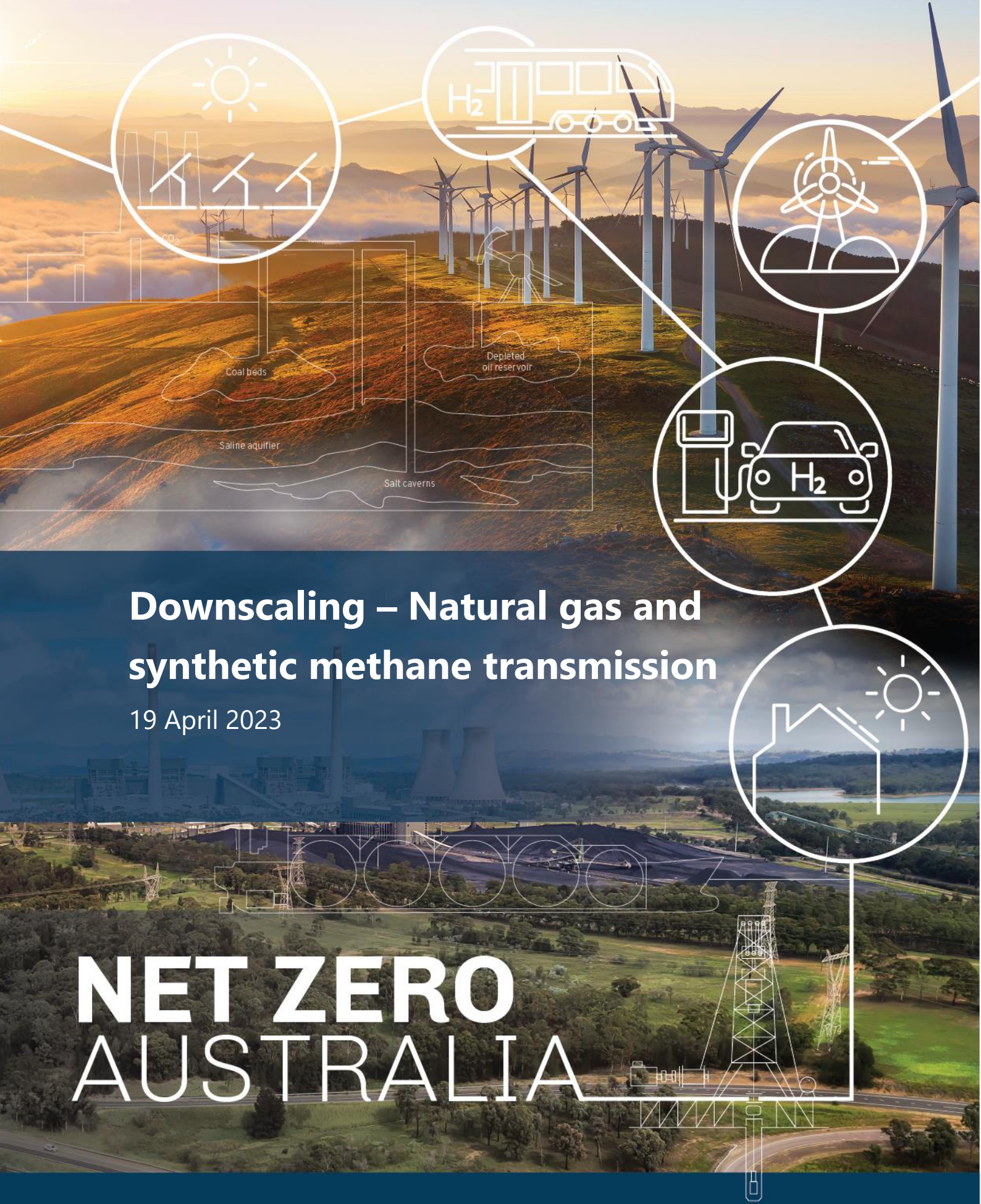

Downscaling – Natural gas and synthetic methane transmission

19 April 2023

NET ZERO
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The Net Zero Australia (NZAu) project is a collaborative partnership between the University of Melbourne, The University of Queensland, Princeton University and management consultancy Nous Group. The study examines pathways and detailed infrastructure requirements by which Australia can transition to net zero emissions, and be a major exporter of low emission energy and products.

Net Zero Australia

Downscaling – Natural gas and synthetic methane transmission

19 April 2023

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Contents

1 Introduction

In the Net Zero Australia (NZAu) project we use the terminology pipeline gas to refer to a gas product that is mostly methane (typically greater than 92% with trace amounts of heavier hydrocarbons, inert gases and carbon dioxide). Pipeline gas can be considered synonymous with traditional natural gas that has been decarbonised. However, to avoid the confusion of the source of the methane, we distinguish fossil methane or natural gas from decarbonised methane by using the term pipeline gas, regardless of origin.

Therefore, the pipeline gas reported in this chapter can either be considered natural gas (ie extracted as a fossil resource) whose emissions have been offset with direct air capture (DAC), traditional biogas, or methane that has been produced using biomass and also includes the capture of CO_2 emitted during processing. NZAu does not report the composition of the pipeline gas, only that it would comply with the Australian Gas Pipeline Standard AS4564-2020 [1]. The NZAu Methods, Assumptions, Scenarios & Sensitivities (MASS) document [2] provides more details of the pipeline gas extraction, production, distribution, and transmission technologies included in modelling.

For context, in 2020 Australia had an extraction capacity of 4,000 PJ/year for conventional natural gas (distributed across the country) and 1,400 PJ/year for coal seam gas (CSG) (distributed in QLD and NSW). Australia's LNG production capacity was 4,400 PJ/year located in NT, QLD and WA. Fuel switching employed in modelling sees natural gas and CSG resources being replaced by electrification, hydrogen, and synthetic methane over the course of the transition. Aside from E+ RE+, all scenarios also continue to use it as pipeline gas used in autothermal reforming with carbon capture and LNG production. Technologies that use natural gas and are considered in NZAu modelling are detailed in the MASS [2].

