PDR: MS20-001670

DEPARTMENT OF THE PRIME MINISTER AND CABINET

PM&C
Secretary
Mr Duggan
Mr Chisholm
Mr Goldsworthy
Mr Brazier
Mr Trease
Mr Poels
Mr Martin

PMO
Dr Kunkel
s 22(1)(a)(ii)

To: Prime Minister

INTERNATIONAL NUCLEAR, COAL AND RENEWABLE ENERGY SUMMARY

For information:

1. Below is a summary of the world's nuclear power plants, and international coal and renewable electricity use, as requested by your Office on 13 December 2020.

SCOTT MORRISON Date:

Comments:

Key Points:

1. The department of the Prime Minister and Cabinet (PM&C) has prepared a summary of the world's nuclear power plants, including generation capacity, age and expected lifecycle (see Attachment A).
   a. We have aggregated information to country-level data, including operational plants and capacity, capacity under construction, and decommissioning plans.
   b. Although publicly available data, including on decommissioning schedules, can be difficult to get, additional country or region-specific data may be available if needed.
2. PM&C has also prepared a summary of coal and renewable energy use for a range of relevant countries (see Attachment B), focused primarily on major trading partners.

Roland Trease
Assistant Secretary
Environment, Energy, Climate Change and Resilience Branch
16 December 2020

Policy Officer: s 22(1)(a)(ii)
Phone no: s 22(1)(a)(ii)
Consultation: DISER

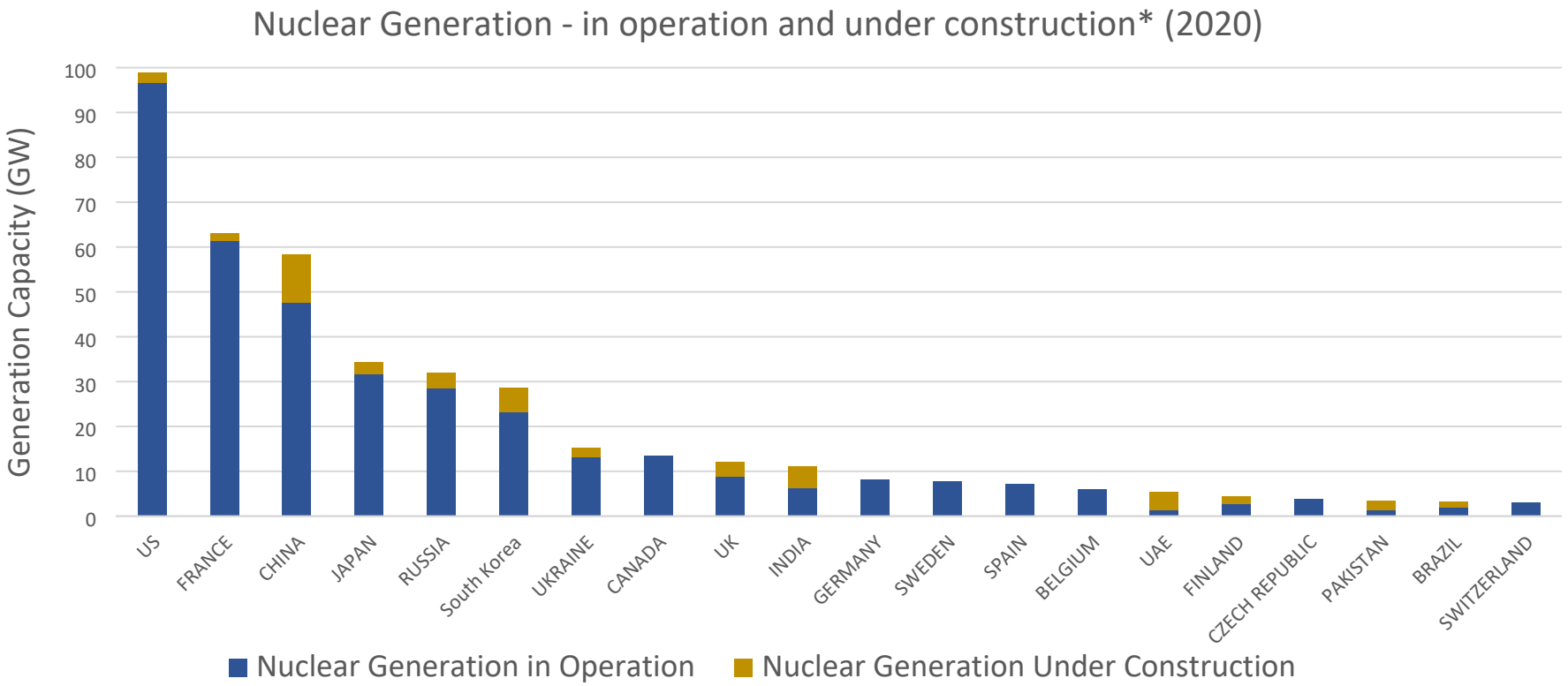
ATTACHMENTS

ATTACHMENT A INTERNATIONAL NUCLEAR ENERGY STATISTICS

ATTACHMENT B INTERNATIONAL RENEWABLE AND COAL ELECTRICITY GENERATION

International Nuclear Energy Statistics

15 December 2020



*Top 20 Countries by nuclear power in operation or under construction. International Atomic Energy Agency (IAEA), Power Reactor Information System (last updated 14 December 2020): https://pris.iaea.org/PRIS/CountryStatistics/CountryStatisticsLandingPage.aspx

Country	Nuclear Generation in Operation [1]		*Nuclear Generation Under Construction*		Total capacity in operation and under construction (GW)	Share of total electricity in 2019 from nuclear generation[1]	Announced Closure Strategy (select countries) [2]
	Reactors/Units	Capacity (GW)	*Reactors/Units*	*Capacity (GW)*			
USA	*94*	96.6	*2*	*2.2*	98.8	19.7%	Plans announced to retire eight reactors by 2025.
FRANCE	*56*	61.4	*1*	*1.6*	63.0	70.6%	Multiyear Energy Plan indicates the closure of 14 reactors by 2035; decision on early shutdowns will be made in 2023, with next closures likely to happen in 2025-26.
CHINA	*50*	47.5	*11*	*10.8*	58.3	4.9%	Information not located in time available.
JAPAN	*33*	31.7	*2*	*2.7*	34.3	7.5%	Strategic Energy Plan aims to reduce Japan's dependency on nuclear to 20-22% by 2030. [3]
RUSSIA	*38*	28.6	*3*	*3.5*	32.0	19.7%	In 2015, Rosenergoatom (Russian nuclear operator) planned to retire nine reactors by 2023, and three more by 2027.
SOUTH KOREA	*24*	23.2	*4*	*5.4*	28.5	26.2%	In 2017, incumbent President Moon announced plans to phase out nuclear over a period of about 40 years.

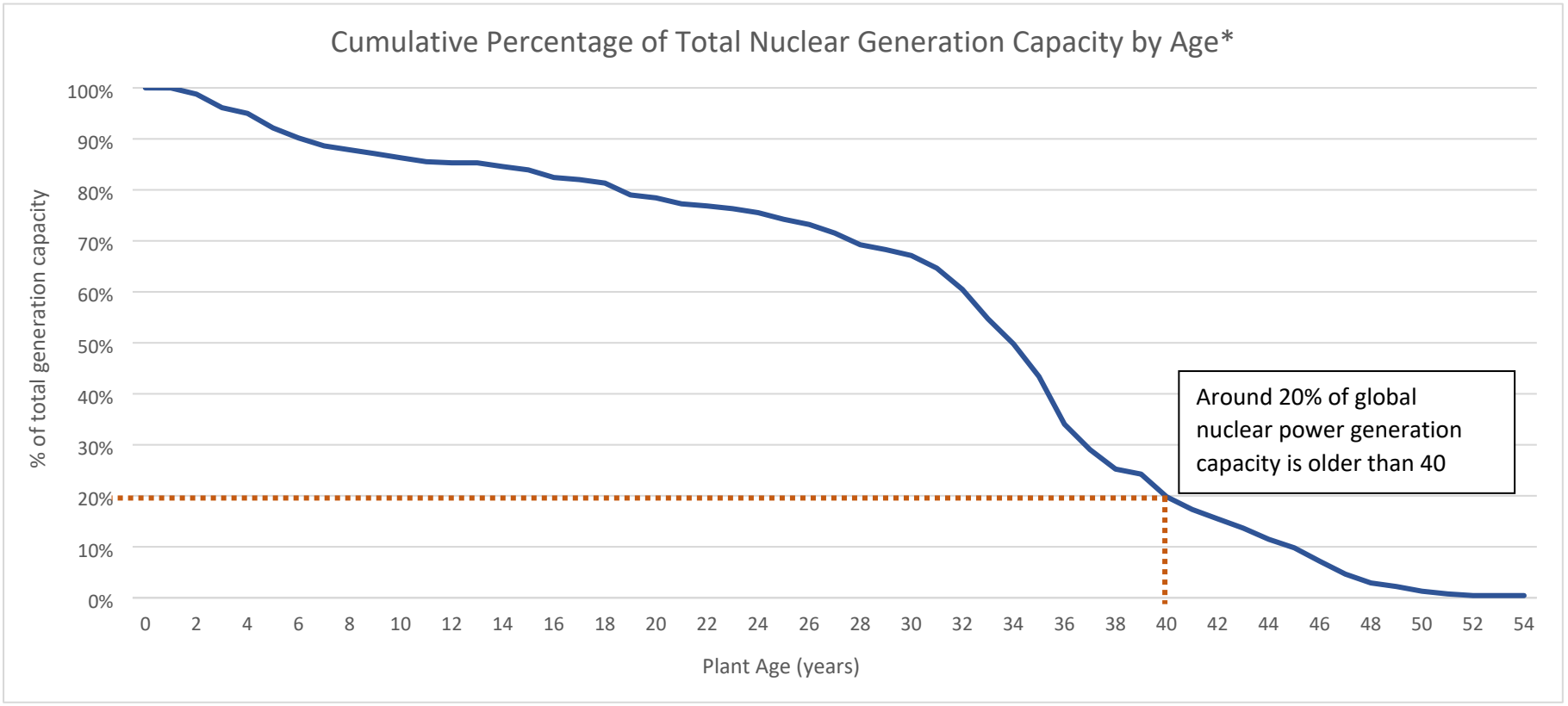
[1] IAEA, Power Reactor Information System (last updated 14 December 2020): https://pris.iaea.org/PRIS/CountryStatistics/CountryStatisticsLandingPage.aspx

[2] IAEA, Country Nuclear Power Profiles (various dates): https://cnpp.iaea.org/pages/index.htm; supplemented by World Nuclear Association Country Profiles (various dates): https://www.world-nuclear.org/information-library/country-profiles.aspx. In time available, PM&C weren't able to identify each countries' closure strategy.

