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Addendum to Roadmap to QRET Report 2020: Pipeline Scenario B

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1. Introduction

Advance Queensland Roadmap to QRET Report 2020 concluded that a managed transition plan was required for Queensland to achieve its Renewable Energy Target (QRET) of 50% by 2030. The requirement for a managed transition plan was a consequence of:

- the challenges associated with a transmission network that was designed for large centralised coal-fired generation requiring adaptation to supply from many small decentralised variable renewable energy (VRE) plants remote from load centres and robust network infrastructure
- investment plans for VRE that will result in high levels of curtailment, should be assessed to avoid over-supply from VRE in locations that will never have the transmission infrastructure to deliver energy generated to demand centres
- the requirement for storage of some form or another to store VRE when generated at periods when surplus energy exists for dispatch at periods when a deficit of energy exists
- the requirement to close coal units to avoid excess supply which results in high levels of curtailment of VRE

Modelling undertaken to consider outcomes of various levels of investment in VRE indicated that high levels of coal generation closure, to avoid excess supply for the majority of the year, results in energy deficits.

This addendum provides some detail of modelling outcomes for the nodal supply demand balance across the rest of the National Electricity Market (NEM). The scenarios that showed evidence of the highest levels of renewable energy within the system in Queensland in 2030, were Pipeline Scenario B and ISP Central Scenario for the year 2040. This addendum will provide details for Pipeline Scenario B only. For analysis and detail on the assumptions and modelling undertaken refer to Roadmap to Queensland Renewable Energy Target 2020 and ANEM NEM Nodal Modelling Report Final 2020.

2. NEW SOUTH WALES: Nodal Supply-Demand Balance for Summer Weekdays in 2030

a) Pipeline Scenario B

i. NSW Underlying assumptions

- N transmission network
- Direction of Flow loss method estimation
- Generation capacity at 2030 with ISP Central scenario demand assumptions
- Coal power in 2030 will decline to 4,040MW in NSW from 10,210MW currently (QLD 4,839MW from 8,059MW; VIC 3,144MW from 4,775MW)
- Coal unit closures:
    - QLD: Units 1-2 Callide B; Units 1-2 Stanwell; Units 1-2,5-6 Gladstone; Units 1-2 Tarong;
    - NSW: Units 1-4 Liddell; Units 1-4 Eraring; Units 5-6 Vales Point
    - VIC: Units 1-4 Yallourn
- Gas power in 2030 will decline to 1,174MW in NSW from 2,155MW currently (QLD 2,691MW from 3,076MW with closure of Swanbank E)
- Wind power in 2030 will reach 5,671MW in NSW (QLD 4,820MW; VIC 8,470MW; SA 3,652MW; TAS 2,302MW)
- Solar power in 2030 will reach 8,021MW in NSW (QLD 8,736MW; VIC 2,141MW; SA 4,213MW)
- Pump hydro (PHES) in 2030 includes Snowy 2.0 to reach 3,180MW in NSW (QLD 2,860MW; SA 610MW)
- Table 2 summarises generation capacity assumptions for NSW
- Transmission augmentation assumed for:
    - QNI to 5436MW
    - corridor from Armidale to Newcastle and Sydney to accommodate 5+GW of energy flows
    - Energy Connect from NSW to VIC and SA
    - Kerang-Link in Victoria
    - Battery of the Nation augmentation VIC to TAS

ii. NSW ANEM nodal structure for sB

Figure 1 provides a graphic representation of the generation capacity at each node and transmission corridors between each node in New South Wales, for the ANEM model to balance supply and demand for each of 17520 periods in the given year.

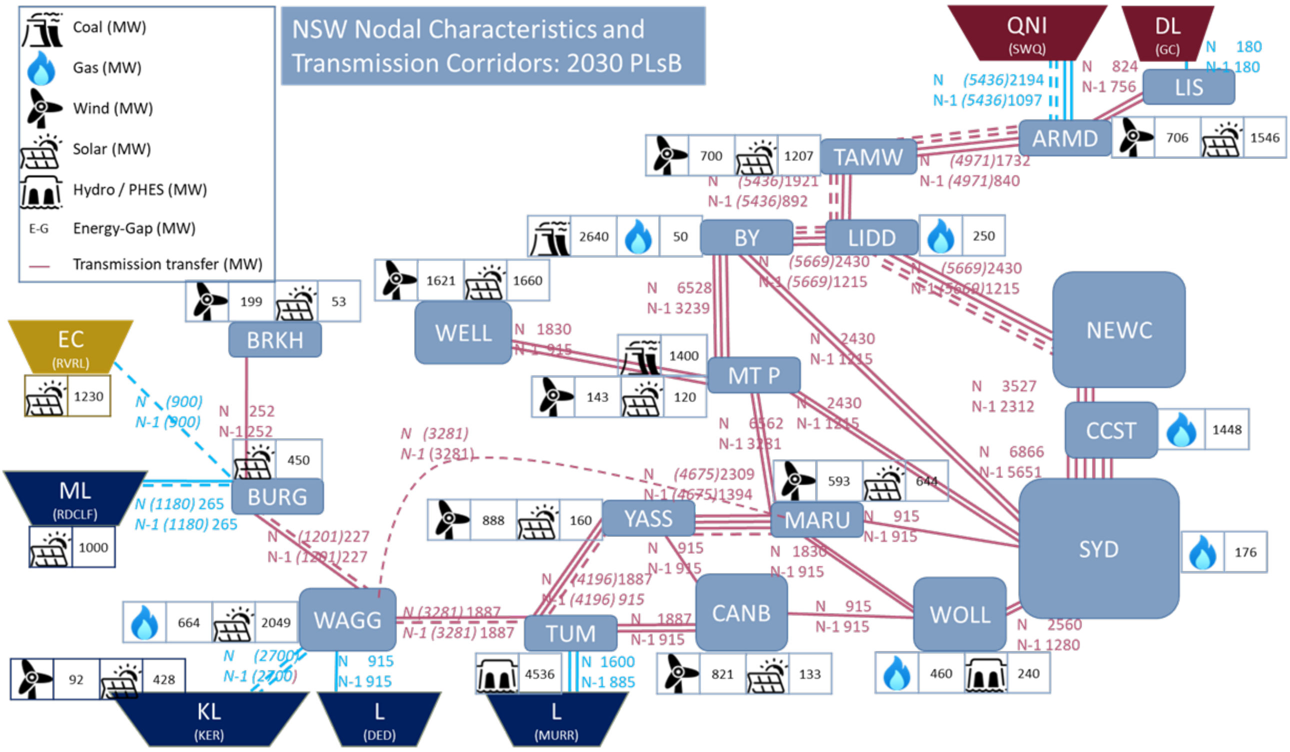

Figure 1: NSW ANEM nodal structure for sB

iii. NSW ANEM transmission corridors for sB

Table 1 provides a summary of the ANEM network transmission corridors used to determine intra-regional and inter-state trade (by reactance and thermal ratings) for co-optimisation of Optimal Power Flow (OPF) and competitive dispatch of identified generation.[1]

Table 1: NSW ANEM transmission corridors for sB

Nodes	Transmission routes	N (MW)	N-1 (MW)
LIS – ARM	Lismore – Coffs Harbour - Armidale Lismore - Casino – Tenterfield – Glen Innes Lismore – Koolkhan – Coffs Harbour Koolkhan - Armidale	824	756
ARM - TAM	***(QNI Major)*** Armidale – Tamworth	***(4971)*** 1732	***(4971)*** 840
TAM – LIDD	***(QNI Major)*** Tamworth – Liddell Tamworth - Musselbrook	***(5160)*** 1921	***(5160)*** 892
LIDD – BY	***(QNI Major)*** Liddell – Bayswater	***(5669)*** 2430	***(5669)*** 1215
LIDD –NEWC	***(QNI Major)*** Liddell – Tomago – Newcastle Liddell – Newcastle	***(5669)*** 2430	***(5669)*** 1215
BY – SYD	Bayswater – Regentville Bayswater – SydneyW	2430	1215
BY – MtP	Bayswater – Mt Piper Bayswater - Wollar	6528	3239
NEWC-CCST	Newcastle - Vales Point Newcastle - Eraring	3527	2312
CCST – SYD	Munmorrah-Tuggerah-SydneyN ValesP - SydneyN Munmorrah - SydneyW Eraring - Vineyard Eraring - KempsCreek	6866	5651
SYD - MtP	SydneyS - Wallerang Ingleburn - Wallerang	2430	1215
SYD - WOLL	SydneyS - Dapto Macauthur - Avon	2560	1280
SYD - MARU	SydneyW – Bannaby	915	915
MtP – WELL	Mt Piper – Wellington Wollar – Wellington	1830	915
MtP – MARU	Mt Piper – Bannaby	6562	3281
WOLL-MARU	Dapto - Marulan Avon – Marulan	1830	915
WOLL-CANB	Wollongong - Canberra	915	915

[1] See ANEM NEM Nodal Modelling Report Final 2020 for further detail.