Coverage of pipeline gas in this chapter includes:

1. National supply and demand results;
2. Australian state/territory supply and demand results;
3. Indicative examples of pipeline gas transmission;

The NZAu scenarios referred to in this document include the high electrification (E+), slow electrification (E–), 100% renewables (RE+), renewables constrained (RE–), onshoring (ON+), and the reference (REF) scenarios. A detailed description of each of these scenarios can be found in the MASS document [2].

2 National supply and demand results

National demand for pipeline gas by scenario, year, and end-use are shown in Figure 1.

Figure 1 | Demand for pipeline gas by scenario, year, and end-use (national)

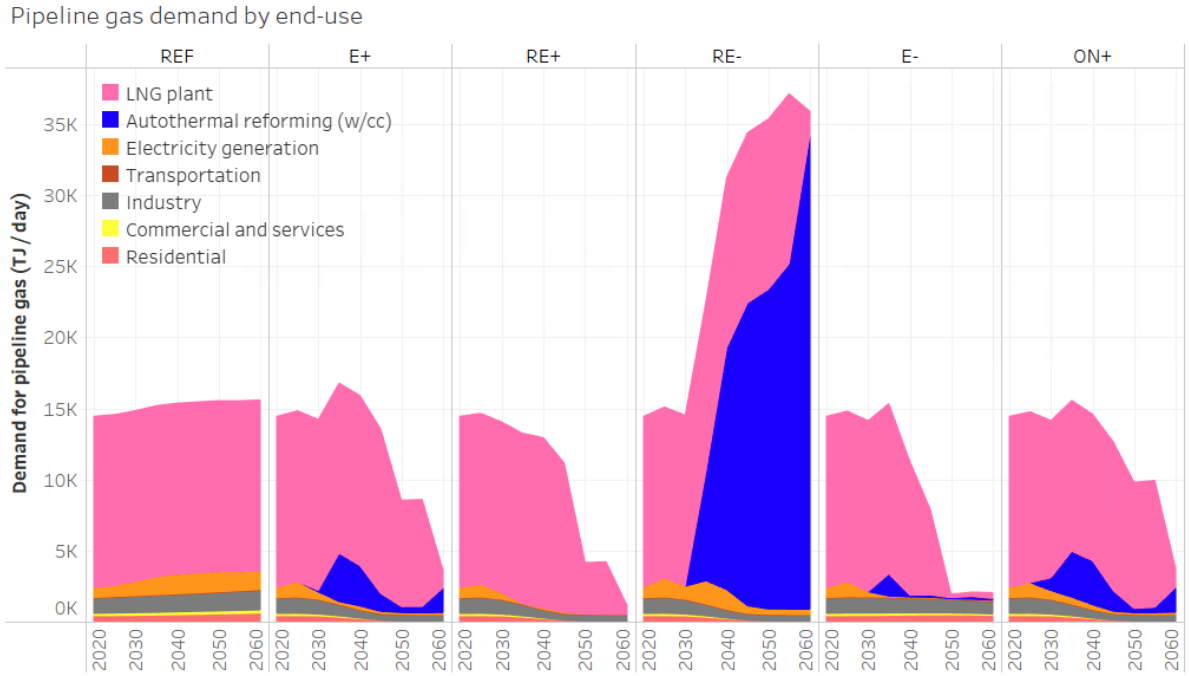
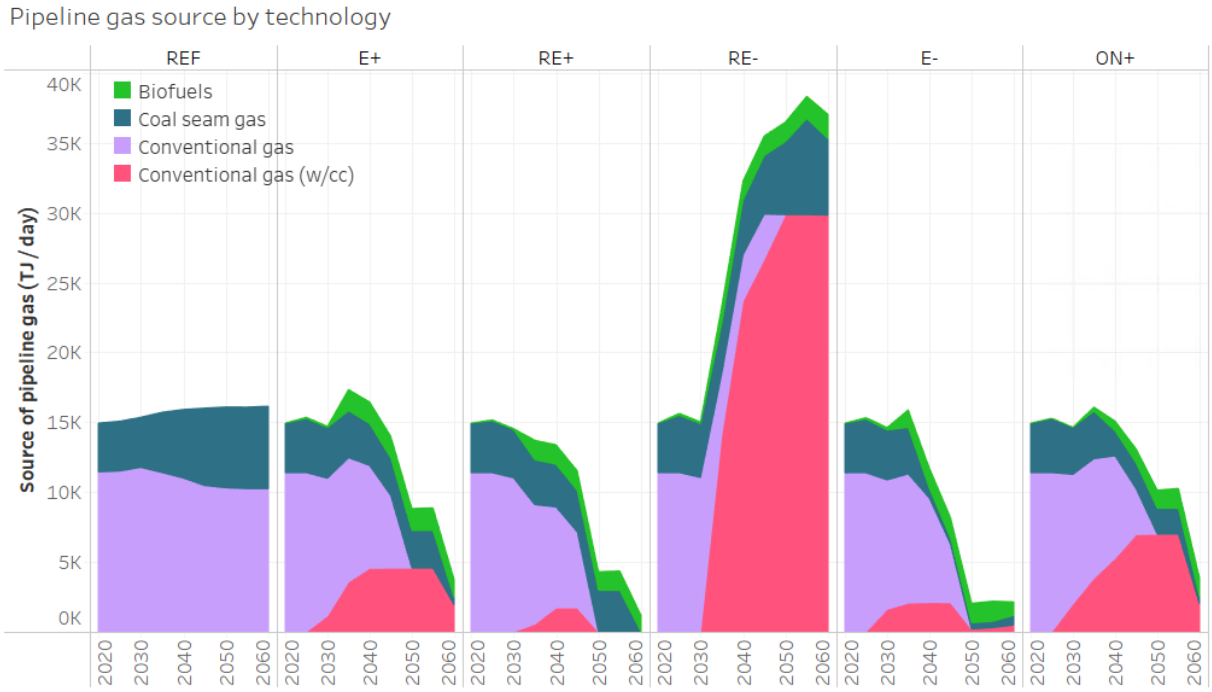


Figure 1 shows an overall decline in pipeline gas demand in all scenarios but the RE– scenario, which sees a 3x increase from today's demand. Within the RE– scenario, nearly all expanded demand for pipeline gas comes from autothermal reforming with carbon capture (ATR w/cc) technology employed for producing hydrogen to supply the export economy. Other significant demand for pipeline gas in the RE– and other scenarios include the production of liquid natural gas for (clean energy) export, industrial uses, and for electricity generation. The only scenario which involves the continued widespread use of pipeline gas by residential, commercial, and service end-uses through 2060 is the E– scenario in which electrification occurs more slowly than in other scenarios. National supply of pipeline gas by scenario, year, and technology are shown in Figure 2. Sources of gas supply less than 20 TJ/day of pipeline gas in all model years are not shown.