[3] Most of Japan's capacity remains offline following the 2011 Fukushima accident. As at 3 December, only 3 reactors were in operation with 3.3 GW of capacity. Between 2005 and 2010, between 25 and 30 per cent of Japan's electricity came from nuclear generation.

UKRAINE	*15*	13.1	*2*	*2.1*	15.2	53.9%	Information not located in time available.
CANADA	*19*	13.6	*0*	*0.0*	13.6	14.9%	Nuclear energy falls under provincial jurisdiction – no national nuclear retirement plan.
UK	*15*	8.9	*2*	*3.3*	12.2	15.6%	Information not located in time available.
INDIA	*22*	6.3	*7*	*4.8*	11.1	3.2%	Information not located in time available.
GERMANY	*6*	8.1	*0*	*0.0*	8.1	*Not available*	Government plans to phase out nuclear power by the end of 2022.
SWEDEN	*7*	7.7	*0*	*0.0*	7.7	34%	Information not located in time available.
SPAIN	7	7.1	*0*	*0.0*	7.1	21.4%	Close all nuclear plants between 2025 and 2035.
BELGIUM	7	5.9	*0*	*0.0*	5.9	47.6%	
UAE	1	1.3	*3*	*4.0*	5.4	*Not available*	
FINLAND	4	2.8	*1*	*1.6*	4.4	34.7%	
CZECH REPUBLIC	6	3.9	*0*	*0.0*	3.9	35.2%	
PAKISTAN	5	1.3	*2*	*2.0*	3.3	6.6%	
BRAZIL	2	1.9	*1*	*1.3*	3.2	2.7%	
SWITZERLAND	4	3.0	*0*	*0.0*	3.0	23.9%	
SLOVAKIA	4	1.8	*2*	*0.9*	2.7	53.9%	
TURKEY	0	0.0	*2*	*2.2*	2.2	*Not available*	
BELARUS	1	1.1	*1*	*1.1*	2.2	*Not available*	
BANGLADESH	0	0.0	*2*	*2.2*	2.2	*Not available*	
BULGARIA	2	2.0	*0*	*0.0*	2.0	37.5%	
HUNGARY	4	1.9	*0*	*0.0*	1.9	49.2%	
IRAN, ISLAMIC REPUBLIC OF	1	0.9	*1*	*1.0*	1.9	1.8%	
SOUTH AFRICA	2	1.9	*0*	*0.0*	1.9	6.7%	

ARGENTINA	3	1.6	*1*	*0.0*	1.7	5.9%	
MEXICO	2	1.6	*0*	*0.0*	1.6	4.5%	
ROMANIA	2	1.3	*0*	*0.0*	1.3	18.5%	
SLOVENIA	1	0.7	*0*	*0.0*	0.7	37%	
NETHERLANDS	1	0.5	*0*	*0.0*	0.5	3.1%	
ARMENIA	1	0.4	*0*	*0.0*	0.4	27.8%	



*IAEA - TABLE 14. OPERATIONAL REACTORS, 31 DEC. 2019. Chart shows what percentage of worldwide nuclear generation capacity (MW) is older than a given age.

List of all operational nuclear power stations – International Atomic Energy Agency (December 2019 data)

- PM&C has re-produced the list of operational nuclear power stations, as compiled by the International Atomic Energy Agency.
- Of the 439 nuclear power stations in the below list, around 45% are in the USA, France or China.
- 28 of the 30 newest nuclear power stations (as at December 2019) were in China, Russia, India, or Pakistan.

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
ARGENTINA	ATUCHA-2	693	2016	4
ARGENTINA	EMBALSE	608	1984	36
ARGENTINA	ATUCHA-1	340	1974	46
ARMENIA	ARMENIAN-2	375	1980	40
BELGIUM	DOEL-4	1038	1985	35
BELGIUM	TIHANGE-3	1038	1985	35
BELGIUM	TIHANGE-2	1008	1983	37
BELGIUM	DOEL-3	1006	1982	38
BELGIUM	DOEL-1	445	1975	45
BELGIUM	DOEL-2	433	1975	45
BELGIUM	TIHANGE-1	962	1975	45
BRAZIL	ANGRA-2	1275	2001	19
BRAZIL	ANGRA-1	609	1985	35
BULGARIA	KOZLODUY-6	1003	1993	27
BULGARIA	KOZLODUY-5	1003	1988	32
CANADA	DARLINGTON-3	878	1993	27
CANADA	DARLINGTON-4	878	1993	27
CANADA	DARLINGTON-1	878	1992	28
CANADA	DARLINGTON-2	878	1990	30
CANADA	BRUCE-8	817	1987	33
CANADA	BRUCE-7	817	1986	34
CANADA	PICKERING-8	516	1986	34
CANADA	BRUCE-5	817	1985	35

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
CANADA	PICKERING-7	516	1985	35
CANADA	BRUCE-6	817	1984	36
CANADA	PICKERING-6	516	1984	36
CANADA	PICKERING-5	516	1983	37
CANADA	POINT LEPREAU	660	1983	37
CANADA	BRUCE-4	750	1979	41
CANADA	BRUCE-3	750	1978	42
CANADA	BRUCE-1	760	1977	43
CANADA	BRUCE-2	760	1977	43
CANADA	PICKERING-4	515	1973	47
CANADA	PICKERING-1	515	1971	49
CHINA	HAIYANG-2	1170	2019	1
CHINA	YANGJIANG-6	1000	2019	1
CHINA	HAIYANG-1	1170	2018	2
CHINA	SANMEN-1	1157	2018	2
CHINA	SANMEN-2	1157	2018	2
CHINA	TAISHAN-1	1660	2018	2
CHINA	TIANWAN-3	1045	2018	2
CHINA	TIANWAN-4	1045	2018	2
CHINA	YANGJIANG-5	1000	2018	2
CHINA	FUQING-4	1000	2017	3
CHINA	YANGJIANG-4	1000	2017	3
CHINA	CHANGJIANG-2	601	2016	4
CHINA	FANGCHENGGANG-1	1000	2016	4
CHINA	FANGCHENGGANG-2	1000	2016	4
CHINA	FUQING-3	1000	2016	4
CHINA	HONGYANHE-4	1061	2016	4
CHINA	NINGDE-4	1018	2016	4
CHINA	YANGJIANG-3	1000	2016	4
CHINA	CHANGJIANG-1	601	2015	5
CHINA	FANGJIASHAN-2	1012	2015	5

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
CHINA	FUQING-2	1000	2015	5
CHINA	HONGYANHE-3	1061	2015	5
CHINA	NINGDE-3	1018	2015	5
CHINA	YANGJIANG-2	1000	2015	5
CHINA	FANGJIASHAN-1	1012	2014	6
CHINA	FUQING-1	1000	2014	6
CHINA	HONGYANHE-2	1061	2014	6
CHINA	NINGDE-2	1018	2014	6
CHINA	YANGJIANG-1	1000	2014	6
CHINA	HONGYANHE-1	1061	2013	7
CHINA	NINGDE-1	1018	2013	7
CHINA	LING AO-4	1007	2011	9
CHINA	QINSHAN 2-4	619	2011	9
CHINA	LING AO-3	1007	2010	10
CHINA	QINSHAN 2-3	619	2010	10
CHINA	TIANWAN-1	990	2007	13
CHINA	TIANWAN-2	990	2007	13
CHINA	QINSHAN 2-2	610	2004	16
CHINA	LING AO-2	950	2003	17
CHINA	QINSHAN 3-2	677	2003	17
CHINA	LING AO-1	950	2002	18
CHINA	QINSHAN 2-1	610	2002	18
CHINA	QINSHAN 3-1	677	2002	18
CHINA	DAYA BAY-1	944	1994	26
CHINA	DAYA BAY-2	944	1994	26
CHINA	QINSHAN-1	298	1994	26
CHINA	CEFR	20	—	---
CHINA	TAISHAN-2	1660	—	----
CZECH REP.	TEMELIN-2	1027	2003	17
CZECH REP.	TEMELIN-1	1027	2002	18
CZECH REP.	DUKOVANY-4	471	1987	33