Nodes	Transmission routes	N (MW)	N-1 (MW)
MARU –YASS	***(Humelink 2 x 500kV)*** Bannaby – Yass Marulan – Yass	***(4675)*** 2309	***(4675)*** 1394
MARU-WAGG	***(Humelink 2 x 500kV)***	***(3281)***	***(3281)***
YASS - CANB	Yass – Canberra	915	915
YASS – TUM	***(Humelink)*** Yass – Upper Tumut Yass – Lower Tumut	***(4196)*** 1887	***(4196)*** 915
CANB – TUM	Canberra – Upper Tumut Canberra – Lower Tumut	1887	915
TUM – WAGG	***(Humelink)*** Tumut - Wagga	***(3281)*** 1887	***(3281)*** 915
WAGG – BURG	***(EnergyConnect)*** Wagga – Darlington Point – Balranald – Buronga	***(1201)*** 227	***(1201)*** 227
BURG – BRKH	Buronga – Broken Hill	252	252
Interconnection			
SWQ – TAM	***(QNI Major)*** Dumesq – Bulli	***(5436)*** 2194	***(5436)*** 1097
GC – LIS	DirectLink Lismore - Mullumbimby	180	180
TUM - MURR	Upper Tumut – Murray Lower Tumut – Murray	1600	885
WAGG - DED	Wagga – Jindera – Wodonga	915	915
WAGG - KER	***(Kerang Link)***	***(2700)***	***(2700)***
BURG - RDCLF	***(Energy Connect; Buronga Red Cliffs augmentation)***	***(1180)*** 265	***(1180)*** 265
BURG RVRL	***(Energy Connect)*** ***Robertstown – Buronga*** ***Buronga – Darlington Pt*** ***Darlington Pt - Wagga***	***(900)***	***(900)***

iv. NSW ANEM generation capacity assumptions for sB

Table 2: New South Wales capacity assumptions under sB

New South Wales Capacity	Current [2] (MW)	2030 (MW)	Notes
Coal	10,185	4,040	Closures: Liddell 2000MW, Eraring 2880MW, Vales Point 1320MW Capacity factor: 67% (full year); 71% (SummWD)
Gas	2,155	3,048	Closures: None Capacity factor: 16% (full year); 17% (SummWD)
Hydro	1,803	1,596	Closures: None Capacity factor: 4% (full year); 3% (SummWD)
Solar	1,126	8,021	Capacity factor: 23% (full year); 27% (SummWD) Curtailment SummWD: 35%, Max 6022MW
Wind	1,516	5,671	Capacity factor: 36% (full year); 35% (SummWD) Curtailment SummWD: 9%, Max 2420MW
PHES	856	3,180	Capacity factor: 6% (full year); 5% (SummWD)
Storage/Other	283	3,819	E-G Capacity factor; 9% (full year); 9% (SummWD)
TOTAL	17,925	29,376	

[2] Source: AEMO Generation Information July 2020

v. NSW modelling outcomes for Summer Weekdays (SummWD)

1. NSW Fuel share of electricity generated

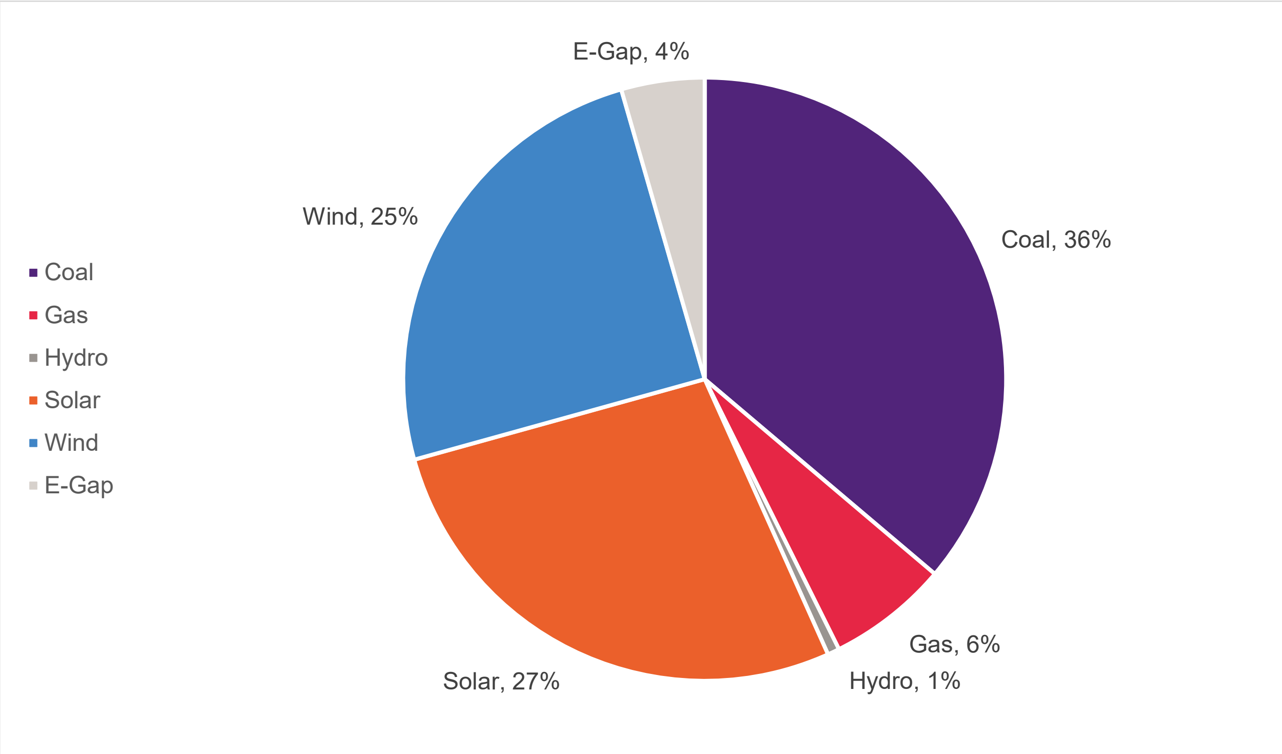

Figure 2: NSW Fuel share during summer weekdays under sB

Modelling outcomes predict that 36% of electricity generated in NSW in 2030 is sourced from coal, 27% from solar, 25% from wind, 6% from gas and 1% from hydro as shown in Figure 2. The Energy-Gap (E-G) that emerges is sizeable, at 511GWh or 4% of energy generated, 59GWh of which occurs during the evening peak. The maximum for coincident E-G is 3.0GW, although the median E-G is 0MW, indicating few very high coincident E-G periods. Table 3 provides detail.

Table 3: Count of NSW co-incident Energy-Gap under sB

Energy-Gap	Periods	>3000	>2500	>2000	>1000	>500	>0
Total		1	5	10	499	335	2030
% of summer weekdays		-	0.2%	0.3%	17%	12%	70%
Overnight	43-48, 0-12	-	-	-	474	275	326
Morning peak	13-19	-	-	-	-	-	420
Evening Peak	34-42	1	2	2	20	25	490
Daytime	20-29	-	-	1	2	13	584
Early Peak	30-33	-	3	7	3	22	210

2. NSW Energy Flows (SummWD)

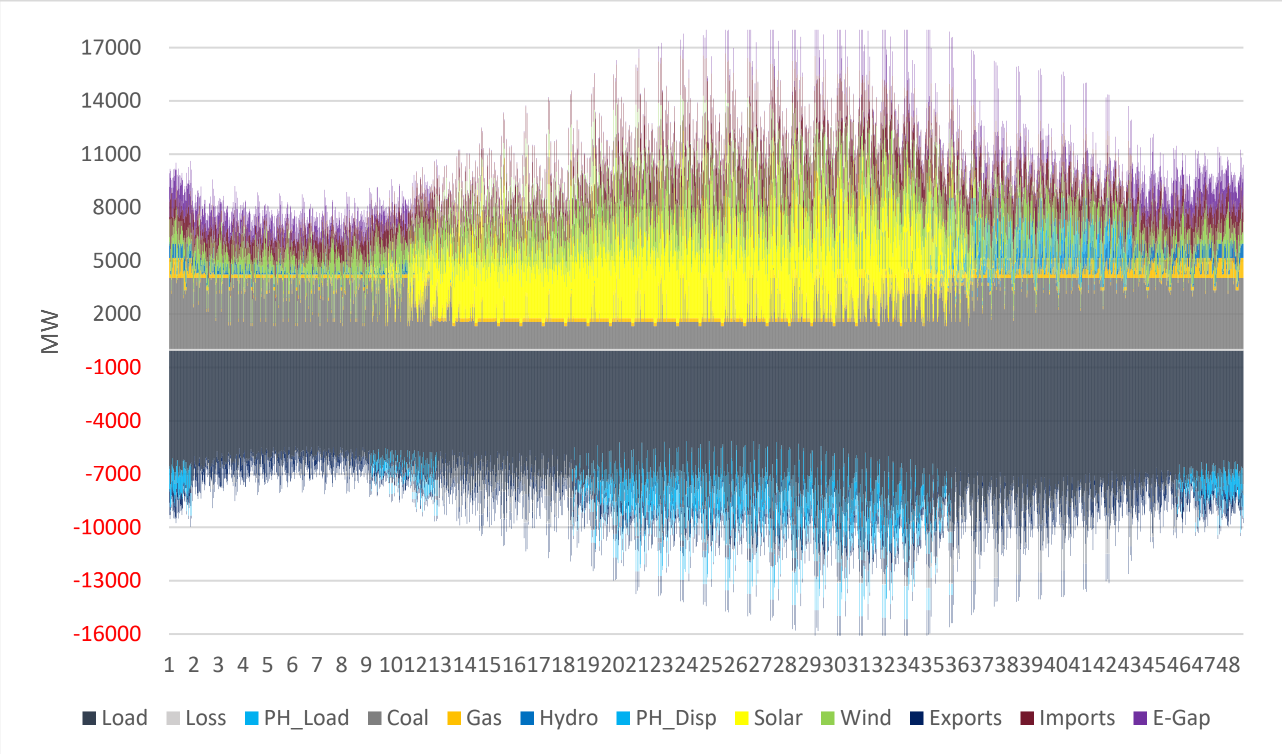

Figure 3: NSW energy flows for SummWD under sB

Figure 3 provides detail on the flow of energy through NSW nodes by time-of-day period by type of supply and demand for all of NSW. Of note:

- the steel grey coloured series indicates NSW demand, an average of 7,641MW
- the maroon coloured series indicates imports from Queensland which are ongoing all day but increase during daylight hours
- the navy coloured series indicates exports to Victoria which occur generally throughout the day but are smaller than the imports from QLD
- the light grey coloured series indicates coal generation within NSW which declines during sunlight hours
- the green and yellow coloured series indicate solar and wind generation
- the brown coloured series indicates NSW load
- the cyan coloured series indicate pump hydro (PHES) dispatch when positive and pumping load when negative
- the purple coloured series indicates Energy-Gap (E-G)

Table 4 provides totals and averages of SummWD energy flows. Coal generation across the state, with the removal of 6GW of capacity, achieves 71% capacity factor. Gas generation capacity factor is very low at 17%. Despite 35% curtailment of solar energy from potential dispatch, solar generation achieves a capacity factor of 27%. Curtailment of wind energy from potential dispatch is lower than solar at 9%, ensuring that wind generation state-wide achieves 35% capacity factor. E-G is persistent overnight at 1260MW and occasionally highly elevated from period 32-42, effectively evening peak, but otherwise very low. NSW imports (primarily from QLD) considerably more than it exports to VIC and NSW, which suggests the important role that imports from QLD play in supporting energy flows to Newcastle when Liddell and Eraring close.