Figure 2 | Sources of pipeline gas by scenario, year, and technology (national)

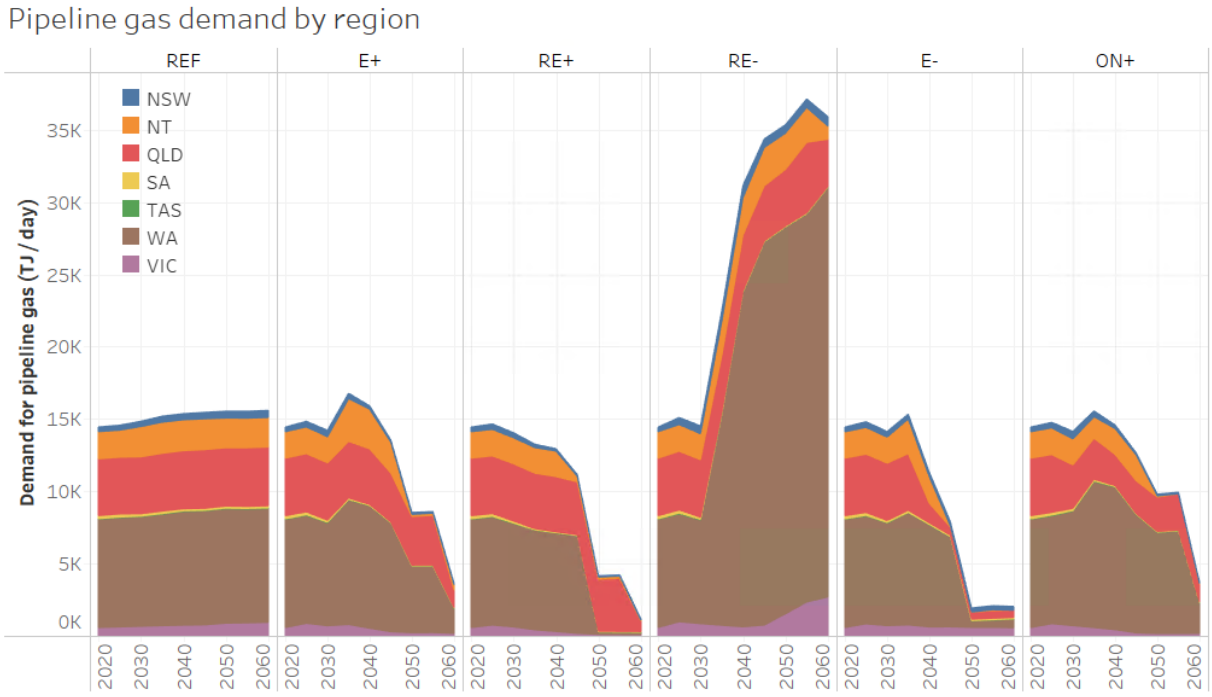


As might be expected from Figure 1, Figure 2 indicates an overall decline in pipeline gas supply in all scenarios but the RE– scenario, which sees a nearly 3x in total supply when compared against today's extraction/production. Within the RE– scenario, conventional gas extraction expands to the full availability allowed in the framing of the scenario by including carbon capture technology. Coal seam gas also plays an expanded role (compared to 2020) in the RE– scenario in Figure 2, but sees much diminished roles by 2060 in all other scenarios (aside from reference). Bio-gasification contributes to pipeline gas supply in all scenarios and appears to make the largest total contributions in the RE– and E– scenarios. In fact, by 2060 pipeline gas supply from biomass industries supplies 35% of the total pipeline gas supply in the E+ and ON+ scenarios, 100% of the total pipeline gas supply in the high renewables scenario (RE+), 45% of the total supply in the E– scenario, and half the total supply in the onshoring scenario (ONS).

3 State/territory supply and demand results

The demand for pipeline gas is shown by scenario, year, and state/territory in Figure 3.

Figure 3 | Demand for pipeline gas by scenario, year, and state/territory



Except for the RE– scenario, Figure 3 shows pipeline gas demand decreasing across all regions of Australia. In the RE– scenario, pipeline gas demand increases from 2020 quantities in WA and VIC, which is expected to be connected to the use of ATR w/cc in those regions to meet H_2 export demand. Pipeline gas demand continues at similar for diminished levels through 2060 in the RE– scenario in the NT, QLD and NSW. In the E– scenario, pipeline gas demand in 2060 decreases from 2020 values, but is maintained at low levels in nearly all regions of Australia. In the E+, RE+ and ON+ scenarios, the main consumers of pipeline gas in 2060 are either in QLD or WA. The supply of conventional and coal seam sourced pipeline gas is shown by scenario, year, and state/territory in Figure 4.

Except for the RE– scenario, Figure 4 indicates a decrease in pipeline gas supply from all conventional and coal seam gas producing regions of Australia. In the RE– scenario conventional and coal seam gas supply from WA in 2060 is 3x the quantity supplied by that state in 2020, and gas supply from QLD is 1.6x the quantity supplied by that state in 2020. The supply of synthetic pipeline gas from biomass is shown by scenario, year, and state/territory in Figure 5.