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
CZECH REP.	DUKOVANY-2	471	1986	34
CZECH REP.	DUKOVANY-3	468	1986	34
CZECH REP.	DUKOVANY-1	468	1985	35
FINLAND	OLKILUOTO-2	890	1982	38
FINLAND	LOVIISA-2	507	1981	39
FINLAND	OLKILUOTO-1	890	1979	41
FINLAND	LOVIISA-1	507	1977	43
FRANCE	CIVAUX-1	1495	2002	18
FRANCE	CIVAUX-2	1495	2002	18
FRANCE	CHOOZ B-1	1500	2000	20
FRANCE	CHOOZ B-2	1500	2000	20
FRANCE	GOLFECH-2	1310	1994	26
FRANCE	CATTENOM-4	1300	1992	28
FRANCE	PENLY-2	1330	1992	28
FRANCE	CATTENOM-3	1300	1991	29
FRANCE	GOLFECH-1	1310	1991	29
FRANCE	PENLY-1	1330	1990	30
FRANCE	BELLEVILLE-2	1310	1989	31
FRANCE	NOGENT-2	1310	1989	31
FRANCE	BELLEVILLE-1	1310	1988	32
FRANCE	CATTENOM-2	1300	1988	32
FRANCE	CHINON B-4	905	1988	32
FRANCE	NOGENT-1	1310	1988	32
FRANCE	CATTENOM-1	1300	1987	33
FRANCE	CHINON B-3	905	1987	33
FRANCE	FLAMANVILLE-2	1330	1987	33
FRANCE	ST. ALBAN-2	1335	1987	33
FRANCE	FLAMANVILLE-1	1330	1986	34
FRANCE	PALUEL-3	1330	1986	34
FRANCE	PALUEL-4	1330	1986	34
FRANCE	ST. ALBAN-1	1335	1986	34

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
FRANCE	CRUAS-2	915	1985	35
FRANCE	CRUAS-4	915	1985	35
FRANCE	GRAVELINES-5	910	1985	35
FRANCE	GRAVELINES-6	910	1985	35
FRANCE	PALUEL-1	1330	1985	35
FRANCE	PALUEL-2	1330	1985	35
FRANCE	CHINON B-1	905	1984	36
FRANCE	CHINON B-2	905	1984	36
FRANCE	CRUAS-1	915	1984	36
FRANCE	CRUAS-3	915	1984	36
FRANCE	BLAYAIS-2	910	1983	37
FRANCE	BLAYAIS-3	910	1983	37
FRANCE	BLAYAIS-4	910	1983	37
FRANCE	ST. LAURENT B-1	915	1983	37
FRANCE	ST. LAURENT B-2	915	1983	37
FRANCE	BLAYAIS-1	910	1981	39
FRANCE	DAMPIERRE-2	890	1981	39
FRANCE	DAMPIERRE-3	890	1981	39
FRANCE	DAMPIERRE-4	890	1981	39
FRANCE	GRAVELINES-3	910	1981	39
FRANCE	GRAVELINES-4	910	1981	39
FRANCE	TRICASTIN-3	915	1981	39
FRANCE	TRICASTIN-4	915	1981	39
FRANCE	BUGEY-5	880	1980	40
FRANCE	DAMPIERRE-1	890	1980	40
FRANCE	GRAVELINES-1	910	1980	40
FRANCE	GRAVELINES-2	910	1980	40
FRANCE	TRICASTIN-1	915	1980	40
FRANCE	TRICASTIN-2	915	1980	40
FRANCE	BUGEY-2	910	1979	41
FRANCE	BUGEY-3	910	1979	41

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
FRANCE	BUGEY-4	880	1979	41
FRANCE	FESSENHEIM-1	880	1978	42
FRANCE	FESSENHEIM-2	880	1978	42
GERMANY	NECKARWESTHEIM-2	1310	1989	31
GERMANY	EMSLAND	1335	1988	32
GERMANY	ISAR-2	1410	1988	32
GERMANY	BROKDORF	1410	1986	34
GERMANY	GROHNDE	1360	1985	35
GERMANY	GUNDREMMINGEN-C	1288	1985	35
HUNGARY	PAKS-4	473	1987	33
HUNGARY	PAKS-3	473	1986	34
HUNGARY	PAKS-2	477	1984	36
HUNGARY	PAKS-1	479	1983	37
INDIA	KUDANKULAM-2	932	2017	3
INDIA	KUDANKULAM-1	932	2014	6
INDIA	KAIGA-4	202	2011	9
INDIA	RAJASTHAN-5	202	2010	10
INDIA	RAJASTHAN-6	202	2010	10
INDIA	KAIGA-3	202	2007	13
INDIA	TARAPUR-3	490	2006	14
INDIA	TARAPUR-4	490	2005	15
INDIA	KAIGA-1	202	2000	20
INDIA	KAIGA-2	202	2000	20
INDIA	RAJASTHAN-3	202	2000	20
INDIA	RAJASTHAN-4	202	2000	20
INDIA	KAKRAPAR-2	202	1995	25
INDIA	KAKRAPAR-1	202	1993	27
INDIA	NARORA-2	202	1992	28
INDIA	NARORA-1	202	1991	29
INDIA	MADRAS-2	205	1986	34
INDIA	MADRAS-1	205	1984	36

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
INDIA	RAJASTHAN-2	187	1981	39
INDIA	RAJASTHAN-1	90	1973	47
INDIA	TARAPUR-1	150	1969	51
INDIA	TARAPUR-2	150	1969	51
IRAN, ISL. REP.	BUSHEHR-1	915	2013	7
JAPAN	TOMARI-3	866	2009	11
JAPAN	SHIKA-2	1108	2006	14
JAPAN	HAMAOKA-5	1325	2005	15
JAPAN	HIGASHI DORI-1 (TOHOKU)	1067	2005	15
JAPAN	ONAGAWA-3	796	2002	18
JAPAN	GENKAI-4	1127	1997	23
JAPAN	KASHIWAZAKI KARIWA-7	1315	1997	23
JAPAN	KASHIWAZAKI KARIWA-6	1315	1996	24
JAPAN	ONAGAWA-2	796	1995	25
JAPAN	GENKAI-3	1127	1994	26
JAPAN	IKATA-3	846	1994	26
JAPAN	KASHIWAZAKI KARIWA-4	1067	1994	26
JAPAN	HAMAOKA-4	1092	1993	27
JAPAN	KASHIWAZAKI KARIWA-3	1067	1993	27
JAPAN	OHI-4	1127	1993	27
JAPAN	SHIKA-1	505	1993	27
JAPAN	OHI-3	1127	1991	29
JAPAN	TOMARI-2	550	1991	29
JAPAN	KASHIWAZAKI KARIWA-2	1067	1990	30
JAPAN	KASHIWAZAKI KARIWA-5	1067	1990	30
JAPAN	SHIMANE-2	789	1989	31
JAPAN	TOMARI-1	550	1989	31
JAPAN	HAMAOKA-3	1056	1987	33
JAPAN	TSURUGA-2	1108	1987	33
JAPAN	KASHIWAZAKI KARIWA-1	1067	1985	35
JAPAN	SENDAI-2	846	1985	35

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
JAPAN	TAKAHAMA-3	830	1985	35
JAPAN	TAKAHAMA-4	830	1985	35
JAPAN	SENDAI-1	846	1984	36
JAPAN	TOKAI-2	1060	1978	42
JAPAN	MIHAMA-3	780	1976	44
JAPAN	TAKAHAMA-2	780	1975	45
JAPAN	TAKAHAMA-1	780	1974	46
MEXICO	LAGUNA VERDE-2	775	1995	25
MEXICO	LAGUNA VERDE-1	777	1990	30
NETHERLANDS	BORSSELE	482	1973	47
PAKISTAN	CHASNUPP-4	313	2017	3
PAKISTAN	CHASNUPP-3	315	2016	4
PAKISTAN	CHASNUPP-2	300	2011	9
PAKISTAN	CHASNUPP-1	300	2000	20
PAKISTAN	KANUPP-1	90	1972	48
ROMANIA	CERNAVODA-2	650	2007	13
ROMANIA	CERNAVODA-1	650	1996	24
RUSSIA	AKADEMIK LOMONOSOV-1	32	2020	0
RUSSIA	AKADEMIK LOMONOSOV-2	32	2020	0
RUSSIA	NOVOVORONEZH 2-2	1101	2019	1
RUSSIA	LENINGRAD 2-1	1101	2018	2
RUSSIA	ROSTOV-4	979	2018	2
RUSSIA	NOVOVORONEZH 2-1	1100	2017	3
RUSSIA	BELOYARSK-4	820	2016	4
RUSSIA	ROSTOV-3	950	2015	5
RUSSIA	KALININ-4	950	2012	8
RUSSIA	ROSTOV-2	950	2010	10
RUSSIA	KALININ-3	950	2005	15
RUSSIA	ROSTOV-1	950	2001	19
RUSSIA	BALAKOVO-4	950	1993	27
RUSSIA	SMOLENSK-3	925	1990	30

