for hosting the facility, to be determined by the community;
- Continuity of individuals involved in development and delivery, allowing relationships to be built and trust to be developed.[394]

Furthermore, it is important to understand any past events that influence the attitudes of people in a location, such as the communities affected by British nuclear testing at Maralinga in SA in the 1950s and 1960s. The Royal Commission report also outlined principles for engagement with Aboriginal communities that apply in addition to the above factors, and can apply equally to

[392] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 121
[393] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 122
[394] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Finding 100, p 122-125

the rest of the community of which they are a part.[395]

21.6 Social licence

Social licence to operate refers to the level of acceptance or approval of the activities of an organisation by stakeholders, especially local impacted communities. Beyond regulatory requirements, corporations also need to consider the expectations of a wide range of stakeholders, from local communities to international NGOs. Otherwise, they risk reputational harm, reduced opportunities, industrial action, protests, legal action and the financial consequences of those factors.[396]

The concept of a social licence to operate initially emerged from the mining industry in the late 1990s. It developed from the concept of corporate social responsibility, as community expectations and scrutiny of environmental and social performance increased.[397] In the context of the mining industry, a social licence to operate referred to the broad and ongoing acceptance or approval of mining operations by local communities and other stakeholders.[398]

A social licence to operate should be distinguished from the more formal social impact assessments, which involve a comparison of expert opinions.[399] A social licence must be earned from the community, while a legal licence is issued by a governing authority; regulatory approval does not necessarily equate to social approval.[400]

Various studies have sought to examine the practical application of the social licence to operate in the mining industry and other energy industries. One study conducted large scale national surveys in three countries, including Australia, which had 5,121 participants.[401] The study examined how three key variables affected the public's trust in the mining industry: distributional fairness in the sharing of the benefits of mining; procedural fairness in the interactions between the mining industry and society; and confidence in the governance arrangements

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[395] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, Finding 104, p 126-127

[396] Vanclay F et al, *Social impact assessment: Guidance for assessing and managing the social impacts of projects*, International Association for Impact Assessment, 2015, p v. See also Boutilier R, Frequently asked questions about the social licence to operate, *Impact Assessment & Project Appraisal*, 2014, Vol 32(4), p 263-272.

[397] Hall N et al., Social licence to operate: understanding how a concept has been translated into practice in energy industries, *Journal of Cleaner Production*, 2015, Vol 86, p 301-303

[398] Zhang A et al., Understanding the social licence to operate of mining at the national scale: a comparative study of Australia, China and Chile, *Journal of Cleaner Production*, 2015, Vol 108, Part A, p 1063

[399] Hall N et al., Social licence to operate: understanding how a concept has been translated into practice in energy industries, *Journal of Cleaner Production*, 2015, Vol 86, p 303

[400] Hall N et al., Social licence to operate: understanding how a concept has been translated into practice in energy industries, *Journal of Cleaner Production*, 2015, Vol 86, p 304

[401] Zhang A et al., Understanding the social licence to operate of mining at the national scale: a comparative study of Australia, China and Chile, *Journal of Cleaner Production*, 2015, Vol 108, Part A, p 1063-1071. The survey in Australia was conducted online with a representative national sample based on national census data: p 1066-1067.

that ensure responsible industry performance.

The results for the Australian sample showed that procedural fairness was the strongest predictor of trust in the mining industry.[402] Generally speaking, perceptions of distributional fairness, procedural fairness, confidence in governance, and trust in the mining industry were relatively low across Australia. The study concluded that no single factor is the panacea to obtaining or maintaining a social licence to operate in mining. Rather, it is the combination of the three key variables that matters. The relatively low public perceptions of the key variables suggest that, in order to minimise social conflict around mining operations, both the mining industry and governments may need to review their methods of engaging with citizens in order to build trust in those relationships.[403]

Another research project compared the use of social licences to operate in four Australian energy industries: mining, wind, carbon dioxide capture/storage, and geothermal. Interviews were conducted with industry representatives (16 in mining).[404] On the issue of a social licence to operate, mining representatives observed that:

- Social licences exist on a continuum as part of a dynamic process that is affected by the different stages of the project's life cycle;
- Social licences are sought at a local level by prioritising relationships with communities and stakeholders who are directly affected by the development (while simultaneously considering regional, national and potentially international perspectives); and
- Social licences will continue to be a core part of business in the future with the possibility that they will evolve into a new type of governance arrangement (such as through formal community agreements).[405]