Pumping for PHES elevates the E-G. This is prevalent when PHES pumping occurs overnight when solar resource is non-existent and wind resource is low. In the analysis conducted here, PH dispatch outside of morning and evening peak, is classified as E-G and PH dispatch that fails to occur during morning and evening peak is detailed in Table 4 as PH spill. While the PHES pumping and dispatch present a modelling challenge, this highlights the reality that storage introduces significant additional load which can exacerbate the E-G. Other than PH pumping and dispatch, the periods of elevated E-G are associated with varying combinations of significantly elevated demand, significantly depressed wind energy and lower levels of imports from QLD.

Table 4: NSW Salient statistics under sB

NSW Energy Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(11003)	(8865)	(7641)	(13399)	57%	(7381)
PH_Load	(1024)	(372)	(711)	(1860)	38%	(200)
Coal	4,134	3,519	2,871	4,040	71%	3,163
Gas	740	838	514	2,659	17%	196
Hydro	73	380	208	2,154	7%	258
PH_Disp	239	692	166	1,940	9%	0
Solar	3,132	1,323	2,175	8,021	27%	1,966
Wind	2,838	2,179	1,971	5,042	35%	1,905
E-G	511	198	355	3,014	12%	0
Exports	(761)	(491)	(529)	(2313)	23%	(437)
Imports	2,474	1,930	1,718	4,269	40%	1,563
Solar_spill	1,723	245	1,196	6,022		4
Wind_spill	296	93	205	2,420		2
PH_Spill	1,215	1,732	844	3,030		0
Solar spill %	35%	16%	35%	43%		
Wind spill %	9%	4%	9%	32%		

3. NSW Variable Renewable Energy (VRE) Resource

Solar provides a predictable resource such that 27% capacity factor is achieved despite 35% curtailment from potential resource due to excess wind and coal generation available during the day as detailed in Figure 4 below. For this reason, PH pumping conducted during the day does not lead to E-G’s in the NSW system. Wind provides a less predictable resource as detailed in Figure 5 below. The NSW coincident wind resource figure below shows a concerning trend to lower wind in evidence overnight which impacts on PH pumping activities overnight and the ability to meet overnight demand, resulting in some E-G’s overnight.

In summary, PHES nodes display a persistent E-G and Central Coast node shows evidence of highly escalated E-G for a few periods.

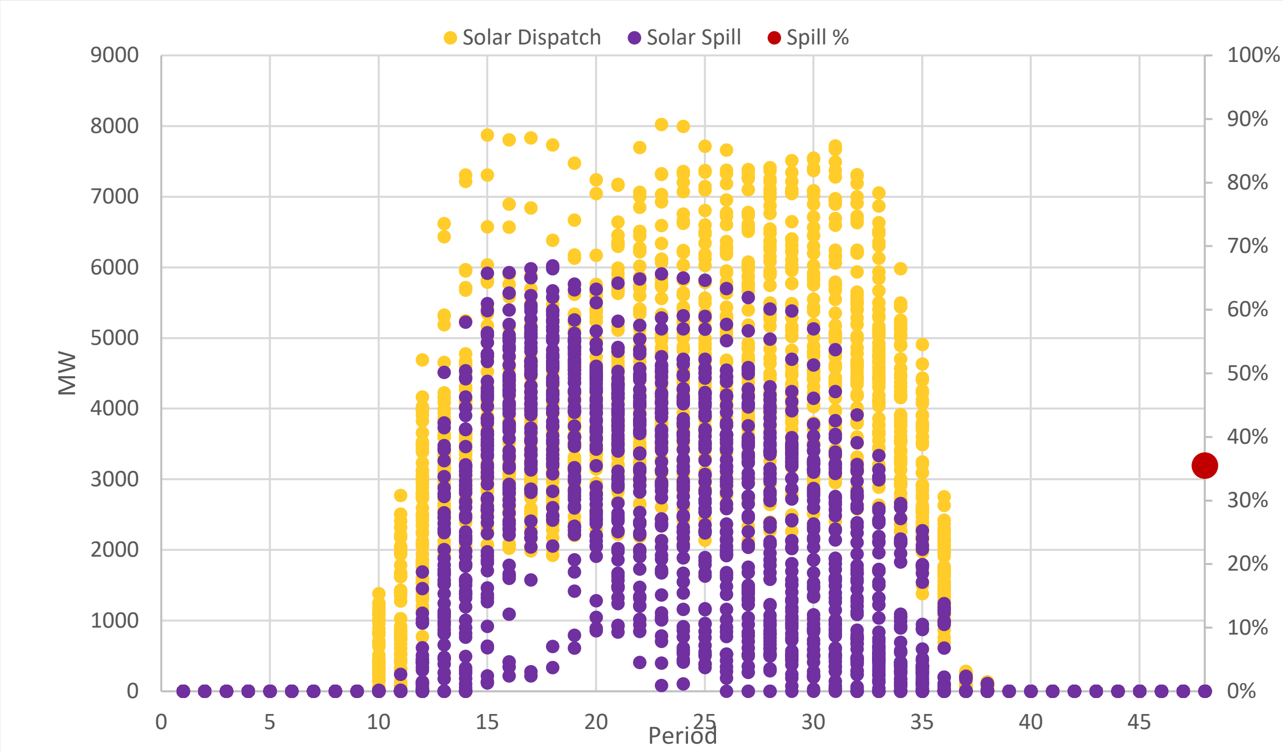

Figure 4: NSW Coincident solar dispatch and curtailment under sB

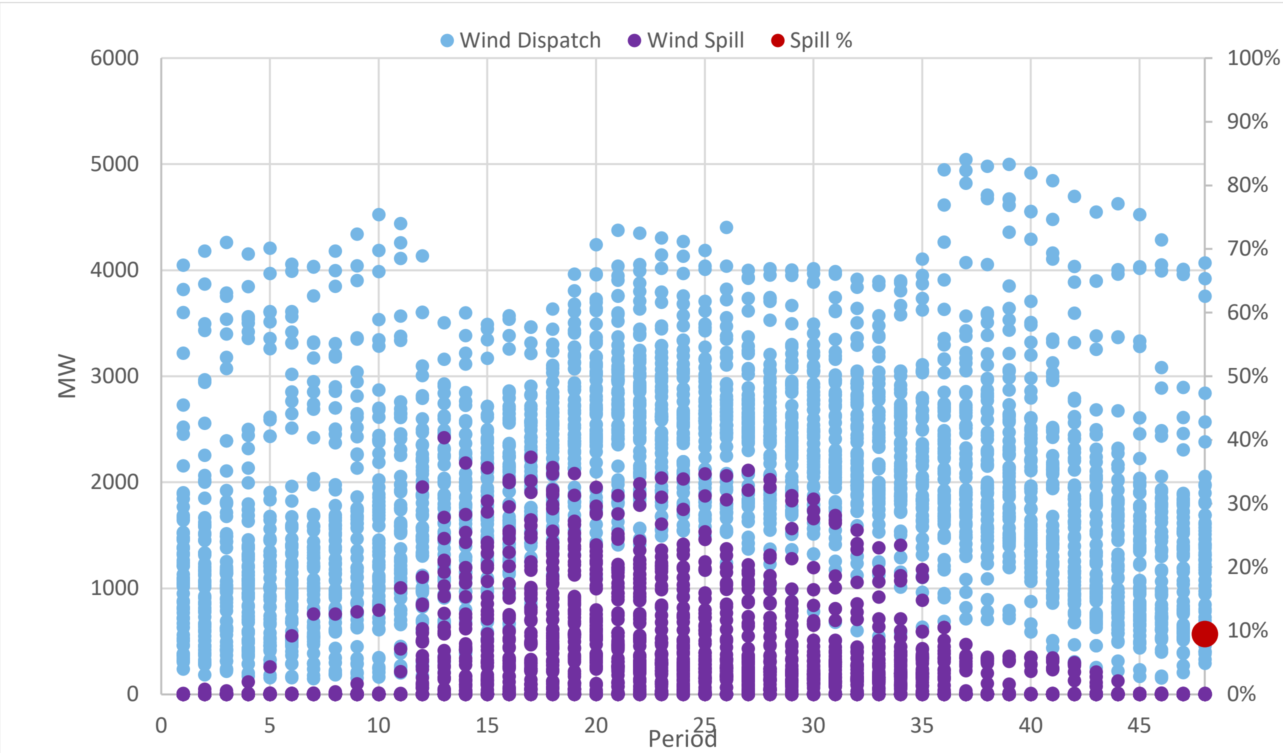

Figure 5: NSW Coincident wind dispatch and curtailment under sB

4. ARMIDALE details for summer weekdays

Assumptions for Armidale (ARMD) generation capacity are detailed in Table 5.