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
RUSSIA	BALAKOVO-3	950	1989	31
RUSSIA	BALAKOVO-2	950	1988	32
RUSSIA	KALININ-2	950	1987	33
RUSSIA	BALAKOVO-1	950	1986	34
RUSSIA	KURSK-4	925	1986	34
RUSSIA	KALININ-1	950	1985	35
RUSSIA	SMOLENSK-2	925	1985	35
RUSSIA	KOLA-4	411	1984	36
RUSSIA	KURSK-3	925	1984	36
RUSSIA	SMOLENSK-1	925	1983	37
RUSSIA	KOLA-3	411	1982	38
RUSSIA	BELOYARSK-3	560	1981	39
RUSSIA	LENINGRAD-4	925	1981	39
RUSSIA	NOVOVORONEZH-5	950	1981	39
RUSSIA	LENINGRAD-3	925	1980	40
RUSSIA	KURSK-2	925	1979	41
RUSSIA	BILIBINO-4	11	1977	43
RUSSIA	KURSK-1	925	1977	43
RUSSIA	BILIBINO-3	11	1976	44
RUSSIA	LENINGRAD-2	925	1976	44
RUSSIA	BILIBINO-2	11	1975	45
RUSSIA	KOLA-2	411	1975	45
RUSSIA	KOLA-1	411	1973	47
RUSSIA	NOVOVORONEZH-4	385	1973	47
SLOVAKIA	MOCHOVCE-2	436	2000	20
SLOVAKIA	MOCHOVCE-1	436	1998	22
SLOVAKIA	BOHUNICE-3	471	1985	35
SLOVAKIA	BOHUNICE-4	471	1985	35
SLOVENIA	KRSKO	688	1983	37
SOUTH AFRICA	KOEBERG-2	930	1985	35
SOUTH AFRICA	KOEBERG-1	930	1984	36

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
SOUTH KOREA	SHIN-KORI-4	1418	2019	1
SOUTH KOREA	SHIN-KORI-3	1416	2016	4
SOUTH KOREA	SHIN-WOLSONG-2	993	2015	5
SOUTH KOREA	SHIN-KORI-2	996	2012	8
SOUTH KOREA	SHIN-WOLSONG-1	997	2012	8
SOUTH KOREA	SHIN-KORI-1	996	2011	9
SOUTH KOREA	HANUL-6	997	2005	15
SOUTH KOREA	HANUL-5	998	2004	16
SOUTH KOREA	HANBIT-5	992	2002	18
SOUTH KOREA	HANBIT-6	993	2002	18
SOUTH KOREA	HANUL-4	999	1999	21
SOUTH KOREA	WOLSONG-4	609	1999	21
SOUTH KOREA	HANUL-3	997	1998	22
SOUTH KOREA	WOLSONG-3	630	1998	22
SOUTH KOREA	WOLSONG-2	606	1997	23
SOUTH KOREA	HANBIT-4	970	1996	24
SOUTH KOREA	HANBIT-3	986	1995	25
SOUTH KOREA	HANUL-2	967	1989	31
SOUTH KOREA	HANUL-1	966	1988	32
SOUTH KOREA	HANBIT-2	988	1987	33
SOUTH KOREA	HANBIT-1	995	1986	34
SOUTH KOREA	KORI-4	1012	1986	34
SOUTH KOREA	KORI-3	1011	1985	35
SOUTH KOREA	KORI-2	640	1983	37
SPAIN	TRILLO-1	1003	1988	32
SPAIN	VANDELLOS-2	1045	1988	32
SPAIN	ASCO-2	997	1986	34
SPAIN	COFRENTES	1064	1985	35
SPAIN	ALMARAZ-2	1006	1984	36
SPAIN	ASCO-1	995	1984	36
SPAIN	ALMARAZ-1	1011	1983	37

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
SWEDEN	FORSMARK-3	1172	1985	35
SWEDEN	OSKARSHAMN-3	1400	1985	35
SWEDEN	RINGHALS-4	1117	1983	37
SWEDEN	FORSMARK-2	1118	1981	39
SWEDEN	RINGHALS-3	1062	1981	39
SWEDEN	FORSMARK-1	990	1980	40
SWEDEN	RINGHALS-1	881	1976	44
SWITZERLAND	LEIBSTADT	1220	1984	36
SWITZERLAND	GOESGEN	1010	1979	41
SWITZERLAND	BEZNAU-2	365	1972	48
SWITZERLAND	BEZNAU-1	365	1969	51
UK	SIZEWELL B	1198	1995	25
UK	DUNGENESS B-2	545	1989	31
UK	HARTLEPOOL A-1	590	1989	31
UK	HARTLEPOOL A-2	595	1989	31
UK	HEYSHAM A-1	485	1989	31
UK	HEYSHAM A-2	575	1989	31
UK	HEYSHAM B-1	620	1989	31
UK	HEYSHAM B-2	620	1989	31
UK	TORNESS-2	605	1989	31
UK	TORNESS-1	595	1988	32
UK	DUNGENESS B-1	545	1985	35
UK	HINKLEY POINT B-1	485	1978	42
UK	HUNTERSTON B-2	495	1977	43
UK	HINKLEY POINT B-2	480	1976	44
UK	HUNTERSTON B-1	490	1976	44
UKRAINE	ROVNO-4	950	2006	14
UKRAINE	KHMELNITSKI-2	950	2005	15
UKRAINE	ZAPOROZHYE-6	950	1996	24
UKRAINE	SOUTH UKRAINE-3	950	1989	31
UKRAINE	ZAPOROZHYE-5	950	1989	31

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
UKRAINE	KHMELNITSKI-1	950	1988	32
UKRAINE	ZAPOROZHYE-4	950	1988	32
UKRAINE	ROVNO-3	950	1987	33
UKRAINE	ZAPOROZHYE-3	950	1987	33
UKRAINE	ZAPOROZHYE-2	950	1986	34
UKRAINE	SOUTH UKRAINE-2	950	1985	35
UKRAINE	ZAPOROZHYE-1	950	1985	35
UKRAINE	SOUTH UKRAINE-1	950	1983	37
UKRAINE	ROVNO-2	376	1982	38
UKRAINE	ROVNO-1	381	1981	39
USA	WATTS BAR-2	1164	2016	4
USA	WATTS BAR-1	1157	1996	24
USA	COMANCHE PEAK-2	1195	1993	27
USA	COMANCHE PEAK-1	1205	1990	30
USA	LIMERICK-2	1134	1990	30
USA	SEABROOK-1	1246	1990	30
USA	SOUTH TEXAS-2	1280	1989	31
USA	VOGTLE-2	1152	1989	31
USA	BRAIDWOOD-1	1194	1988	32
USA	BRAIDWOOD-2	1160	1988	32
USA	FERMI-2	1115	1988	32
USA	NINE MILE POINT-2	1277	1988	32
USA	PALO VERDE-3	1312	1988	32
USA	SOUTH TEXAS-1	1280	1988	32
USA	BEAVER VALLEY-2	905	1987	33
USA	BYRON-2	1136	1987	33
USA	CLINTON-1	1062	1987	33
USA	HARRIS-1	964	1987	33
USA	PERRY-1	1240	1987	33
USA	VOGTLE-1	1150	1987	33
USA	CATAWBA-2	1150	1986	34

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
USA	DIABLO CANYON-2	1118	1986	34
USA	HOPE CREEK-1	1172	1986	34
USA	LIMERICK-1	1134	1986	34
USA	MILLSTONE-3	1210	1986	34
USA	PALO VERDE-1	1311	1986	34
USA	PALO VERDE-2	1314	1986	34
USA	RIVER BEND-1	967	1986	34
USA	BYRON-1	1164	1985	35
USA	CATAWBA-1	1160	1985	35
USA	DIABLO CANYON-1	1138	1985	35
USA	GRAND GULF-1	1401	1985	35
USA	SUSQUEHANNA-2	1257	1985	35
USA	WATERFORD-3	1168	1985	35
USA	WOLF CREEK	1200	1985	35
USA	CALLAWAY-1	1215	1984	36
USA	COLUMBIA	1131	1984	36
USA	LASALLE-1	1137	1984	36
USA	LASALLE-2	1140	1984	36
USA	MCGUIRE-2	1158	1984	36
USA	SUMMER-1	973	1984	36
USA	ST. LUCIE-2	987	1983	37
USA	SUSQUEHANNA-1	1257	1983	37
USA	SEQUOYAH-2	1139	1982	38
USA	FARLEY-2	883	1981	39
USA	MCGUIRE-1	1158	1981	39
USA	SALEM-2	1158	1981	39
USA	SEQUOYAH-1	1152	1981	39
USA	ANO-2	988	1980	40
USA	NORTH ANNA-2	944	1980	40
USA	HATCH-2	883	1979	41
USA	COOK-2	1168	1978	42

Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
USA	DAVIS BESSE-1	894	1978	42
USA	NORTH ANNA-1	948	1978	42
USA	BROWNS FERRY-3	1210	1977	43
USA	BRUNSWICK-1	938	1977	43
USA	CALVERT CLIFFS-2	855	1977	43
USA	FARLEY-1	874	1977	43
USA	SALEM-1	1169	1977	43
USA	BEAVER VALLEY-1	908	1976	44
USA	INDIAN POINT-3	1030	1976	44
USA	ST. LUCIE-1	981	1976	44
USA	BROWNS FERRY-2	1200	1975	45
USA	BRUNSWICK-2	932	1975	45
USA	CALVERT CLIFFS-1	877	1975	45
USA	COOK-1	1030	1975	45
USA	DUANE ARNOLD-1	601	1975	45
USA	FITZPATRICK	813	1975	45
USA	HATCH-1	876	1975	45
USA	MILLSTONE-2	869	1975	45
USA	ANO-1	836	1974	46
USA	BROWNS FERRY-1	1200	1974	46
USA	COOPER	769	1974	46
USA	INDIAN POINT-2	998	1974	46
USA	OCONEE-2	848	1974	46
USA	OCONEE-3	859	1974	46
USA	PEACH BOTTOM-2	1300	1974	46
USA	PEACH BOTTOM-3	1331	1974	46
USA	PRAIRIE ISLAND-2	519	1974	46
USA	OCONEE-1	847	1973	47
USA	PRAIRIE ISLAND-1	522	1973	47
USA	QUAD CITIES-1	908	1973	47
USA	QUAD CITIES-2	911	1973	47