A case study relating to coal seam gas mining in the Northern Rivers area of NSW highlighted differences between the industry and the community over the meaning of social licence, how social licence is won, and the political implications of an absence of social licence.[406] Metgasco's plans to expand its gas wells near Casino triggered widespread community opposition, culminating in its withdrawal from the location in 2013. The company planned to resume operations in 2014 at Bentley and obtained a legal licence with the associated environmental assessment approvals. However, it would appear that the majority of the

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[402] Zhang A et al., Understanding the social licence to operate of mining at the national scale: a comparative study of Australia, China and Chile, *Journal of Cleaner Production*, 2015, Vol 108, Part A, p 1070

[403] Zhang A et al., Understanding the social licence to operate of mining at the national scale: a comparative study of Australia, China and Chile, *Journal of Cleaner Production*, 2015, Vol 108, Part A, p 1071-1072

[404] Hall N et al., Social licence to operate: understanding how a concept has been translated into practice in energy industries, *Journal of Cleaner Production*, 2015, Vol 86, p 304

[405] Hall N et al., Social licence to operate: understanding how a concept has been translated into practice in energy industries, *Journal of Cleaner Production*, 2015, Vol 86, p 305-307

[406] Curran G, Social licence, corporate social responsibility and coal seam gas: framing the new political dynamics of contestation, *Energy Policy*, 2017, Vol 101, p 427-435

community felt that Metgasco lacked a social licence to undertake these operations. This was evidenced in the near-unanimous opposition to Metgasco's plans as measured in an exit poll (administered by the Australian Electoral Commission) during local government elections in 2012.[407] The exit poll recorded that, from the 4.2% of participants randomly selected, 86.9% of participants voted no to coal seam gas in their area, while 13.1% voted yes.[408] The NSW Government intervened in 2014 by suspending Metgasco's legal licence to operate. The Government's reasoning that the company did not undertake effective consultation with the community implied there was a lack of social licence.[409] Metgasco succeeded in challenging the 2014 suspension of its legal licence in the Supreme Court but sold its exploration licence back to the Government in 2016.[410] The author concludes that the politicisation of social licence can prove an effective tool in contesting a development, and "to underestimate the influence of social licence, or to simply treat it rhetorically, is fraught with commercial and political risk".[411]

21.7 Partnership case studies

The Belgian partnership model

The Belgian partnership model is an example of a successful community partnership. Belgium's nuclear waste management agency (ONDRAF/NIRAS) engaged with three potential host communities which had volunteered to receive information about a radioactive waste disposal facility.[412] The community members were consulted about the facility design, safety and health issues, and the processes for disseminating information to their wider communities. The members had site visits and were provided with resources to fund their own research into aspects of the proposal.[413]

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407 Curran G, Social licence, corporate social responsibility and coal seam gas: framing the new political dynamics of contestation, *Energy Policy*, 2017, Vol 101, p 431

408 Curran G, Social licence, corporate social responsibility and coal seam gas: framing the new political dynamics of contestation, *Energy Policy*, 2017, Vol 101, p 431

409 Curran G, Social licence, corporate social responsibility and coal seam gas: framing the new political dynamics of contestation, *Energy Policy*, 2017, Vol 101, p 431

410 Curran G, Social licence, corporate social responsibility and coal seam gas: framing the new political dynamics of contestation, *Energy Policy*, 2017, Vol 101, p 434. *Metgasco Limited v Minister for Resources and Energy* [2015] NSWSC 453 was decided on procedural fairness grounds, rather than the community consultation issue. However, the Court (Button J) observed that the State consultation guidelines provided no guidance as to the precise meaning of "effective consultation": [69]-[70]. Button J nevertheless rejected Metgasco's submission that it was unreasonable for the Minister's delegate to find that the community consultation undertaken was inherently ineffective, in the sense of lacking attributes and qualities that would make it efficacious: at [74].

411 Curran G, Social licence, corporate social responsibility and coal seam gas: framing the new political dynamics of contestation, *Energy Policy*, 2017, Vol 101, p 434

412 The facility was a surface repository of low-level and intermediate-level short-lived waste, with disposal occurring for an indicative duration of 50 years from 2022, and monitoring and surveillance for 250 years after closure: Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 228

413 Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 123

Each of the three community partnerships received an annual budget and two paid staff members. Membership was voluntary and open to any resident, with working groups established on topics of importance to the partnership members.[414] The chosen host community in Dessel, Antwerp, had a population of 9,200 residents, of which 1,650 were already employed in the nuclear industry. ONDRAF/NIRAS worked with the community members to incorporate additional monitoring mechanisms into the proposed design and develop a benefits package for the community.[415]

This partnership model showed that:

- Local stakeholders can provide knowledge and can help develop creative or innovative solutions if the framework allows genuine engagement;
- The value of the regulator (Federal Agency for Nuclear Control) being involved from the start and engaged in an active dialogue with the community;
- The safety case is central to community consent; and
- The development process can involve long timeframes.