Table 5: Armidale capacity assumptions under sB

ARMD Capacity	Current [3] (MW)	2030 (MW)	Notes
Solar	76	1,546	Capacity factor: 27% 32% curtailed, Max curtailment 1,306MW
Wind	442	706	Capacity factor: 42% 3% curtailed, Max curtailment 394MW
Storage/Other/ E-G	-	377	Capacity factor: 2% Incidences: EvPeak 304 (51%); ONight 136 (13%); Sunlight: 532 (44%)
TOTAL	518	2,629	

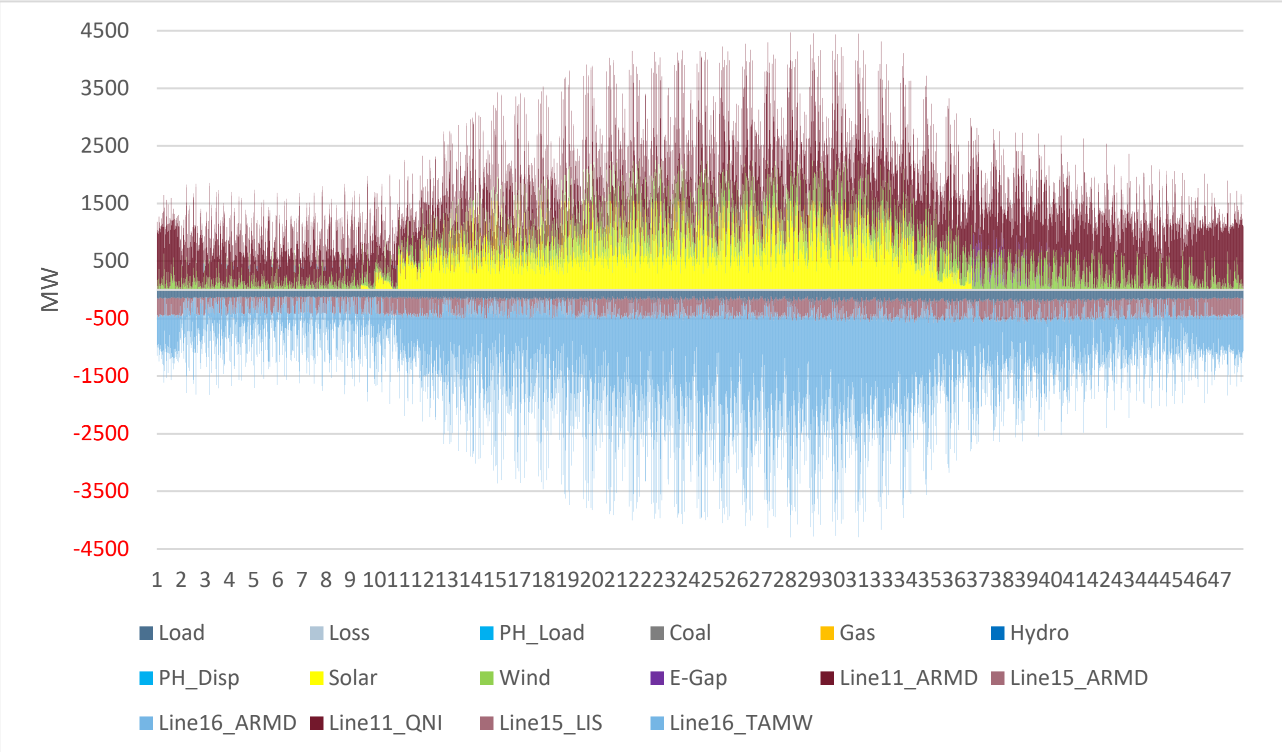

Figure 6: Armidale energy flows for SummWD under sB

Figure 6 provides detail on the flow of energy through ARMD node by time-of-day period by type of supply and demand for ARMD. Of note:

- the steel grey coloured series indicates ARMD demand, an average of 161MW

[3] Source: AEMO Generation Information July 2020

- the maroon coloured series indicates imports from QNI which are ongoing all day but increase during daylight hours
- the light blue coloured series indicates exports southwards towards Tamworth and ultimately Newcastle and Sydney, which elevate significantly during sunlight hours reflecting the solar resource in both QLD and ARMD
- the green and yellow coloured series indicate solar and wind generation which is small relative to the capacity available for dispatch and the flows in and out of the node
- the purple coloured series indicates Energy-Gap (E-G). E-G occurs only during periods 37-40, as is shown in Figure 7.

Figure 7: Armidale Energy Gap during SummWD in SB

This clustering of E-G from 6:30pm to 8pm results from NSW evening peak coinciding with a significant decline in solar energy coupled with low wind energy across all of NSW. This is evident in Figures 4 and 5 where solar and wind energy across NSW decline in tandem just as demand is increasing in the load centres. Although there is capacity to transfer from QLD via QNI, QLD experiences similar supply-demand constraints at this time of the day, resulting in restricted imports from QLD.

Solar curtailment in ARMD is high at 32%, primarily as a result of insufficient load during the day in NSW to sustain wind (5,671MW), solar (8,021MW) and coal generation at minimum stable operating levels (1316MW), a total supply of 15GW for an average load of 7.7GW plus PH pumping of 1.9GW at mid-day. Although wind curtailment in ARMD is less severe at 3%, it faces the same problems as solar when it occurs during sunlight hours. Curtailment of wind is less severe than solar because solar output during the day is so high.

Table 6 provides the energy flow statistics for ARMD and Figures 8 and 9 show solar and wind dispatch and curtailment for Armidale.

Table 6: Armidale salient statistics under sB

ARMD Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(232)	(189)	(161)	(282)	57%	(156)
Solar	596	212	414	1,546	27%	286
Wind	428	363	297	706	42%	253
E-G	8	28	6	377	2%	0
Exports (node)	(2,175)	(1,548)	(1,510)	(4,044)	37%	(1,358)
Imports (node)	1,430	1,183	993	2,557	39%	983
Solar_spill	280	4	194	1,306		0
Wind_spill	13	1	9	394		0
Solar spill %	32%	2%	32%	46%		
Wind spill %	3%	0%	3%	36%		