Figure 5 shows pipeline gas supply from biomass industries growing across all regions of Australia. NSW and QLD see the largest increases in pipeline gas supply from biomass across all scenarios, with other biomass containing regions (VIC, WA, TAS, SA) also seeing growth of a domestic industry. Only the NT fails to grow a domestic pipeline gas industry – likely due to a relative lack of biomass to use in the process (see MASS [2] and biomass downscaling document). In depth coverage of biomass to pipeline gas technologies can be found in the biomass downscaling document. Notably, while methanation is an option for producing synthetic pipeline gas in NZAu modelling, it is not selected as a supply technology in any core scenario.

Figure 4 | Supply of conventional and coal seam sourced pipeline gas by scenario, year, and state/territory

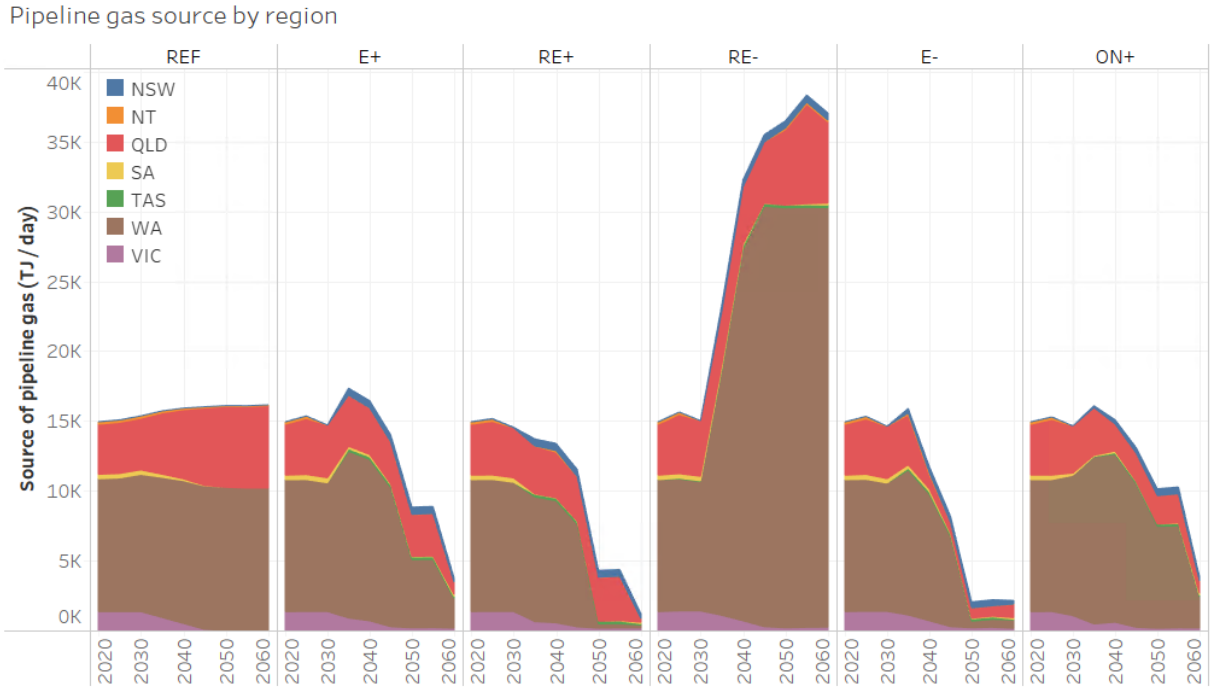
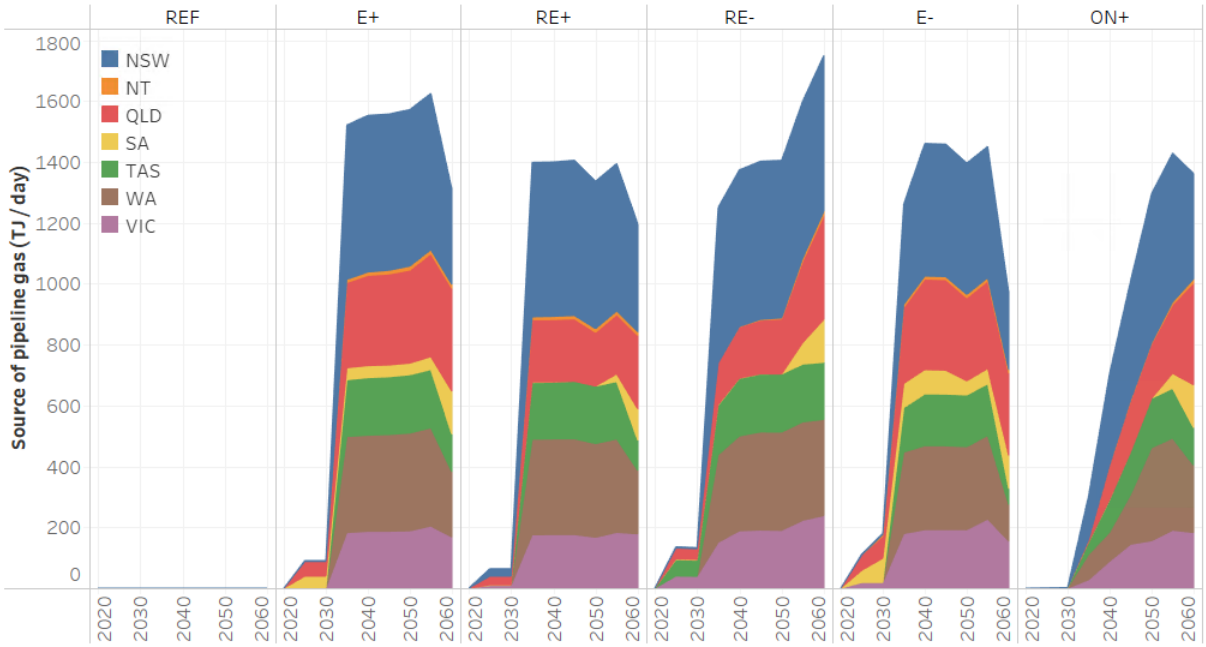


Figure 5 | Supply of synthetic pipeline gas from biomass by scenario, year, and state/territory



4 Pipeline gas transmission

The transfer of gas within and between regions requires pipeline gas transmission technology. All pipeline gas transmission infrastructure called for by NZAu scenarios is conventional pipeline gas transmission technology. Conventional pipeline gas transmission technology covers "transmission lines including compressor stations to deliver gas from processing plants' gates or storage facilities to major consumers (e.g., cities, power plants, LNG facilities or industry zones)" [2, p. 181]. An Australia Energy Market Operator (AEMO) [3] map of pipeline gas corridors and major facilities is shown in Figure 6. The simplified NZAu pipeline gas infrastructure map with AEMO [4] and AEMC [5] listed transfer capacities of major pipelines is shown in Terajoules per day (TJ/day) in Figure 7.