The realisation of the Dessel surface-level radioactive waste disposal facility will take over 25 years; from the Belgian Government's announcement in 1998 of the process to identify the location for the repository to its expected operation in 2024.[416]

Examples of failed "top-down" models

The Royal Commission report provides examples of "top-down" approaches of governments which did not involve substantial public input and were less successful. In South Korea, there were nine failed attempts to site a nuclear repository from 1986 to 2004. In 2005, the South Korean Government changed its site selection strategy, providing veto power to local residents at a referendum and offering a package of benefits to the successful host city.[417]

An Australian example of a top-down model with a troubled relationship with the community is the Ranger Mine at Jabiru, in the Northern Territory. The mine commenced operations in 1980 after the Australian Government determined the project was in the national interest and should proceed. The traditional owners opposed developing Ranger and did not have a right of veto. As a result, for the first two decades of the mine's operation, the relationship between the parties

[414] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 230

[415] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 123

[416] Note that the later dates in the timeline on p 229 of the Royal Commission report have shifted. The licence application to the Federal Agency for Nuclear Control (FANC) was resubmitted in early 2019, due to hundreds of questions from FANC about the initial application in 2013. If FANC considers the application complete, it will prepare a report on the application and submit it to the Scientific Council, an independent body composed of experts in the nuclear sector: Licence resubmitted for Belgian repository, *World Nuclear News*, 6 February 2019.

[417] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 235

was characterised by distrust and disengagement. The traditional owners have refused to participate in periodic social impact assessments, so as not to confer legitimacy on the operations. This example highlights the need to gain community consent at the start of the development proposal.[418]

21.8 NSW Government: community consultative committees

Mandatory community participation requirements for planning authorities, including the Minister and the IPC, are provided by section 2.22 and Schedule 1 of the EP&A Act 1979. Additionally, the NSW Government states that it encourages proponents of State Significant Developments (SSDs) to engage with the community and stakeholder groups through the use of Community Consultative Committees.[419] Developments are deemed to be SSDs due to their "size, economic value or potential impacts".[420] Under section 4.36 of the EP&A Act 1979, a project may be declared to be a SSD by: the Minister; a State environmental planning policy; or a Ministerial planning order. Existing categories of SSD are set out in Schedule 1 of the *State Environmental Planning Policy (State and Regional Development) 2011* and include mining, waste management and electricity generation.[421]

The NSW Government has developed a guideline to "clarify the roles and responsibilities of Community Consultative Committees, and to help these committees operate effectively".[422] The guideline states that the committee's purpose is to provide a discussion forum between a proponent and community representatives, stakeholder groups and the local council on issues directly relating to a specific State significant project. In summary, the committee should:

- Establish good working relationships and promote information sharing;
- Allow the proponent to keep the community informed about projects, seek their views, and respond to any matters raised; and
- Allow community members and local councils to seek information from the proponent and provide feedback on project development and implementation to deliver balanced social, environmental and economic outcomes for the community.[423]

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[418] Scarce K, *Nuclear Fuel Cycle Royal Commission Report*, May 2016, p 237-240

[419] NSW Government, *Community Consultative Committees*, no date [website – accessed 24 July 2019]

[420] NSW Government, *State Significant Development*, no date [website – accessed 24 July 2019]. For an overview of the NSW planning system, see: Montoya D, *The NSW Planning System*, NSW Parliamentary Research Service, e-brief 06/2019, July 2019.

[421] See also: NSW Government, *State Significant Development*, no date [website – accessed 24 July 2019]

[422] NSW Government, *Community Consultative Committees*, no date [website – accessed 24 July 2019]. See also: NSW Government, *Community Consultative Committee Guideline: State Significant Projects*, January 2019.

[423] NSW Government, *Community Consultative Committee Guideline: State Significant Projects*, January 2019

QUESTIONS FROM COMMUNITY ENGAGEMENT

(14) In addition to the community engagement concepts discussed above (e.g. social impact), what other factors are relevant to decisions about uranium mining and nuclear energy in NSW?

(15) What model of community engagement should be used to include the NSW public in decisions about uranium mining and nuclear energy?

(16) What is the best method of including the community in decisions about:

a. Location of a nuclear reactor;
b. Nuclear waste disposal; and
c. Nuclear non-proliferation.

(17) What are the other key decisions on uranium mining and nuclear energy that require community engagement?