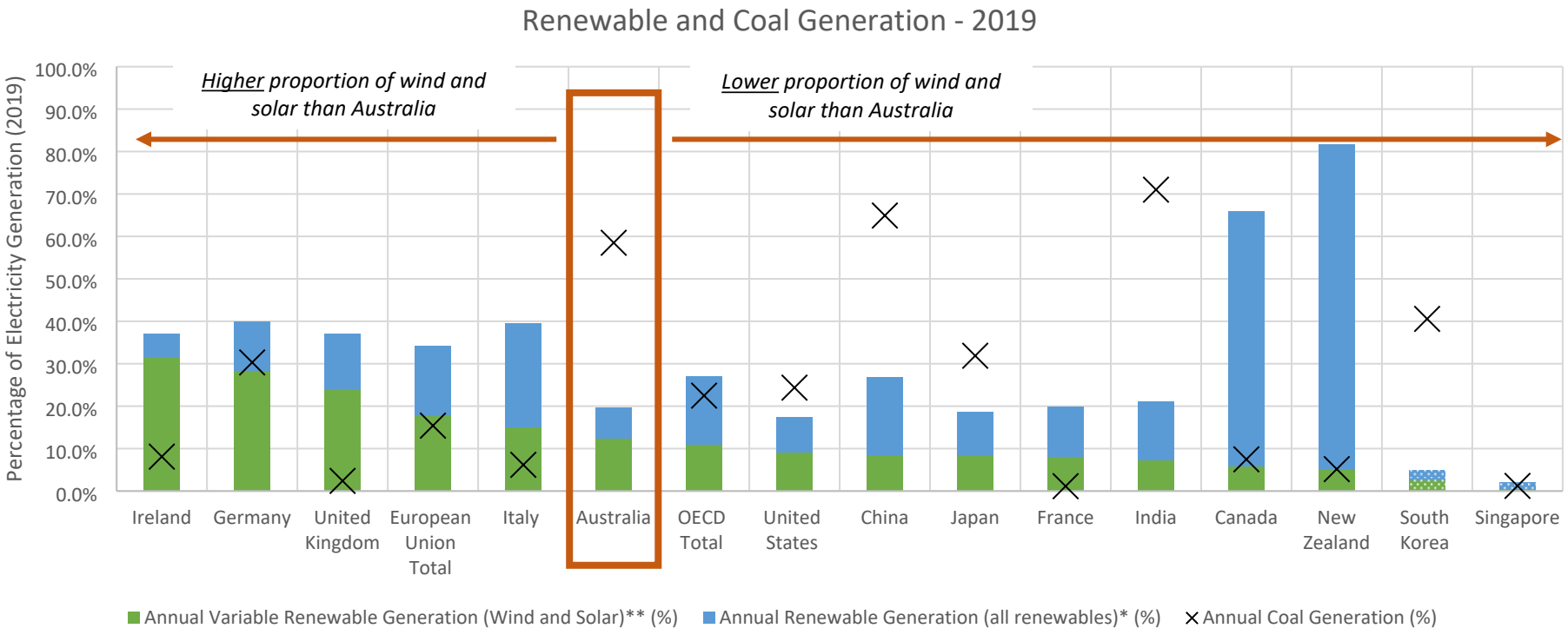
Country	Name	Capacity Output (MW)	Start of Commercial Operation	Age
USA	SURRY-2	838	1973	47
USA	TURKEY POINT-4	821	1973	47
USA	POINT BEACH-2	591	1972	48
USA	SURRY-1	838	1972	48
USA	TURKEY POINT-3	837	1972	48
USA	DRESDEN-3	879	1971	49
USA	MONTICELLO	628	1971	49
USA	PALISADES	805	1971	49
USA	ROBINSON-2	741	1971	49
USA	DRESDEN-2	894	1970	50
USA	GINNA	560	1970	50
USA	POINT BEACH-1	591	1970	50
USA	NINE MILE POINT-1	613	1969	51

Source: International Atomic Energy Agency, RDS-2 2019, Operational Reactors as at 31 December 2019 https://www.iaea.org/publications/14756/nuclear-power-reactors-in-the-world

*Please note – Due to the volume of data and timeframe for this request, PM&C has not been able to verify the accuracy or exhaustiveness of this list.

International Electricity Generation Statistics – Coal and renewables

15 December 2020



Source: IEA World Energy Balances (2020 edition)

** includes solar PV, solar thermal, wind, hydro, geothermal, tidal, biofuels, municipal waste (renewable)*

*** variable renewable generation includes solar PV, solar thermal, wind*

Country	Annual electricity generation (TWh)	Annual Renewables Generation (Wind and Solar)**		Annual Renewables Generation (all renewables)*		Annual Coal Generation	
		TWh	% of total	TWh	% of total	TWh	% of total
Ireland	30	9	31.4%	11	37.0%	2	8.1%
Germany	612	173	28.3%	244	39.9%	185	30.3%
United Kingdom	322	77	23.9%	119	37.1%	8	2.4%
EU Total	3,212	568	17.7%	1,095	34.1%	495	15.4%
Italy	290	44	15.2%	115	39.6%	18	6.2%
Australia	264	33	**12.3%**	52	**19.6%**	154	**58.5%**
OECD Total	10,979	1,203	11.0%	2,964	27.0%	2,468	22.5%
United States	4,346	401	9.2%	758	17.4%	1,059	24.4%
China	7,485	630	8.4%	2,000	26.7%	4,859	64.9%
Japan	992	82	8.2%	184	18.6%	316	31.9%
France	566	46	8.1%	113	19.9%	6	1.1%
India	1,594	117	7.3%	335	21.0%	1,132	71.0%
Canada	653	38	5.9%	431	66.0%	49	7.5%
New Zealand	45	2	5.3%	37	81.7%	2	5.2%
South Korea	578	16	2.7%	28	4.9%	234	40.6%
Singapore	54	0	0.6%	1	2.1%	1	1.2%

Source: IEA World Energy Balances (2020 edition)

** includes solar PV, solar thermal, wind, hydro, geothermal, tidal, biofuels, municipal waste (renewable)*

*** includes solar PV, solar thermal, wind*

Country^	Existing coal Generation (GW)*	Coal power generation capacity under construction (GW)**	Current wind and solar capacity (GW)*	Wind and solar capacity under construction (GW)**
China	1,127	115	445	109
India	248	31	81	6
Indonesia	37	16	-	-
Vietnam	19	12	6	3
Russian Federation	64	8	1	1
South Korea	41	7	13	1
Pakistan	5	6	6	-
Bangladesh	1	4	-	-
United Arab Emirates	-	4	3	1
Philippines	13	2	1	-
Malaysia	12	2	1	-
Japan	52	2	67	5
Mongolia	1	2	-	-
EU Total	158	2	324	33
Turkey	17	2	15	2
Poland	32	1	7	1
Brazil	5	1	21	1
Dominican Republic	-	1	-	-
Serbia	6	1	-	-
Chile	5	1	5	5
Ghana	-	1	-	-
Greece	4	1	6	1
Iran (Islamic Republic)	-	1	1	-
Zimbabwe	1	1	-	1
Thailand	9	1	5	-
Bosnia and Herzegovina	2	-	-	-
Jordan	-	-	2	1
United States	280	-	182	28

Germany	47	-	109	-
Australia	26	-	21	10
United Kingdom	10	-	37	10
Italy	10	-	32	-
Canada	9	-	17	1
France	4	-	26	2
New Zealand	1	-	1	-
Ireland	1	-	4	-
Singapore	-	-	-	-

^Given the timeframe for this request and the potential for alternative methodologies for quantifying and reporting these metrics, we would advise any public reliance or referencing should be appropriately caveated.

* Bloomberg New Energy Finance, 2019 data; other sources may report slightly different data. For instance, In June 2020 Reuters reported that China has 97.8 GW of coal generation under construction, with an additional 151.8 GW at the planning stage.