Figure 6 | AEMO [3] map of Australia pipeline gas networks and key sites

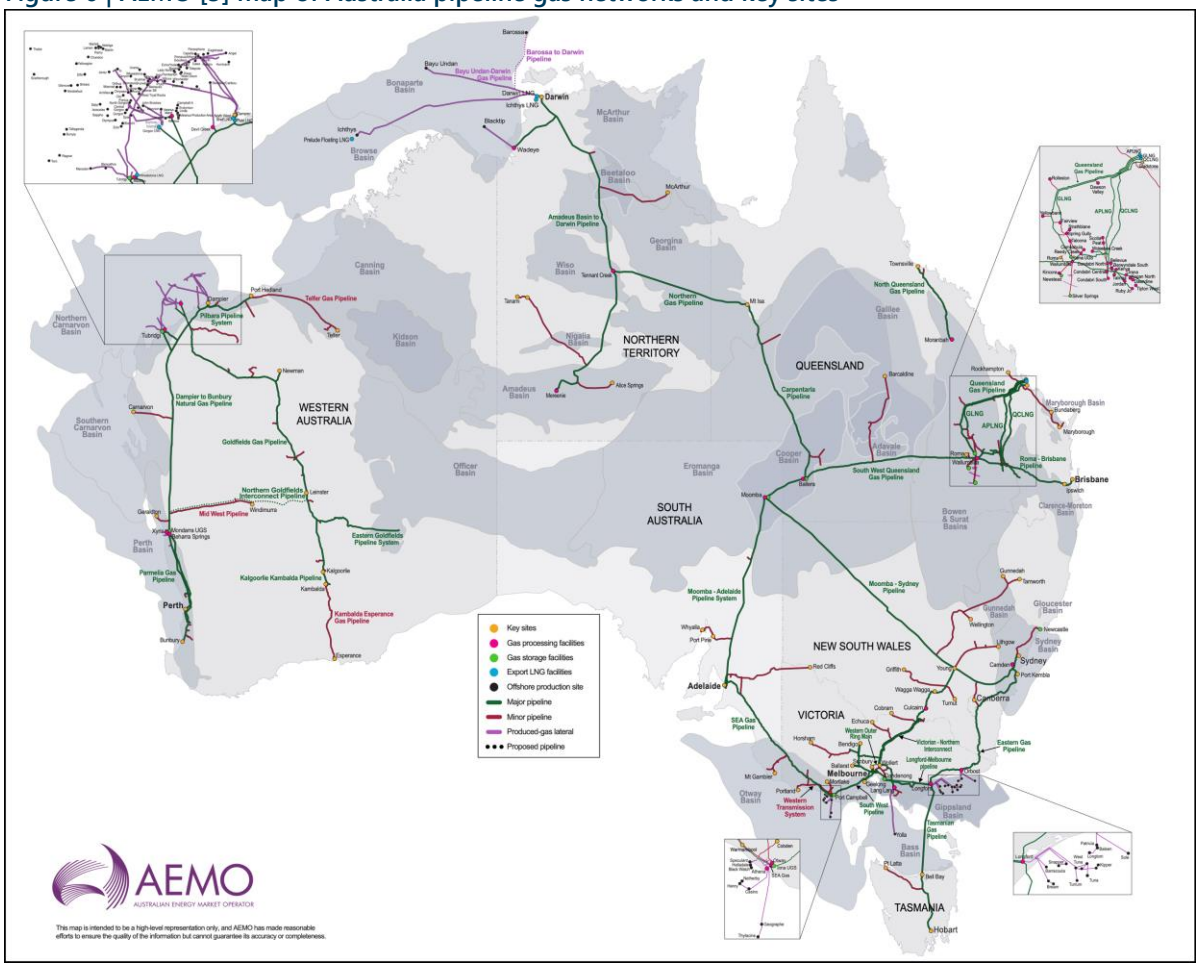
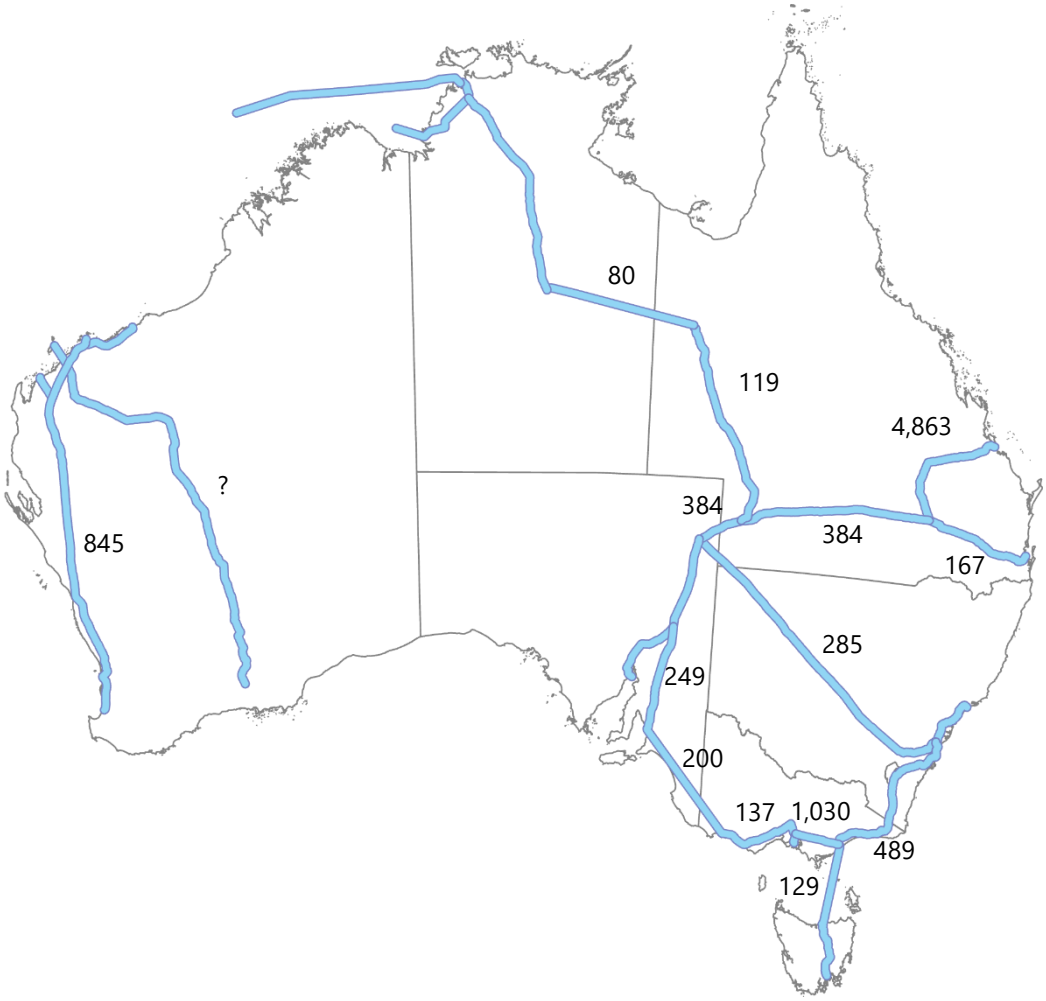