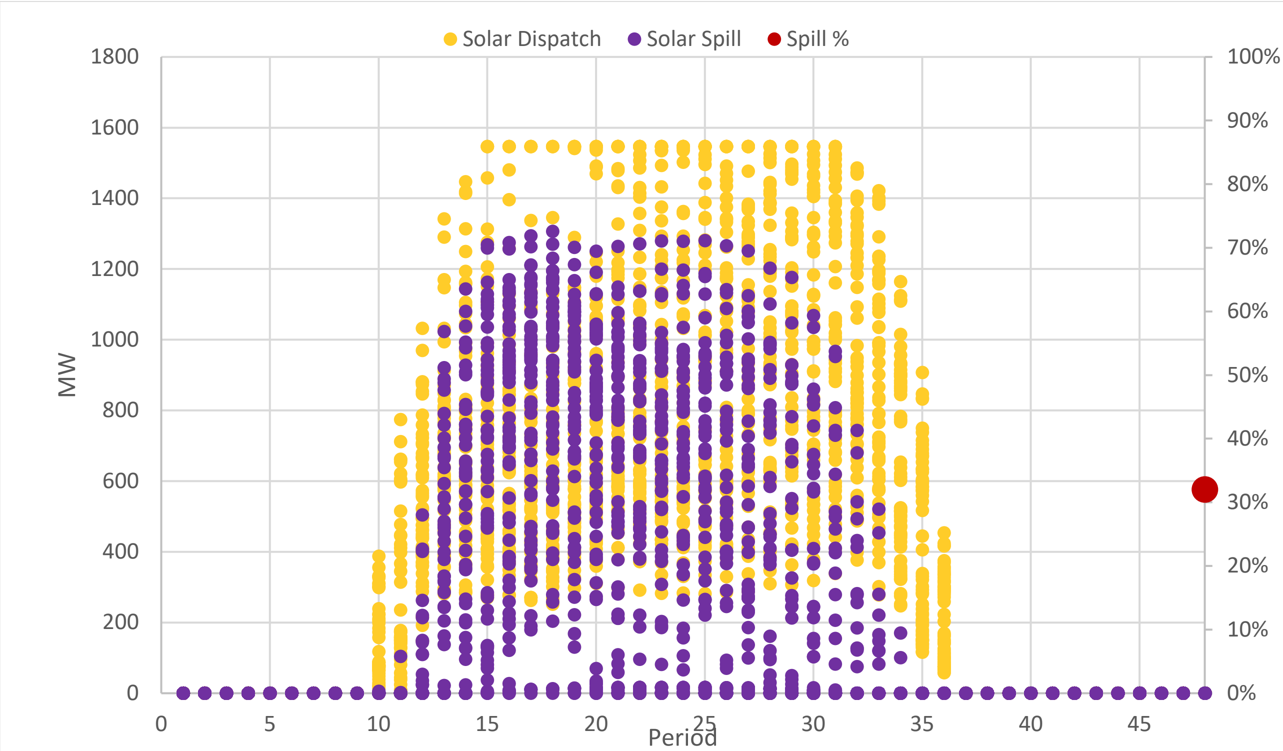

Figure 8: Armidale solar dispatch and curtailment under sB

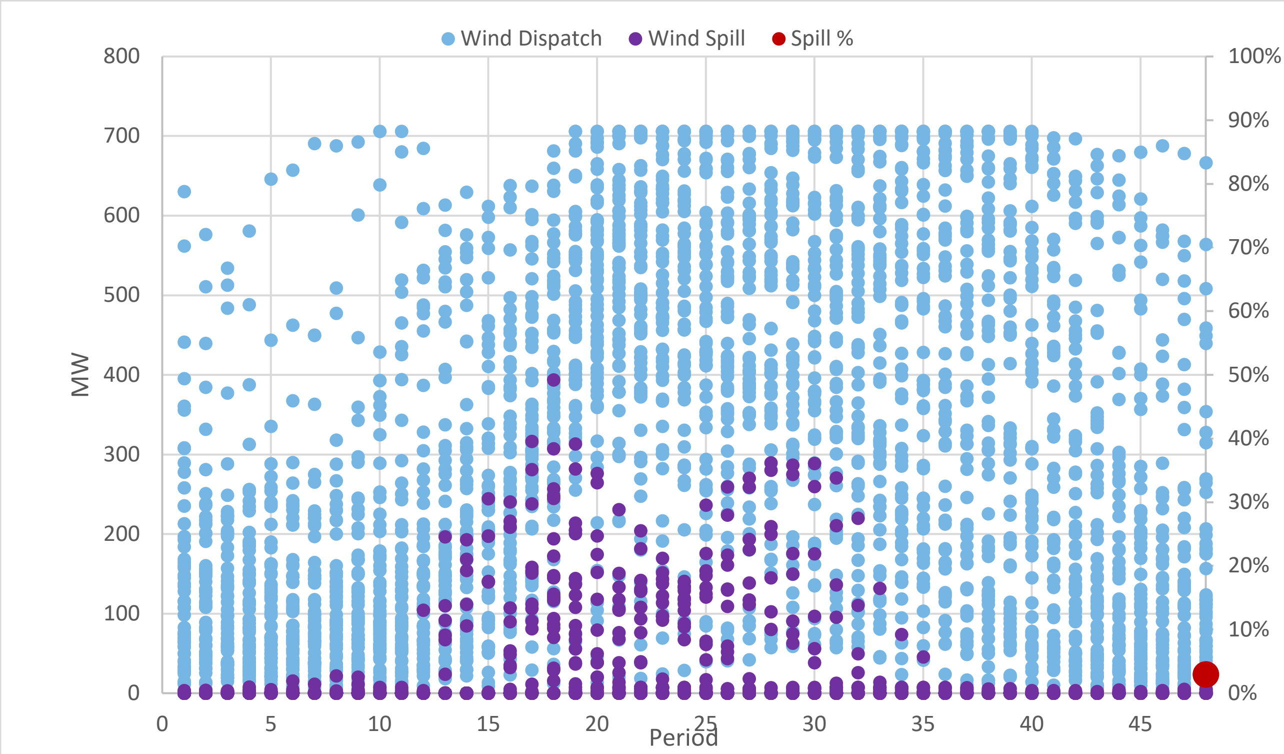

Figure 9: Armidale wind dispatch and curtailment under sB

5. TAMWORTH details for summer weekdays

Table 7 provides a summary of Tamworth (TAMW) generation capacity assumptions

Table 7: Tamworth capacity assumptions under sB

TAMW Capacity	Current [4] (MW)	2030 (MW)	Notes
Solar	-	1,207	Capacity factor: 31% 24% curtailed, Max curtailment 968MW
Wind	-	700	Capacity factor: 34% 12% curtailed, Max curtailment 548MW
Storage/Other/ E-G	-	323	Capacity factor: 4% Incidences: EvPeak 465 (78%); ONight 188 (17%); Sunlight: 438 (37%)
TOTAL	-	2,230	

[4] Source: AEMO Generation Information July 2020

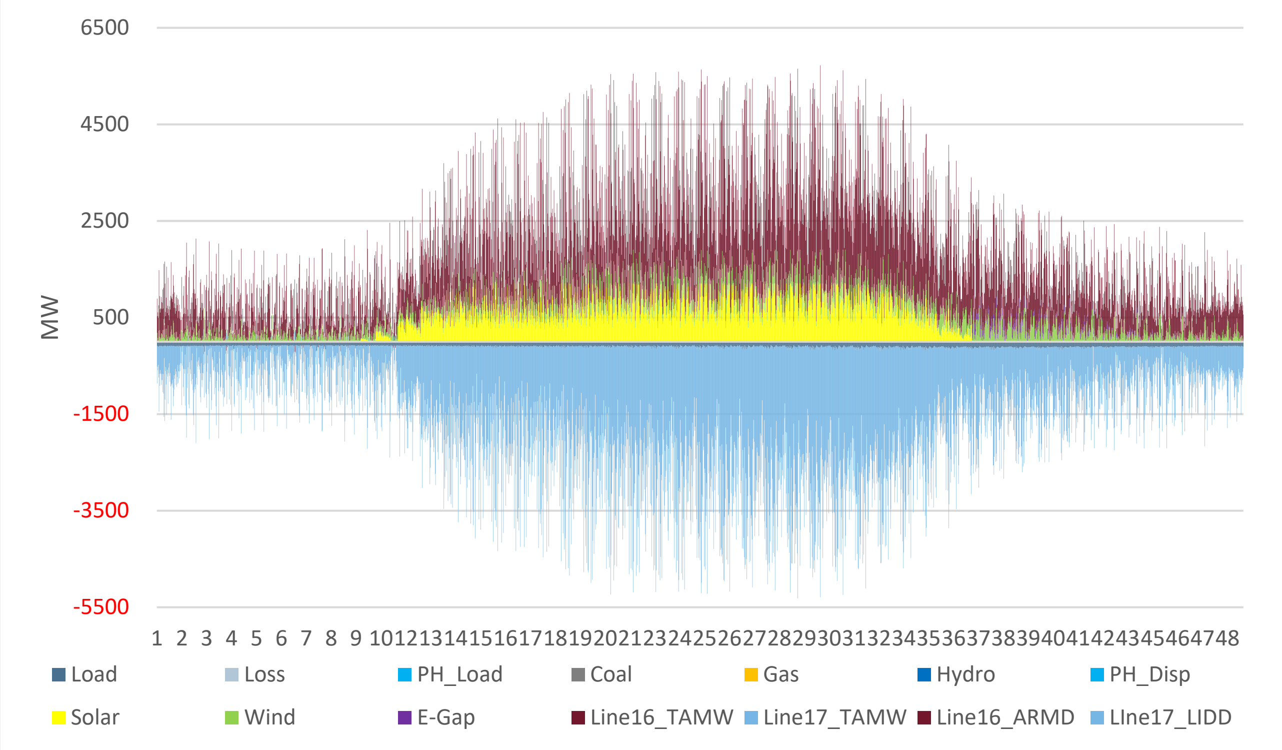

Figure 10: Tamworth energy flows for SummWD under sB

Figure 10 provides detail on the flow of energy through TAMW node by time-of-day period by type of supply and demand for TAMW. Of note:

- the maroon coloured series indicates imports from ARMD and ultimately from QNI which are ongoing all day but increase during daylight hours
- the light blue coloured series indicates exports southwards towards Liddell and ultimately Newcastle and Sydney, which elevate significantly during sunlight hours reflecting the solar resource in both QLD, ARMD and TAMW
- there is little evidence of nodal load because demand is small (average of (101MW) in TAMW
- the green and yellow coloured series indicate solar and wind generation which is small relative to both the resource available for dispatch and the flows in and out of the node. Figures 12 and 13provide further detail
- the purple coloured series indicates Energy-Gap (E-G). E-G in Tamworth is slightly smaller than that in Armidale at a maximum of 323MW but also occurs persistently during peak periods 37-43 for the same reasons as detailed in the Armidale section. Figure 11 provides detail

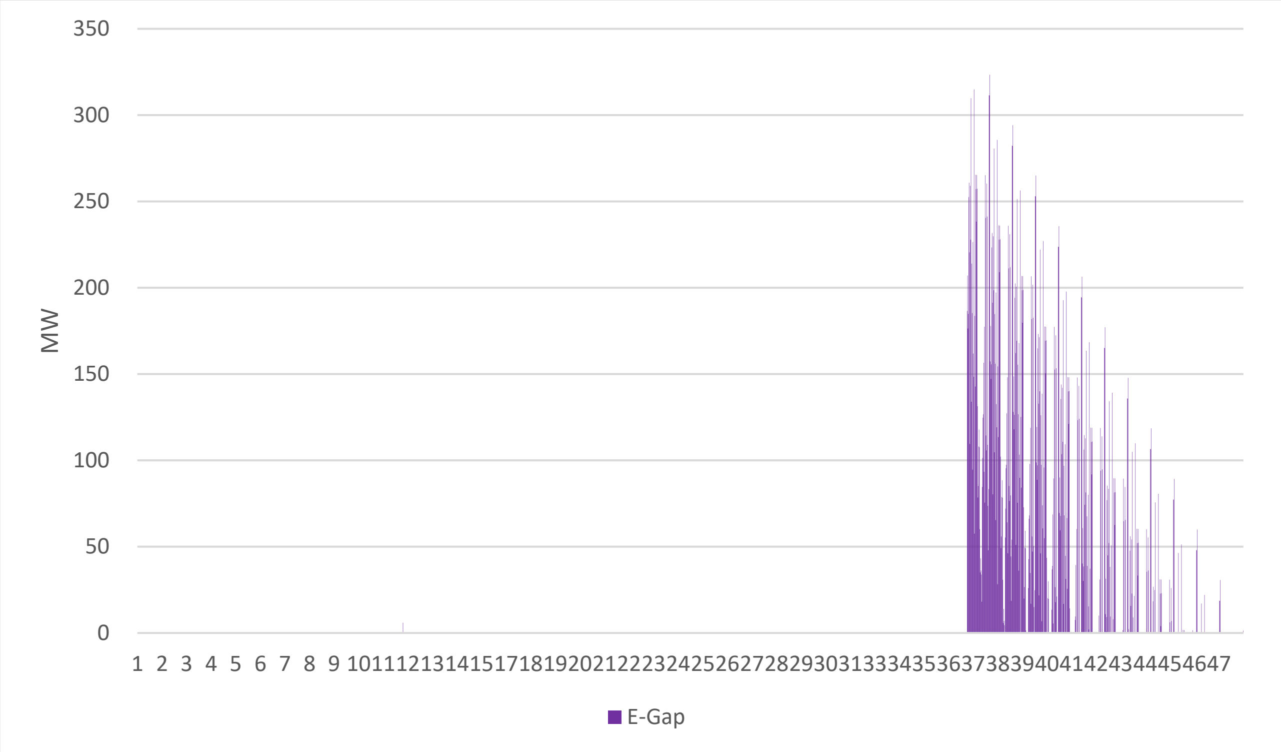

Figure 11: Tamworth energy gap for SummWD under sB

- Table 8 details statistics for Tamworth energy flows

Table 8: Tamworth salient statistics under sB

TAMWORTH Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(146)	(118)	(101)	(181)	56%	(97)
Solar	539	192	374	1,207	31%	271
Wind	342	296	238	700	34%	206
E-G	20	60	14	323	4%	0
Exports (node)	(2,476)	(1,637)	(1,719)	(5,160)	33%	(1,514)
Imports (node)	1,856	1,297	1,289	3,999	32%	1,118
Solar_spill	170	2	118	968		0
Wind_spill	49	7	34	548		0
Solar spill %	24%	1%	24%	45%		
Wind spill %	12%	2%	12%	44%		