** Bloomberg New Energy Finance, current as at 15 December 2020; other sources may report slightly different data.

PDR: MS21-000073

DEPARTMENT OF THE PRIME MINISTER AND CABINET

PM&C
Secretary
Mr Duggan
Mr Trease
Mr Pullen
Mr Poels
Mr Meagher
Ms McFarlane

PMO
Dr Kunkel
s 22(1)(a)(ii)

CABINET SECRETARY

To: Prime Minister

MEETING WITH s 47F

Purpose: [Meeting Details]	**Timing and Venue:** 2.00pm Wednesday 27 January 2021

Key Points: (Further background is at Attachment A)

s 22(1)(a)(ii)

s 22(1)(a)(ii)

Nuclear Energy

- Noting his long-term advocacy, s 47F may raise the prospects of nuclear energy to reduce emissions in Australia, ar ar technology should have been included in the Government's low-emissions technology investment roadmap.
  - While not a priority technology in the Roadmap, Small Modular Reactors (SMR) are identified as a 'watching brief technology' that could play a role over the long-term.
  - Although forecasts are highly uncertain for a nascent technology like SMR, the CSIRO forecast SMR will remain more expensive than comparable dispatchable electricity generation until at least 2040 (absent a price on carbon emissions).
- In December 2019, the Committee, s 47F completed an inquiry into the prerequisites for nuclear technology in Australia. The Committee recommended the Australian Government:
  - consider nuclear energy as part of Australia's future energy mix;
  - undertake further technical and economic assessments of nuclear energy reactors; and
  - lift the moratoria on next-generation nuclear reactors, including SMR, subject to informed consent of affected communities for any nuclear power or waste facility.
- *If raised:* The Government is still considering its response to the Inquiry, but s 47F may wish to raise the matter with the Minister for Energy and Emissions Reduction, the Hon Angus Taylor MP.

s 22(1)(a)(ii)

s 22(1)(a)(ii)

David Pullen
Assistant Secretary
Infrastructure and Agriculture
26 January 2021

Contact Officer: s 22(1)(a)(ii)
phone no. s 22(1)(a)(ii)
Consultation: II&E, SPD, International

NOTED:

Date:

~~PROTECTED CABINET~~

PDR: MS21-000792

DEPARTMENT OF THE PRIME MINISTER AND CABINET

PM&C
Secretary
Mr Duggan
Mr Chisholm
Ms Horvat
Mr Brazier
Mr Rush
Ms McGregor
Mr Trease
Mr Roper
Mr Poels
Mr Hupalo
Mr Goldie
Ms Gartmann
Mr Martin

PMO
Dr Kunkel
s 22(1)(a)(ii)

CABINET SECRETARY
s 22(1)(a)(ii)

To: Prime Minister

NUCLEAR ENERGY RESEARCH AND DEVELOPMENT IN AUSTRALIA

Recommendation that you:

1. Note at the request of your Office, we have prepared a summary of the current state of nuclear energy research and development in Australia.

Noted

SCOTT MORRISON Date:

Comments:

Key Points:

1. Nuclear energy is primarily regulated through two pieces of Commonwealth legislation – the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Australian Radiation Protection and Nuclear Safety Act 1998*.
   a. Both Acts prohibit the construction or operation of a nuclear power plant, enrichment plant or reprocessing facility anywhere in Australia.
   b. Neither Act expressly prohibits research and development (R&D) activities relating to nuclear energy technologies, including Small Modular Reactors (SMRs), to the extent that the R&D does not trigger one of the prohibitions. A permit from the Australian Safeguards and Non-Proliferation Office and/or a licence from Australian Radation Protection and Nuclear Safety Agency (ARPaNSA) or the relevant state radiation regulator might be required for some activities.
2. SMR technology is identified as a 'watching brief technology' in Australia's inaugural Low-Emissions Technology Statement – in recognition of its transformative potential and the work being done internationally to develop SMRs including in North America, Europe and the United Kingdom (UK).
3. The South Australian Nuclear Fuel Cycle Royal Commission (the Commission), established in 2015, undertook a comprehensive investigation of the potential for increasing South Australia's participation in the nuclear fuel cycle – including an analysis of the viability and economic impacts of nuclear energy.

a. The Commission found that neither a large nuclear power plant, nor small modular reactors, would be commercially viable (in South Australia) between 2030 (the earliest capacity could be commissioned) and 2050, under current market rules and assuming a 10 per cent internal rate of return (required to cover the commercial cost of capital).

b. Despite commercial challenges, the Commission found there would be value in maintaining an option to develop nuclear energy generation in Australia, beyond 2030, particularly if external pressure was to be applied to Australia to decarbonise more rapidly.

Potential pathways for Nuclear R&D in Australia

4. The Australian Nuclear Science and Technology Organisation (ANSTO) is currently conducting technical and commercially-focussed work relating to Generation IV nuclear reactors and SMRs. This includes participation in international research programs led by the International Atomic Energy Agency (IAEA) and the OECD-Nuclear Energy Agency.

   a. ANSTO has advised there is scope to broaden and deepen strategic bilateral and multilateral partnerships – engagement to date has been limited, in line with Government priorities.

5. Under the *Australian Nuclear Science and Technology Organisation Act 1987* the responsible Minister can direct ANSTO to undertake R&D activities on any matter, including nuclear energy.

6. The clearest mechanism to allow the Australian Renewable Energy Agency (ARENA) to support nuclear energy R&D would be amendment to its legislation.

   a. s 34(3)

   b. s 47C

   c. As an interim measure, the Minister for Energy and Emissions Reduction has progressed new regulations to prescribe additional ARENA functions, including one to allow it to provide financial assistance for R&D into any clean energy technology that could be reasonably expected to control, reduce or prevent emissions to a material extent. This could credibly include nuclear energy R&D, subject to the specifics of the particular investment proposal.

      i. The ARENA Regulations were approved by Executive Council on 14 May 2021 and are expected to come into force on 19 May 2021.

7. Even with the above legislative or regulatory amendments, the responsible Minister (the Minister for Energy and Emissions Reduction) cannot direct ARENA to invest in any particular matter, however the responsible Minister can request ARENA consider investing in a particular project and ARENA's overarching investment strategy must be approved by the responsible Minister.

8. s 47C [redacted]

9. Australia is not currently viewed as an attractive destination for nuclear energy research, given legislative constraints on demonstration and deployment of these technologies.

    a. This could make it unlikely that government investment in nuclear energy R&D will attract any significant private sector co-investment.

    b. By contrast, ANSTO has advised more than a billion dollars of private investment in SMR-focused companies has been made in North America.

SMR technology and economics

10. SMRs are a class of small, modern nuclear reactors, generally with an electrical output of 300 MW or less (though some designs have a higher output). They differ from existing nuclear power reactors in a number of key ways:

    a. Simplistic design, allowing for the prospect of assembly-line manufacturing.

    b. 3-5 years build time, rather than 6-12 years.

    c. They can be constructed with a single module, or use units in combination for greater power output (i.e. they are 'modular').

11. Current cost forecasts for SMRs in Australia remain high compared to other low emissions energy sources. CSIRO's 2021 GenCost report (an annual publication providing electricity generation costs for a range of technologies) found the capital costs for a first-of-a-kind SMR would be $16,487 per kilowatt if built in 2020, with potential to decline to $7,237 per kilowatt by 2030.

    a. On the basis of these capital costs, the Levelised Cost of Electricity (LCOE) for SMRs is forecast to be between $143 and $336 per MWh in 2030.

b. For comparison, the LCOE of an electricity system in 2030 with up to 90 per cent variable renewable energy (wind and solar) is estimated to cost less than $87 per MWh, possibly as low as $46 per MWh, including transmission and energy storage.

12. Australian nuclear energy advocacy group, Bright New World, disputes the veracity of CSIRO's capital cost assumptions for SMRs. It also notes CSIRO's GenCost LCOE estimates for SMRs are three times higher than estimates reported in Canada's SMR action plan.

13. At this stage in the development cycle, and given the lack of commercially operating examples, it is not possible to validate cost assumptions for SMR technologies.

Next steps

14. s 47C
s 47C , s 34(3)
s 34(3)

a. s 47C

b. s 47C s 34(3)
s 34(3) s 47C
s 47C

Roland Trease
Assistant Secretary
Energy and Climate Change Branch
18 May 2021

Policy Officer: s 22(1)(a)(ii)
Phone no: s 22(1)(a)(ii)
Consultation: II&E, Fiscal, CabDiv, Leg, INTL.

From: s 22(1)(a)(ii)
To:
Cc: s 22(1)(a)(ii) Climate Change; s 22(1)(a)(ii)
Subject: For information: nuclear R&D [SEC=OFFICIAL:Sensitive]
Date: Monday, 22 February 2021 6:06:30 PM
Attachments: image001.jpg

OFFICIAL: Sensitive

Hi s 22(1)
s 47C

s 47C We have included key points below, and copied background provided by DISER which also notes the grey areas.

There are two sets of nuclear prohibitions under commonwealth law:

- Nuclear weapons-related research
- The construction of certain specified facilities (nuclear power plants, enrichment plants, fuel fabrication facilities and reprocessing facilities) under the *Australian Radiation Protection and Safety and Environment Protection Act 1998* and *Environment Protection, Biodiversity and Conservation Act 1999*.

There's no prohibition on nuclear energy R&D, and the Australian Nuclear Science and Technology Organisation (ANSTO) has always had a research program in this space.

- Specifically, under s.5(1) of the ANSTO Act 1987, ANSTO is permitted to undertake R&D in relation to:
  - nuclear science and technology and its application and its use;
  - the production and use of radioisotopes and the use of isotopic techniques and nuclear radiation for medicine, science, industry, commerce and agriculture;
  - other matters at the Minister's direction
- ANSTO is also permitted to encourage and facilitate the application and use of the results of such R&D
- For example, the Commonwealth was able to build and license a multipurpose research reactor at Lucas Heights for a range of activities.

s 47C , s 47E(d)

Regards,

s 22(1)(a)(ii) Adviser
Climate Change and Energy | Department of the Prime Minister and Cabinet
p. s 22(1)(a)(ii) e. s 22(1)(a)(ii) @pmc.gov.au

acknowledgment of country

Background advice from DISER:

s 47C

Regarding "nuclear", the prohibitions which exist in Commonwealth law are on:

- nuclear weapons-related research; and
- the construction of certain specified facilities (nuclear power plants, enrichment plants, fuel fabrication facilities and reprocessing facilities) under the *Australian Radiation Protection and Safety and Environment Protection Act 1998* and *Environment Protection, Biodiversity and Conservation Act 1999*.