Figure 7 | Map of current Australia pipeline gas networks with transfer capacities in TJ/day from the AEMO [4] and AEMC [5]



4.1 Pipeline gas transmission in E+ scenario

Pipeline gas from within-region sources are listed by year and state/territory in TJ/day, for the E+ scenario in Table 1. Pipeline gas sources by state/territory for all other scenarios can be found in the Appendix. Note that under NZAu accounting, most of natural gas supply off the coast of northern WA in Browse and Bonaparte basins are allocated to WA.

Table 1 | Pipeline gas from within-region sources in TJ/day for the E+ scenario, by year and state/territory

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	12	11	7	507	515	513	514	514	313
NT	171	170	0	10	11	12	13	13	15
QLD	3,641	4,016	3,769	3,650	3,329	2,994	2,997	3,030	866
SA	319	358	357	168	162	66	38	42	141
TAS	0	0	0	187	189	190	192	191	124
VIC	1,351	1,358	1,356	895	692	269	188	204	168
WA	9,446	9,444	9,216	11,929	11,549	9,952	4,886	4,886	2,135
Total	14,940	15,358	14,705	17,345	16,448	13,997	8,828	8,881	3,762

Pipeline gas demand by year and state/territory in TJ/day are listed for the E+ scenario in Table 2. Pipeline gas demand by year and state/territory for all other scenarios can be found in the Appendix. Note that in NZAu accounting, pipeline gas that is exported to foreign markets is included as part of state/territory demand (before being exported).

Table 2 | Pipeline gas demand by state/territory in TJ/day for the E+ scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	347	416	470	403	254	165	147	123	124
NT	1,885	1,906	1,862	*3,041**	2,822	2,200	148	153	*392**
QLD	*4,105**	4,159	4,088	4,038	3,967	3,495	3,472	3,548	*1,234**
SA	227	204	154	106	71	49	48	49	49
TAS	33	51	41	32	27	23	25	27	27
VIC	611	914	736	820	550	294	225	237	177
WA	7,732	7,709	7,353	8,898	8,734	7,764	4,751	4,744	1,759
Total	*14,940*	15,358	14,704	*17,336*	16,426	13,991	8,815	8,879	*3,765*

* Small adjustments of less than 3 TJ/day were made to demand in these years and regions to allow demand and supply to balance in next Table. As upstream (3%) and distribution losses (3% for residential, commercial, and productive; 1% for transportation) are included in the regional demand values in this Table, these small adjustments can be interpreted as efficiency improvements made in the supply chain in the model year.

Pipeline gas flow balances are listed by state/territory for the E+ scenario in Table 3. A negative value (in red) in Table 3 indicates a deficit of pipeline gas that must be met by other state/territories. A positive value in Table 3 indicates a surplus of pipeline gas that can be transmitted to other state/territories to meet demand there.

Table 3 | Pipeline gas flow balances by state/territory in TJ/day for the E+ scenario