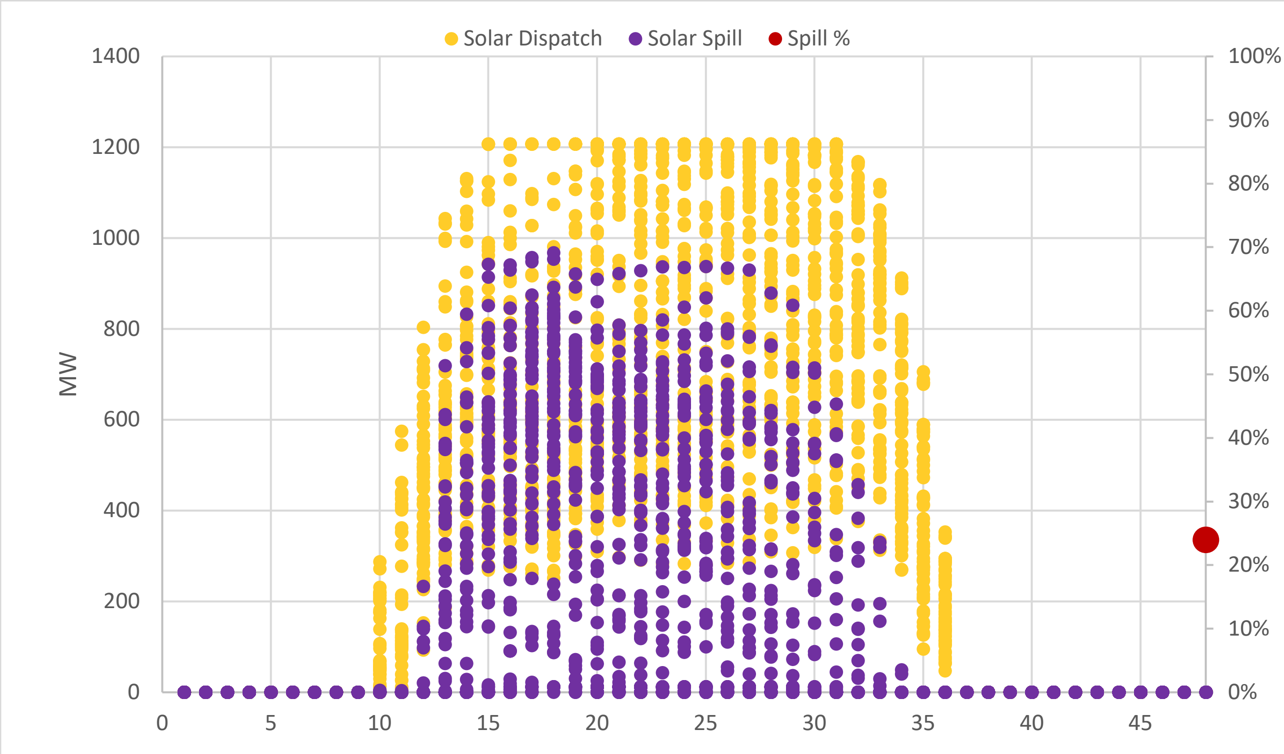

Figure 12: Tamworth solar dispatch and curtailment under sB

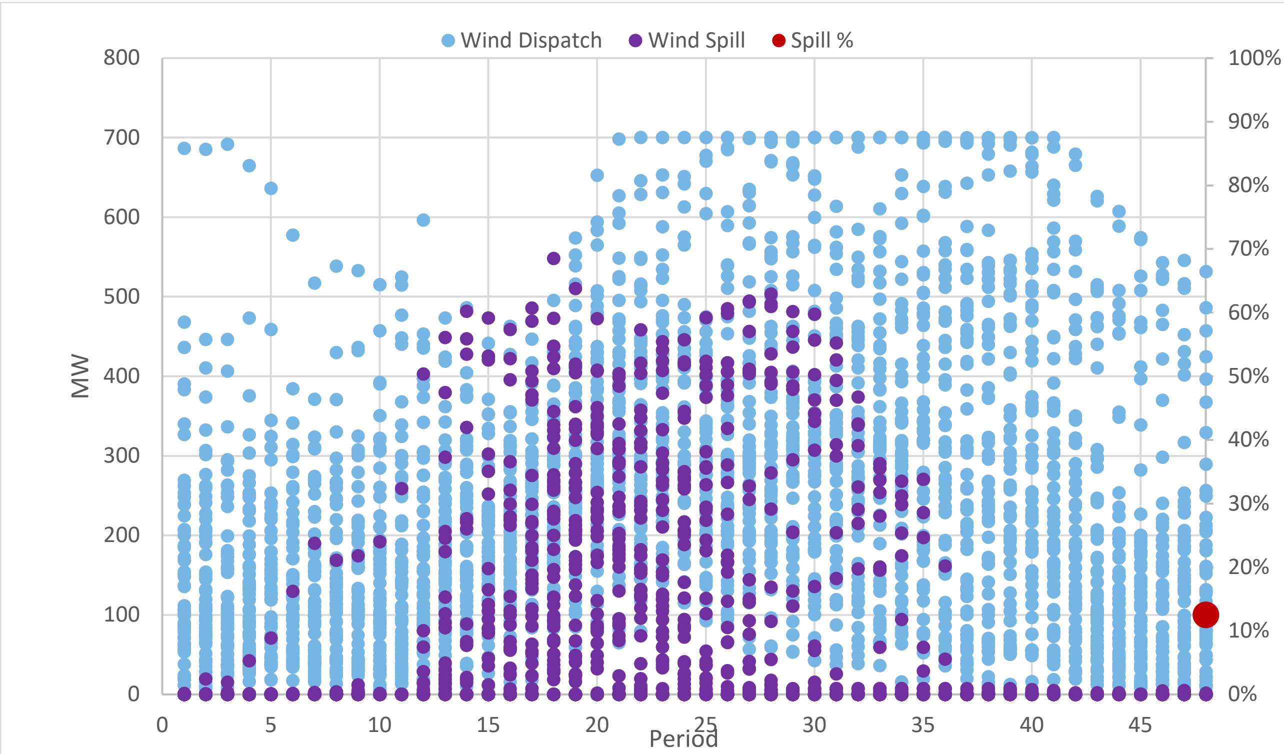

Figure 13: Tamworth wind dispatch and curtailment under sB

6. LIDDELL details for summer weekdays

Table 9 summarises the generating capacity assumptions for Liddell (LIDD)

Table 9: Liddell capacity assumptions under sB

LIDD Capacity assumptions	Current [5] (MW)	2030 (MW)	Notes
Coal	2000	-	Liddell scheduled to close
Gas	-	-	
Storage/Other/ E-G	-	-	
TOTAL	2000	-	