There is no prohibition on nuclear energy research and development (note distinction below), and ANSTO has had a program of research in that space since it was created. Specifically, under s.5(1) of the ANSTO Act 1987, they are permitted:

a) to undertake research and development in relation to:

i. nuclear science and nuclear technology; and

ia. the application and use of nuclear science and nuclear technology; and

ii. the production and use of radioisotopes, and the use of isotopic techniques and nuclear radiation, for medicine, science, industry, commerce and agriculture; and

iii. such other matters as the Minister directs; and

b) to encourage and facilitate the application and use of the results of such research and development

The case in point, the Commonwealth was able to build and license a multipurpose research reactor at Lucas Heights for a range of activities.

s 47C , s 47E(d)

s 22(1)(a)(ii)

From: s 22(1)(a)(ii)
Sent: Wednesday, 24 March 2021 6:44 PM
To: s 22(1)(a)(ii)
Cc: Climate Change ; Trease, Roland ; s 22(1)(a)(ii) ; s 22(1)(a)(ii) s 22(1)(a)(ii) s 22(1)(a)(ii) Chisholm, James
Subject: RE: Advice on nuclear ~~[SEC=PROTECTED, CAVEAT=SH:CABINET]~~

~~**PROTECTED//CABINET**~~

Hi s 22(1)

s 47C , s 47E(d)

- **As an overarching comment:** the current legislative environment acts as a major disincentive to serious private sector investment in advanced Small Modular Reactor (SMR) R&D in Australia. Given the prohibition on deployment, private developers are more likely to conduct serious R&D in more supportive and enabling environments, including North America and Europe.
    - Having said that, ANTSO advise there are **no legislative barriers to R&D in the Small Modular Reactor (SMR) space** (in some circumstances, a permit from the Australian Safeguards and Non-Proliferation Office and/or a licence from ARPANSA or the relevant state radiation regulator might be required).

s 47C , s 47E(d)

- **ANSTO is already conducting technical and commercially-focussed work relating to SMRs.**

On the latter, ANSTO advise many countries are grappling with the likely timeframes and real costs of SMR construction and operation, and the likely cost of electricity generated by SMRs. The International Atomic Energy Agency (IAEA) has recently created a new coordinated research project on the economics of SMRs. An ANSTO-led project team contributes to this work, focusing on four pillars: technology readiness, economic viability, legal authority and social acceptability.

s 47C , s 47E(d)

[redacted]

Cheers,

s 22(1)(a)(ii) [redacted]

Senior Advisor| Climate Change and Energy

Ph: s 22(1)(a)(ii) [redacted]

M: [redacted]

Department of Prime Minister and Cabinet

s 22(1)(a) [redacted] @pmc.gov.au

acknowledgment of country

From: Trease, Roland <Roland.Trease@pmc.gov.au>
Sent: Wednesday, 24 March 2021 9:26 AM
To: s 22(1)(a)(ii) @pm.gov.au>; s 22(1)(a)(ii)
s @pmc.gov.au>
Cc: s 22(1)(a)(ii) @pmc.gov.au>
Subject: RE: Advice on nuclear ~~[SEC=PROTECTED, CAVEAT=SH:CABINET]~~

~~**PROTECTED//CABINET**~~

Morning

s 47C , s 47E(d)

Cheers
Roland

s 22(1)(a)(ii)

s 22(1)(a)(ii)

From: Talbot, Louise <Louise.Talbot@pmc.gov.au>
Sent: Tuesday, 26 October 2021 6:10 PM
To: s 22(1)(a)(ii) _pm.gov.au>
Cc: s 22(1)(a)(ii) @pmc.gov.au>; Patteson, Carolyn <Carolyn.Patteson@pmc.gov.au>; Samuels, Richard <Richard.Samuels@pmc.gov.au>
Subject: Energy Technologies on the List of Critical Technologies in the National Interest [SEC=PROTECTED]

PROTECTED

Hi s 22(1)(a)(ii)
As per earlier chat, s 47B(a)
s 47B(a) , and I am providing some further information re energy technologies.

s 47C , s 47E(d)

Thanks

Louise Talbot | Deputy Coordinator

Critical Technologies Policy Coordination Office

Department of the Prime Minister and Cabinet
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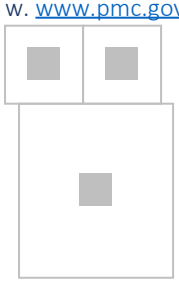
EA s 22(1)(a)(ii) @pmc.gov.au
w. www.pmc.gov.au/domestic-policy/critical-technologies-policy-coordination-office



The Department acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.

From: s 22(1)(a)(ii)
To:
Cc: Energy; Trease, Roland; s 22(1)(a)(ii)
Subject: For advice please: Brief to PM re Nuclear Energy R&D - proposed approach [SEC=PROTECTED]
Date: Thursday, 6 May 2021 12:07:50 PM
Attachments: image001.png

PROTECTED

Hello s 22(1)(a)(ii)

I've recently joined the Energy team at PMC and will be progressing the requested brief to the Prime Minister on the extent to which Australia could pursue R&D on nuclear energy, in particular SMRs. Below is a sense of what we are proposing to cover and a proposed handling strategy. Welcome your thoughts on whether this broad approach captures all the issues you had hoped and your thoughts on the handling strategy.

Key points

- Nuclear energy is currently regulated under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Australian Radiation Protection and Nuclear Safety Act 1998* (ARPaNSA Act).
    - Neither Act precludes the conduct of R&D on SMRs in Australia
    - In some circumstances, a permit from the Australian Safeguards and Non-Proliferation Office and/or a licence from ARPANSA or the relevant state radiation regulator might be required – s 47C

ANSTO

- ANSTO is already conducting technical and commercially-focused work related to SMRs.
    - ANSTO is collaborating internationally on SMR's including with the International Atomic Energy Agency (IAEA) and the OECD – Nuclear Energy Agency
    - There is further scope to pursue bi-lateral and multi-lateral partnerships with key strategic countries/regions – e.g. US, Canada, Europe.
- Under the ANSTO Act, Minister Porter can direct ANSTO to undertake research and development on any matter – including nuclear energy
- It is unlikely government investment in nuclear R&D could leverage any significant private sector investment, given Australia is not a particularly attractive destination for this type of research, given the moratorium.

s 47C , s 47E(d)

ARENA

- ARENA would require amendments to its legislation to allow it conduct R&D on nuclear energy
    - Even if with a legislative amendment, the Minister is not able to direct ARENA to invest in nuclear R&D but ARENA's investment strategy will have regard to Government priorities

s 47C

s 47C

Happy to discuss.

s 22(1)(a)(ii) Adviser
Energy | Industry, Infrastructure and Environment Division
Department of the Prime Minister and Cabinet
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The Department acknowledges the Traditional Custodians of Country throughout Australia and their continuing connection to land, waters and community. We pay our respect to their Cultures, Country and Elders both past and present.

From: s 22(1)(a)(ii)
To:
Cc: Climate Change; Trease, Roland; DLO; Roper, Matthew
Subject: RE: Nuclear briefing [SEC=PROTECTED]
Date: Thursday, 18 February 2021 1:34:56 PM
Attachments: Nuclear Energy - Note 18 February 2021.docx

PROTECTED

Hi s 22(1)(a)(ii)

Thanks for the chat just now. Please see attached an updated version of the nuclear 2 pager we provided you earlier today, including a few of the edits/additions I mentioned (in track). These are adjustments to the info on:

- *Use* vs *generation* of nuclear by OECD countries – suggest using **generated** noting interconnection across countries (e.g. the EU) makes use difficult to track.
- Updated LCOE point on renewables (using the 'up to 90%' figures and explaining what's in that LCOE calculation)
- Australia's proportion of uranium deposits
- s 47C

Hope that helps!!

Cheers,

s 22(1)(a)(ii) | Advisor
Energy and Climate Change
Industry, Infrastructure & Environment Division | Department of the Prime Minister and Cabinet
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One National Circuit Barton ACT 2600 | PO Box 6500 CANBERRA ACT 2600

From: s 22(1)(a)(ii)@pmc.gov.au>
Sent: Thursday, 18 February 2021 11:13 AM
To: s 22(1)(a)(ii)@pm.gov.au>
Cc: Climate Change s 47E(d)@pmc.gov.au>; DLO <dlo@pm.gov.au>;s 22(1)(a)(ii) s 22(1)(a)(ii)@pmc.gov.au>; Trease, Roland <Roland.Trease@pmc.gov.au>
Subject: RE: Nuclear briefing [SEC=PROTECTED]

PROTECTED

Hi s 22(1)(a)(ii)

As requested, brief attached along with some supplementary attachments.

Cheers,

s 22(1)(a)(ii) Advisor
Department of the Prime Minister and Cabinet
p. s 22(1)(a)(ii) | m. s 22(1)(a) | e. s 22(1)(a)(ii)@pmc.gov.au

s 22(1)(a)(ii)

Nuclear Energy – For Information Note

18 February 2021

Moratorium and Regulation of Nuclear Energy in Australia

- In addition to any relevant state or territory legislation, nuclear energy is currently regulated under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Australian Radiation Protection and Nuclear Safety Act 1998* (ARPaNSA Act).
- The EPBC Act states the Minister must not approve the construction or operation of the following nuclear installations:
    - a nuclear fuel fabrication plant;
    - a nuclear power plant;
    - an enrichment plant;
    - a reprocessing facility.
- The recent Independent Review of the EPBC Act (Samuel Review) found the *"Commonwealth should retain the capacity to ensure nuclear (radioactive) activities are managed effectively and in accordance with best practice"*, for community confidence.
- The ARPaNSA Act also prohibits the Commonwealth Government from authorising the construction or operation of nuclear installations such as nuclear power plants.