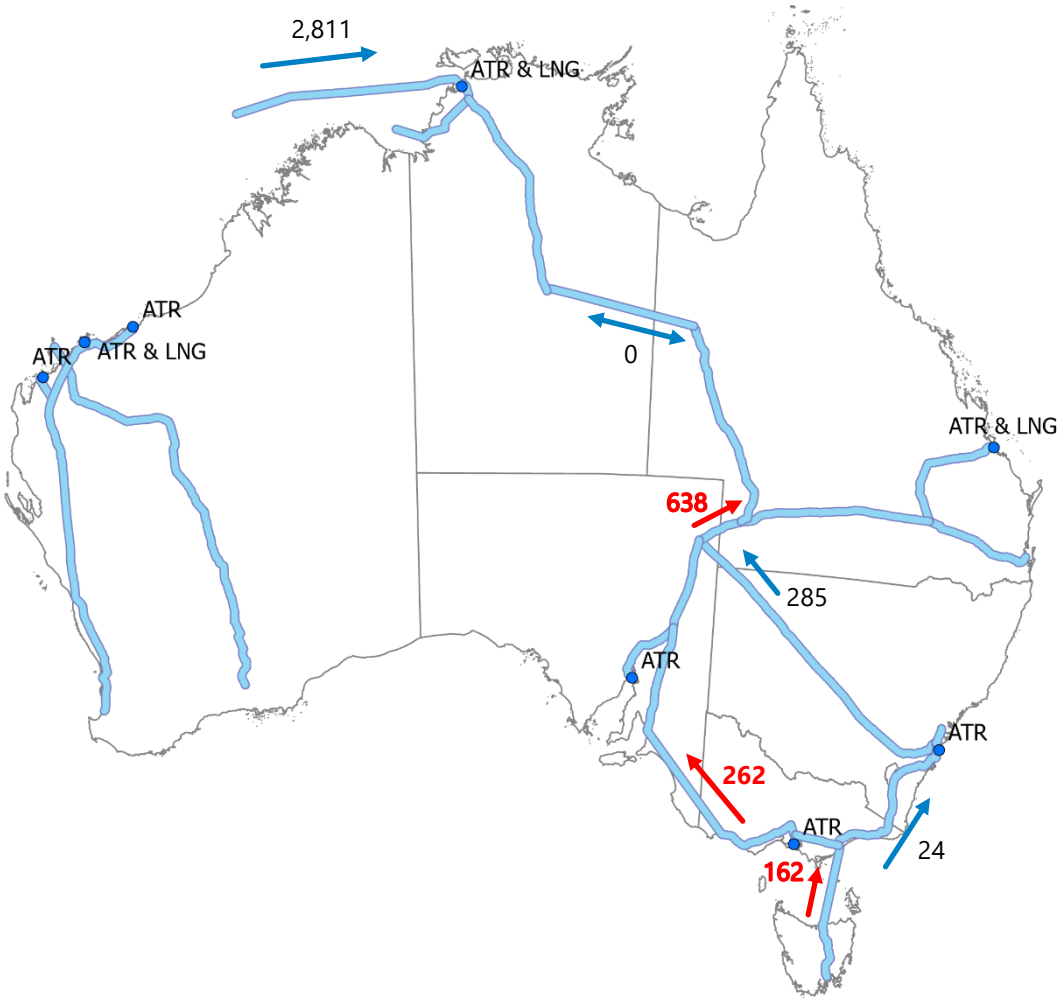
	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	-335	-405	-462	105	261	348	368	391	190
NT	-1714	-1736	-1862	-3031	-2811	-2188	-135	-140	-377
QLD	-464	-143	-319	-388	-638	-501	-475	-518	-368
SA	92	154	203	62	91	17	-10	-7	92
TAS	-33	-51	-41	155	162	166	167	165	96
VIC	740	444	620	75	143	-25	-37	-33	-9
WA	1714	1736	1862	3031	2815	2188	135	142	377
Total	0	0	1	9	22	6	12	1	0

Table 3 highlights that only WA has a pipeline gas surplus in all modelled years, while the NT and QLD run deficits over the entire modelling period. Interestingly, and as might be expected from comparison of Figure 5 and Figure 3, both New South Wales and Tasmania move from being net-importers of pipeline gas to net exporters in 2035. In both states the transition to surplus occurs due to a combination of a reduction in demand (due to electrification) and industrial production of pipeline gas from bio-gasification industries.

Victoria's transition from pipeline gas surplus to deficit in 2045 in Table 3, occurs as natural gas wells are retired rather than being converted to less carbon intensive pipeline gas with carbon capture (as happens with some conventional gas supply in WA), and synthetic pipeline gas flows into the state from neighbouring regions where it is produced more cheaply. Balancing of the supply and demand tables found in the Appendix, result in a finding of Victoria as a net-importer in 2060 in the RE– and E– scenarios, and a net-exporter of pipeline gas in 2060 in the RE+ and ON+ scenarios.

Figure 8 presents an indicative example of inter-state/territory pipeline gas flows for the E+ scenario in model year 2040, along with the likely locations of pipeline gas demand (LNG, and autothermal reforming w/cc) in that year.

Figure 8 | Map of current Australia pipeline gas networks with indicative depiction of inter-regional transfers for the E+ scenario in 2040, along with the likely locations of pipeline gas demand (LNG, and autothermal reforming w/cc) in that year



Limited insights may be drawn from Figure 8. For instance, Figure 8 details pipeline gas transfers between TAS and VIC and VIC, SA and QLD (in red) that exceed the combined pipeline gas corridor capacities shown in Figure 7. However, the reader is advised that the individual gas corridors, intra-regional flows and spatially explicit pipeline gas supply and demand locations (as are shown in Figure 6) are not included in core modelling or downscaling, and that – using the same results data – a number of differing flow maps might be drawn to connect the regions and we present only one indicative version in Figure 8.

Appendices

Appendix A

Pipeline gas sources by state/territory for all scenarios

Table 4 | Pipeline gas sources by state/territory in TJ/day for the RE+ scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	12	33	29	507	507	510	484	484	355
NT	171	170	0	9	122	11	12	12	12
QLD	3,642	3,838	3,591	3,420	3,261	3,172	3,143	3,162	242
SA	319	320	319	30	29	28	0	25	103
TAS	0	0	0	186	186	189	189	189	99
VIC	1,351	1,364	1,363	632	555	257	167	183	179
WA	9,446	9,445	9,244	8,928	8,730	7,356	308	307	207
Total	**14,940**	**15,170**	**14,546**	**13,713**	**13,391**	**11,523**	**4,303**	**4,362**	**1,196**

Table 5 | Pipeline gas sources by state/territory in TJ/day for the RE– scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	12	13	8	511	515	520	518	517	512
NT	171	170	0	0	1	2	115	122	126
QLD	3,639	4,236	3,984	3,816	4,112	4,382	5,411	7,145	5,808
SA	319	322	320	224	127	28	0	71	141
TAS	0	54	53	163	189	190	191	190	188
VIC	1,351	1,402	1,400	1,086	696	273	190	223	239
WA	9,446	9,444	9,261	17,498	26,618	30,092	30,062	30,062	30,023
Total	**14,937**	**15,640**	**15,027**	**23,299**	**32,257**	**35,487**	**36,486**	**38,329**	**37,037**