Nuclear Power around the world and net zero emissions

- The International Atomic Energy Agency (IAEA) identify there are 443 operational nuclear power stations in the world, with around 45 per cent in the USA, France or China.
    - The IAEA estimates nuclear power provides around 10 per cent of global electricity.
    - Mycle Schneider Consulting estimate the average age of global nuclear reactors is nearly 31 years old.
    - The IAEA estimate 51 nuclear power stations are currently under construction.
- Of the 34 OECD countries which have made an announcement to achieve net zero emissions by 2050 (or earlier), 18 used nuclear energy in 2019.
- The US, UK, Canada, Republic of Korea, France, Germany and Japan have all made announcements to achieve net zero emissions by 2050, and currently use nuclear power in their energy mix.
    - President Biden's clean energy platform aims to drive cost reductions in clean energy technology, including through advanced nuclear.
    - The UK's Clean Growth Strategy aspires to bring down the costs of nuclear power, including committing £460 million to future nuclear fuels, new nuclear manufacturing techniques, recycling and reprocessing, and advanced reactor design.
    - Nuclear comprised over 15 per cent of Canada's electricity generation in 2019.
    - Despite being in decline, nuclear still comprised around 25 per cent of Korea's total electricity generation in 2019.
    - We note Germany plans to phase out nuclear energy by 2022.
    - France's long-term strategy contains a goal for 50 per cent of electricity generation from nuclear by 2035.

Technology and cost of Nuclear Energy

- The LCOE for traditional nuclear generations the United States is around $US71 per megawatt hour.
- CSIRO's draft 2021 GenCost report found a first-of-a-kind Nuclear SMR generator would cost $16,482 per kilowatt if built in 2020, with potential to decline to $7,237 per kilowatt in 2030.
    - This gives a Levelised Cost of Electricity (LCOE) for nuclear SMR technology between $143/MWh and $336/MWh in 2030.
    - By comparison, it estimates the LCOE of an electricity system in 2030 with up to 70 per cent variable renewable energy (wind and solar) will cost less than $75 per megawatt.

- While current cost forecasts remain relatively high, there is international effort to support development of SMR technology. Professor Lyndon Edwards of the Australian Nuclear Science and Technology Organisation notes there is: "now a huge international effort to develop SMRs…"
    - He notes more than one billion dollars of private investment in SMR companies has been made in North America alone.
- PM&C is not aware of any Nuclear SMRs in operation globally.
- NuScale Power in the United States is developing a SMR in Utah. NuScale are aiming for their first plant to begin generating power in 2029, although no final investment decision has been made.
    - In September 2020, NuScale's SMR achieved regulatory design approval from the US Nuclear Regulatory Commission.
    - NuScale is targeting a LCOE of $65 USD per megawatt hour for its SMR first plant, which will comprise 12 modules generating up to 60 MW each ($65 USD is around $84 AUD).

Australia's low-emissions technology roadmap and emissions reduction

- The discussion paper for Australia's Low-Emissions Technology Investment Roadmap canvassed nuclear power, noting:
    - *"New nuclear technologies (for example, small modular nuclear) have potential but require R&D and identified deployment pathways. The engineering, cost and environmental challenges, alongside social acceptability of nuclear power in Australia will be key determinants of any future deployment."*
- SMR technology is identified as a 'watching brief technology' in Australia's inaugural Low-Emissions Technology Statement, which is defined as:
    - *"Prospective technologies with transformative potential, perhaps where developments are currently driven primarily overseas. International developments will be closely monitored and supporting infrastructure needs assessed."*
- The Australian Nuclear Science and Technology Organisation (ANSTO) has developed world leading 'Synroc' technology to store waste from nuclear medicine. The UK Government's recent support for the nuclear industry and Rolls Royce-led consortium is expected to lead to a SMR demonstration project in the UK.
    - s 33(a)(iii)

Uranium

- According to the OECD's Nuclear Energy Agency, Australia held 28% of the world's identified and recoverable uranium resources as of January 2019.

Radioactive Waste

- Successive Commonwealth Governments have tried for over forty years to establish a national radioactive waste management facility.
- On 1 February 2020, the Minister announced Napandee in Kimba as the successful host site for the National Radioactive Waste Management Facility, as well as legislative amendments to the National Radioactive Waste Management Act 2012.
    - These amendments were introduced into the House of Representatives on 13 February 2020. The amendments passed the House of Representatives on 11 June 2020, and are scheduled for debate in the Senate next week (the week of 22 February).
- The Facility will bring together low and intermediate level radioactive waste accumulated over 60 years.

- This waste is currently spread across more than 100 storage facilities across Australia including science facilities, universities and hospital basements. The facility will permanently dispose of low level waste, and temporarily store intermediate level waste. A separate process will site a facility at a different location for the permanent disposal of this waste.

Government consideration and recent Inquiries

- s 34(3)
- In the foreword to the recent House of representatives Standing Committee on the Environment and Energy, Committee Chair, Mr Ted O'Brien MP, noted consideration of removing the moratorium on nuclear energy for new and emerging technologies should be "subject to the results of a technology assessment and to a commitment to community consent for approving nuclear facilities."
- The South Australian Royal Commission noted nuclear power 'may be required' as part of a 'lower carbon electricity system', but found a nuclear power plant would not be commercially viable (in South Australia) beyond 2030 under current market rules.

Background

s 34(3)

PM statements on Nuclear Energy

"The arrangements around nuclear are well known and the government's policy has been clear there about the need for there to be bipartisanship, to be able to move forward. But nothing will ever stop us from looking over the horizon."

6 February 2020 – Press Conference

"Well there have been a number of reports that have done this. I remember the Howard Government did one, Ziggy Switkowzki, and the recommendations of that weren't terribly favourable in terms of stacking up. But as I said on your program last time, where something can stack up and can actually bring prices down, I'm all for it and you've just to do the work to make sure it does that."

16 October 2018– Press Conference

Nuclear Energy – For Information Note

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  - By comparison, it estimates the LCOE of an electricity system in 2030 with up to 90 per cent variable renewable energy (wind and solar) will cost less than $87 per MWh and as low as $46 per MWh, including required transmission and energy storage.
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  - s 33(a)(iii)

Uranium

- According to the Uranium 2020 joint report between the International Atomic Energy Agency and the OECD's Nuclear Energy Agency, Australia held 31% of the world's reasonably assured uranium resources as of 31 December 2018.

Radioactive Waste

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- On 1 February 2020, the Minister announced Napandee in Kimba as the successful host site for the National Radioactive Waste Management Facility, as well as legislative amendments to the National Radioactive Waste Management Act 2012.

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16 October 2018– Press Conference

From: s 22(1)(a)(ii)
To:
Cc: Climate Change; Trease, Roland
Subject: For info - CEFC Operations ~~[SEC=PROTECTED, CAVEAT=SH:CABINET]~~
Date: Friday, 15 October 2021 5:57:51 PM
Attachments: 2021 Spring Week 5 - Forecast (13 October).pdf
For information - CEFC Amendment Bill and Funding Proposal SECPROTECTED CAVEATSHCABINET.msg
image003.png
Importance: High

~~PROTECTED//CABINET~~

Hi s 22(1)(a)(ii)

Following your earlier conversation with Roland, please find below further information on the operations of the Clean Energy Finance Corporation (CEFC).

Governance

- The CEFC's investments are governed by legislation, as well as a mandate set by the Minister for Finance and the Minister for Industry, Energy and Emissions Reduction.
- The CEFC's legislation (2013) requires it to:
  - Invest in clean energy technologies, as defined by the CEFC Board.
    - Carbon capture and storage and nuclear energy are explicitly prohibited.
  - Ensure 50% of its total investments are in renewable energy.
  - Invest mainly or solely in Australia.
    - In practice, this means the CEFC invests only in Australian projects, though these may involve international companies.

s 47C

- The CEFC's current mandate (2020) requires the it to:
  - Target a portfolio-wide average return of +3 to +4% above the Australian Government's five year bond rate
  - Take on an 'acceptable but not excessive' level of *average* risk (i.e. can make some riskier investments balanced against less risky ones)
  - Provide concessional funding for specific purposes, most notably:
    - $300 million for hydrogen (the Advancing Hydrogen Fund) and $200 million for low emissions technology companies in between the R&D and commercial stages (the Clean Energy Innovation Fund), targeting a return of +1 per cent above the five year bond rate.

Funding history

- The CEFC was originally allocated $10 billion in 2013. To date, they have committed $9.54 bn, with $2.5bn so far returned (to be reinvested).
  - Around half of CEFC's $9.54bn commitment to date has been for projects in regional Australia.
    - Examples of regional projects include the CEFC's recent $295 million to Project Energy Connect across regional NSW and SA, $16.5 million commitment to Circular Plastics Australia's Albury-Wodonga facility, and $21.2 million commitment to the Hayman and Daydream solar farms in

north QLD.

- The Government agreed to increase CEFC's funding allocation in 2019 through the $1 billion Grid Reliability Fund (GRF), to support Government investment in new energy generation, storage and transmission infrastructure, including eligible projects shortlisted under the Underwriting New Generation Investments (UNGI) program.
    - The legislation for the GRF has not yet been passed, preventing the CEFC from accessing these funds.

s 47C [redacted]

Very happy to dig in further as needed,

s 22(1)(a)(ii) Adviser, Climate Change
Department of the Prime Minister and Cabinet
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