Table 6 | Pipeline gas sources by state/territory in TJ/day for the E– scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	12	12	8	330	436	435	431	431	255
NT	171	170	5	124	121	10	11	11	17
QLD	3,643	3,972	3,746	3,577	1,043	747	723	738	956
SA	319	359	311	230	203	80	46	50	109
TAS	0	0	0	146	170	170	170	170	52
VIC	1,351	1,376	1,373	1,108	697	274	192	227	155
WA	9,444	9,443	9,181	10,373	9,066	6,472	473	574	602
Total	**14,940**	**15,331**	**14,623**	**15,889**	**11,737**	**8,188**	**2,046**	**2,201**	**2,146**

Table 7 | Pipeline gas sources by state/territory in TJ/day for the ON+ scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	12	8	4	144	301	392	490	489	346
NT	171	170	0	0	1	2	3	8	15
QLD	3,641	3,988	3,373	3,408	1,939	2,020	2,031	2,076	856
SA	319	319	159	69	125	28	0	49	141
TAS	0	0	0	40	107	141	163	164	123
VIC	1,351	1,357	1,069	469	596	229	156	191	183
WA	9,445	9,444	10,041	11,959	12,017	10,273	7,298	7,292	2,211
Total	**14,939**	**15,286**	**14,646**	**16,089**	**15,086**	**13,085**	**10,141**	**10,269**	**3,875**

Table 8 | Pipeline gas flow balances by state/territory in TJ/day for the REF scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	12	8	4	0	0	0	0	0	0
NT	170	170	170	141	113	83	57	57	57
QLD	3,587	3,661	3,692	4,390	4,951	5,553	5,791	5,842	5,904
SA	319	319	317	222	124	28	0	0	0
TAS	0	0	0	0	0	0	0	0	0
VIC	1,351	1,351	1,352	930	506	83	0	0	0
WA	9,506	9,565	9,825	10,034	10,223	10,266	10,249	10,189	10,189
Total	**14,946**	**15,075**	**15,361**	**15,717**	**15,917**	**16,013**	**16,097**	**16,088**	**16,150**

Pipeline gas demand by state/territory for all scenarios

Table 9 | Pipeline gas demand by state/territory in TJ/day for the RE+ scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	347	404	374	255	179	122	98	92	89
NT	1,885	1,889	1,859	1,825	1,821	406	157	161	66
QLD	4,106	4,120	4,083	3,962	3,939	3,777	3,710	3,787	738
SA	228	198	151	87	66	50	45	46	48
TAS	31	46	36	23	23	22	22	24	25
VIC	612	788	656	445	319	181	106	95	84
WA	7,732	7,726	7,384	7,113	7,027	6,961	163	159	157
Total	**14,942**	**15,170**	**14,544**	**13,710**	**13,373**	**11,520**	**4,300**	**4,365**	**1,208**

Table 10 | Pipeline gas demand by state/territory in TJ/day for the RE– scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	347	517	570	810	884	616	594	612	674
NT	1,885	1,903	1,854	2,411	2,674	2,735	2,589	2,489	933
QLD	4,106	4,194	4,108	4,043	3,982	3,924	4,039	5,019	3,347
SA	225	222	159	136	84	54	59	62	59
TAS	33	54	39	35	29	22	22	24	25
VIC	610	1,026	885	763	652	772	1,579	2,412	2,775
WA	7,732	7,712	7,407	15,019	23,851	27,320	27,573	27,681	29,217
Total	**14,938**	**15,627**	**15,023**	**23,216**	**32,156**	**35,443**	**36,455**	**38,298**	**37,030**

Table 11 | Pipeline gas demand by state/territory in TJ/day for the E– scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	348	423	408	361	333	328	305	298	282
NT	1,884	1,905	1,858	2,474	1,892	69	21	59	
QLD	4,106	4,166	4,089	4,037	1,407	570	489	551	520
SA	227	208	156	152	117	114	108	106	102
TAS	32	46	37	29	29	29	29	31	32
VIC	612	873	746	796	654	660	625	624	594
WA	7,731	7,708	7,328	8,013	7,291	6,409	461	527	617
Total	**14,940**	**15,329**	**14,621**	**15,862**	**11,722**	**8,180**	**2,039**	**2,195**	**2,147**

Table 12 | Pipeline gas demand by state/territory in TJ/day for the E+ ON+ scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	348	409	548	428	267	155	133	120	117
NT	1,884	1,904	1,857	1,533	1,844	1,836	88		59
QLD	4,106	4,129	3,100	2,925	2,230	2,342	2,452	2,593	1,261
SA	226	195	158	121	69	48	47	47	49
TAS	33	53	40	50	38	32	27	36	37
VIC	611	885	742	603	449	217	161	163	174
WA	7,732	7,710	8,182	10,420	10,173	8,435	7,216	7,301	2,164
Total	**14,940**	**15,285**	**14,628**	**16,080**	**15,071**	**13,066**	**10,125**	**10,260**	**3,861**

Table 13 | Pipeline gas flow demand by state/territory in TJ/day for the REF scenario

	2020	2025	2030	2035	2040	2045	2050	2055	2060
NSW	347	368	391	445	453	477	506	511	525
NT	1,935	1,929	2,159	2,218	2,199	2,196	2,114	2,108	2,108
QLD	4,054	4,051	4,062	4,128	4,149	4,191	4,166	4,189	4,194
SA	225	227	178	182	153	147	155	154	159
TAS	30	38	35	42	44	43	39	42	45
VIC	611	655	700	744	781	803	924	950	989
WA	7,742	7,807	7,834	7,965	8,129	8,149	8,188	8,142	8,141
Total	**14,945**	**15,076**	**15,358**	**15,725**	**15,907**	**16,004**	**16,093**	**16,095**	**16,161**

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