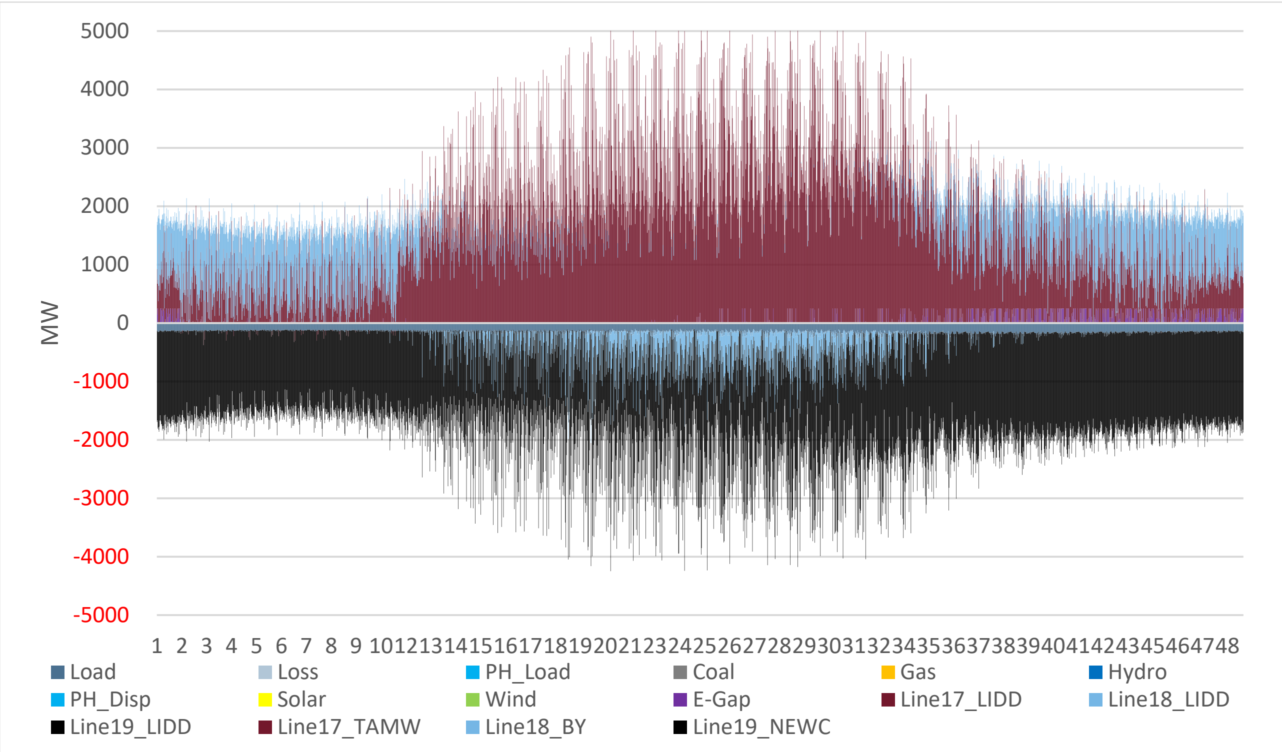

Figure 14: Liddell energy flows for SummWD under sB

Figure 14 provides detail on the flow of energy through LIDD node by time-of-day period by type of supply and demand for LIDD. Of note:

[5] Source: AEMO Generation Information July 2020

- the maroon coloured series indicates imports from TAMW, ARMD and ultimately from QNI primarily during daylight hours
- the light blue coloured series indicates imports, primarily overnight from evening peak through to morning peak from Bayswater, required for Newcastle load.
- the black coloured series indicates exports from LIDD southwards to Newcastle, which elevates during sunlight hours reflecting the solar resource in QLD, ARMD and TAMW
- there is little evidence of nodal load because demand is small (average of (149MW) in LIDD
- there is no E-G in the LIDD node, despite the closure of Liddell power station
- Table 10 details statistics for LIDD energy flows

Table 10: Liddell salient statistics under sB

LIDDL Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(215)	(173)	(149)	(264)	57%	(144)
Solar						
Wind						
E-G	-	-	-	-	-	0
Exports (node)	(2,723)	(1,936)	(1,891)	(4,052)	47%	(1,730)
Imports (node)	3,172	2,194	2,203	5,160	43%	1,914

7. NEWCASTLE details for summer weekdays

Table 11 summarises generating capacity assumptions for Newcastle (NEWC)

Table 11: Newcastle capacity assumptions under sB

NEWC Capacity assumptions		Current [6] (MW)	2030 (MW)	Notes
Coal		-	-	
Gas		-	-	
Storage/Other/ E-G		-	-	
TOTAL		-	-	Load only node

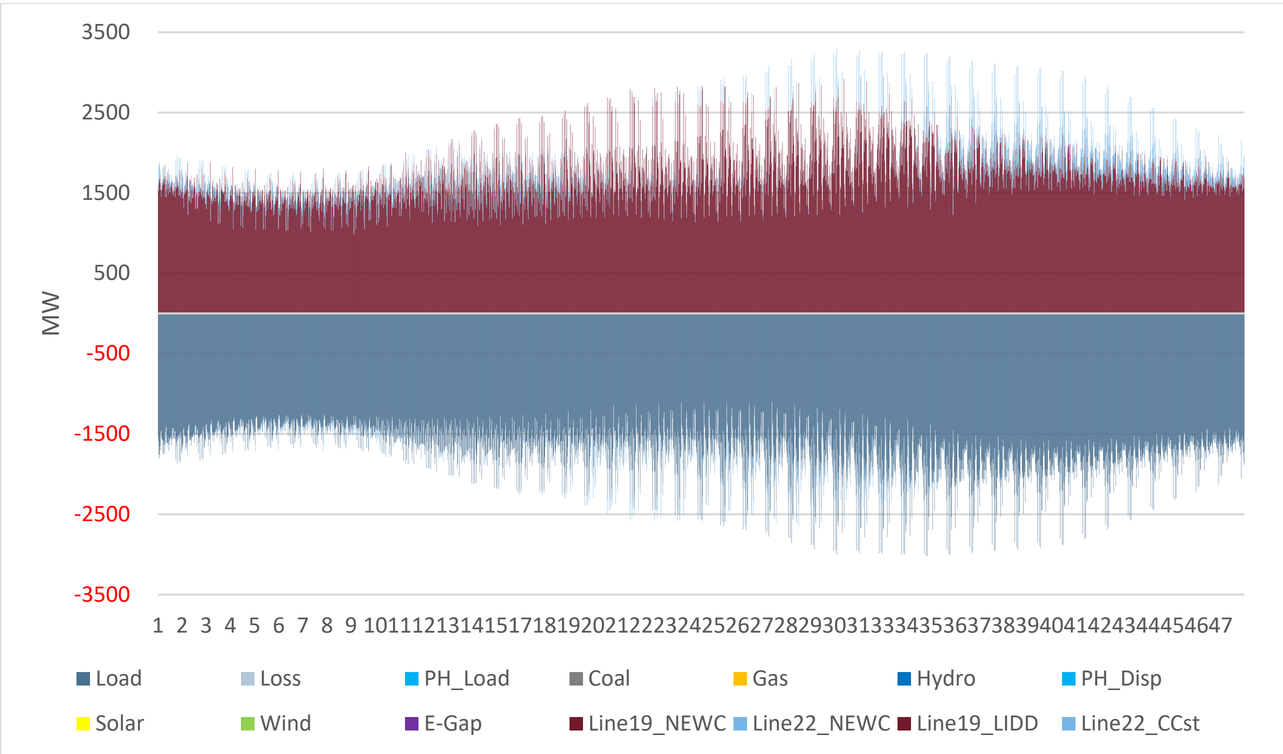

Figure 15: Newcastle energy flows for SummWD under sB

Figure 15 provides detail on the flow of energy through NEWC node by time-of-day period by type of supply and demand. Of note:

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[6] Source: AEMO Generation Information July 2020

- NEWC has no local generation and is reliant on energy flows from LIDD
- the maroon coloured series indicates imports from LIDD, TAMW, ARMD and ultimately from QNI
- the light blue coloured series indicates imports from or to the Central Coast required to meet Newcastle load.
- the steel blue coloured series indicates NEWC load which averages 1,715MW
- there is no E-G in the NEWC node
- Table 12 details statistics for NEWC energy flows

Table 12: Newcastle salient statistics under sB

NEWC Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(2,470)	(1,967)	(1,715)	(3,020)	57%	(1,654)
Solar						
Wind						
E-G	0	0	0	0	0%	0
Exports (node)	(33)	(12)	(23)	(402)	6%	0
Imports (node)	2,635	2,091	1,830	3,294	56%	1,754

8. CENTRAL COAST details for summer weekdays

Table 13 summarises generating capacity assumptions for Central Coast (CCST) node

Table 13: Central Coast capacity assumptions under sB

CCST Capacity assumptions	Current [7] (MW)	2030 (MW)	Notes
Coal	4,200	-	Closures: Eraring (2,880MW) & Vales Point B (1,320MW)
Gas	766	1,448	Additions: Balancing OCGT (724MW) Capacity factor: 5%
Storage/Other/ E-G	-	1,578	E-G Capacity factor: 1% Incidences: EvPeak 35 (6%), ONight 1 (-%), Sunlight 9 (0.7%)
TOTAL	4,966	3,026	

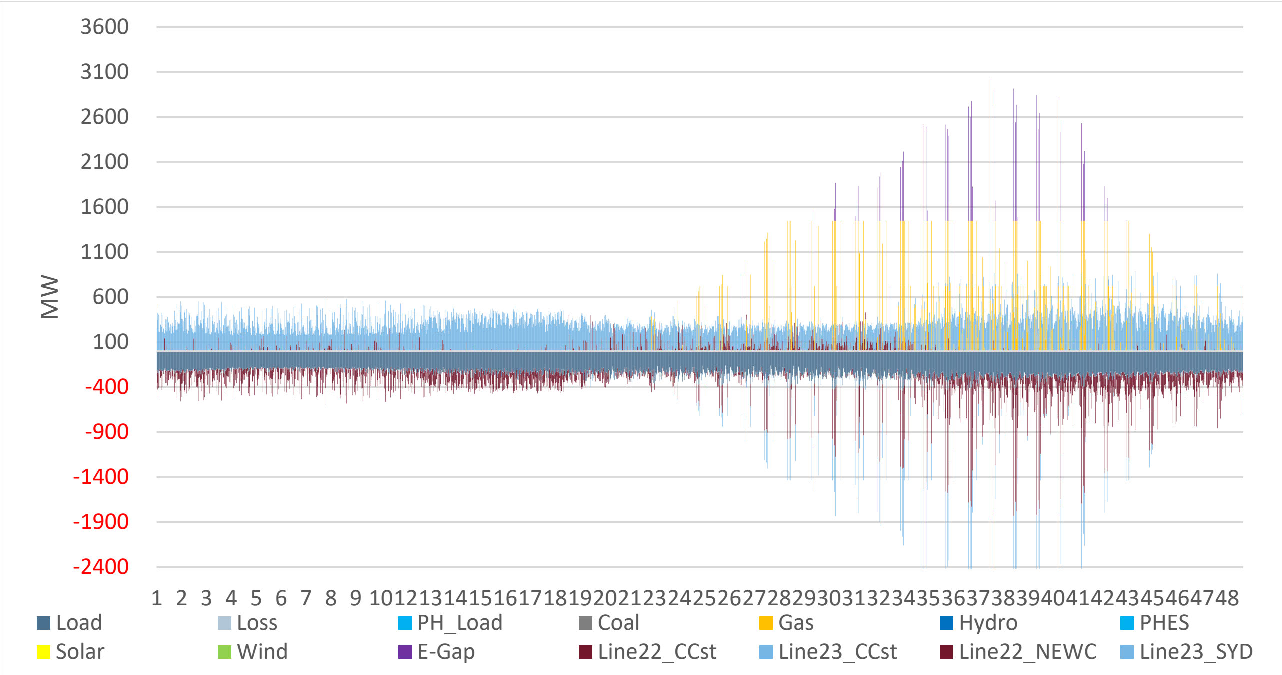

Figure 16: Central Coast energy flows for SummWD under sB

Figure 16 provides detail on the flow of energy through CCST node by time-of-day period by type of supply and demand. Of note:

[7] Source: AEMO Generation Information July 2020

- CCST hosts 2.88GW Eraring and Vales Point Power Stations which sB assumes will be closed by 2030. This has implications for meeting demand in Sydney during evening peak.
- the maroon coloured series indicates exports to NEWC to meet demand.
- the light blue coloured series indicates imports from Sydney throughout the day.or to the CCST required to meet NEWC load.
- the steel blue coloured series indicates CCST load which averages 244MW
- the gold coloured series indicates energy sourced from Colongra and another gas generator of the same capacity, assumed under sB, to balance NSW supply-demand.
- there is a significantly elevated E-G in the CCST node for 38 periods, primarily periods 32-42 on days 350, 357 and 364 which reflect extremely elevated demand over Christmas-New Year. The model predicts that CCST node will be incapable of importing adequate energy from NEWC-LIDD to meet exports required to service load in Sydney. This will result in very large E-Gs for approximately 17 hours. Figure 17 provides detail

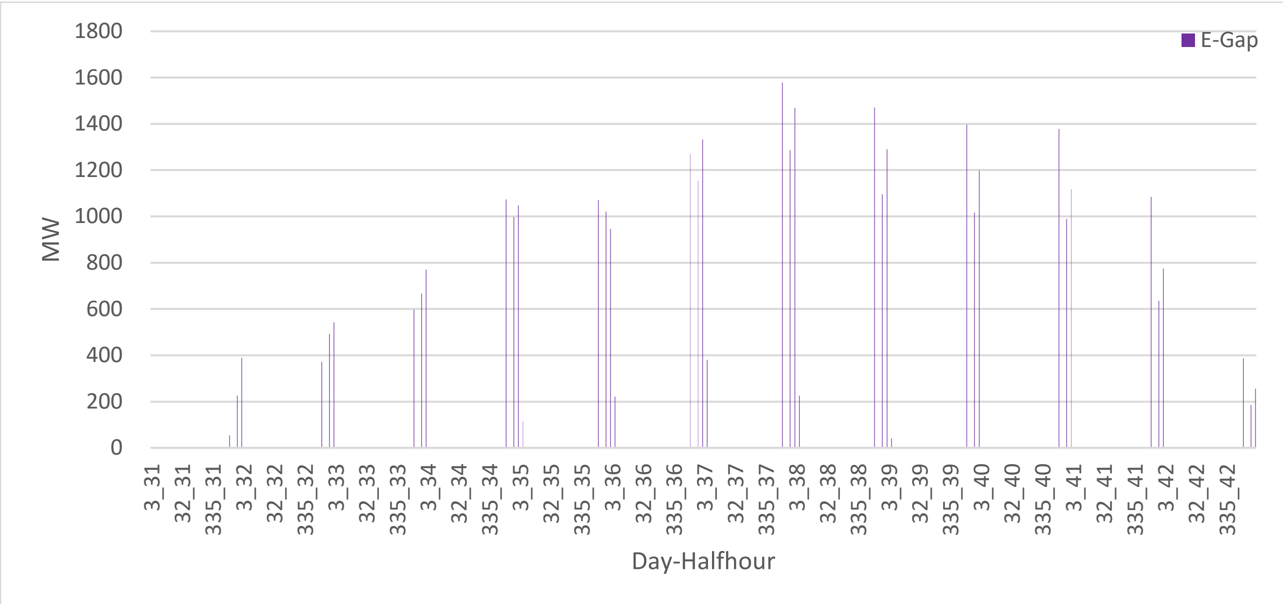

Figure 17: CCst energy-gap for SummWD under sB

- Table 14 details statistics for CCST energy flows

Table 14: Central Coast salient statistics under sB

CCST Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(351)	(285)	(244)	(440)	55%	(235)
E-G	17	53	12	1,578	1%	17
Exports (node)	(189)	(259)	(131)	(2,509)	5%	(71)
Imports (node)	421	276	292	587	50%	293

9. BAYSWATER details for summer weekdays

Table 15 provides detail on generating capacity assumptions for Bayswater (BY) node

Table 15: Bayswater capacity assumptions under sB

BY capacity assumptions	Current [8] (MW)	2030 (MW)	Notes
Coal	2665	2640	Capacity factor: 76%
Gas	50	50	Capacity factor: 2%
Storage/Other/ E-G	-	-	
TOTAL	2715	2690	

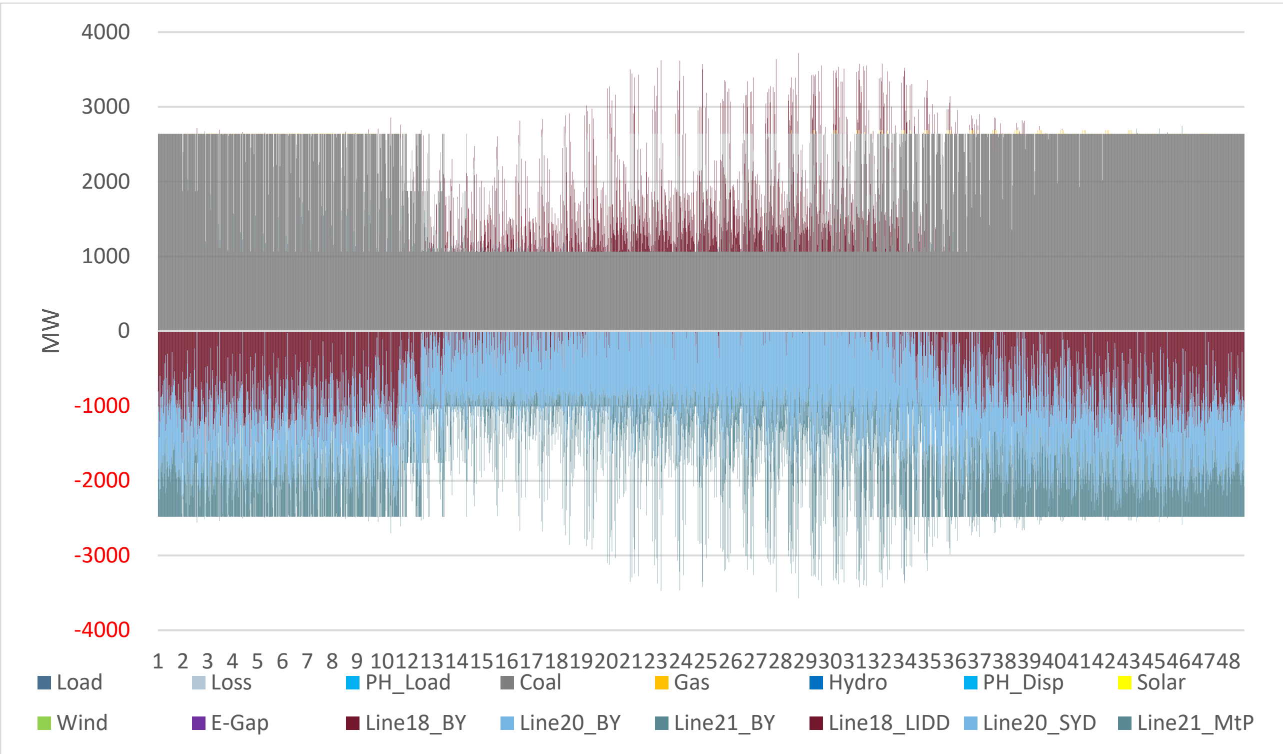

Figure 18: Bayswater energy flows for SummWD under sB

Figure 18 provides detail on the flow of energy through BY node by time-of-day period by type of supply and demand. Of note:

- BY node hosts 2.64GW Bayswater Power Station. The grey coloured series indicates Bayswater power station generation, which reduces significantly during sunlight hours.

[8] Source: AEMO Generation Information July 2020

- the maroon coloured series indicates imports from LIDD, TAMW, ARMD and ultimately QLD, primarily during sunlight hours, but with exports to LIDD after sundown and before sun-up, presumably to supply NEWC
- the light blue coloured series indicates exports to Sydney throughout the day
- the aqua-blue coloured series indicates exports to Mt Piper node, also to meet demand in Sydney
- there is no E-G in BY
- Table 16 details statistics for BY energy flows

Table 16: Bayswater salient statistics under sB

BY Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	0	0	0	0	0%	0
Coal	2,884	2,453	2,003	2,640	76%	2,639
E-G	0	0	0	0	0%	0
Exports (node)	(2,969)	(2,361)	(2,062)	(3,556)	58%	(2,481)
Imports (node)	258	52	179	1,912	9%	0

10. SYDNEY details for summer weekdays

Table 17 provides a summary of generating capacity assumptions for Sydney (SYD) node

Table 17: Sydney capacity assumptions under sB

Sydney capacity assumptions	Current [9] (MW)	2030 (MW)	Notes
Gas	185	176	Capacity factor: 48%
Storage/Other/ E-G		-	
TOTAL	185	176	

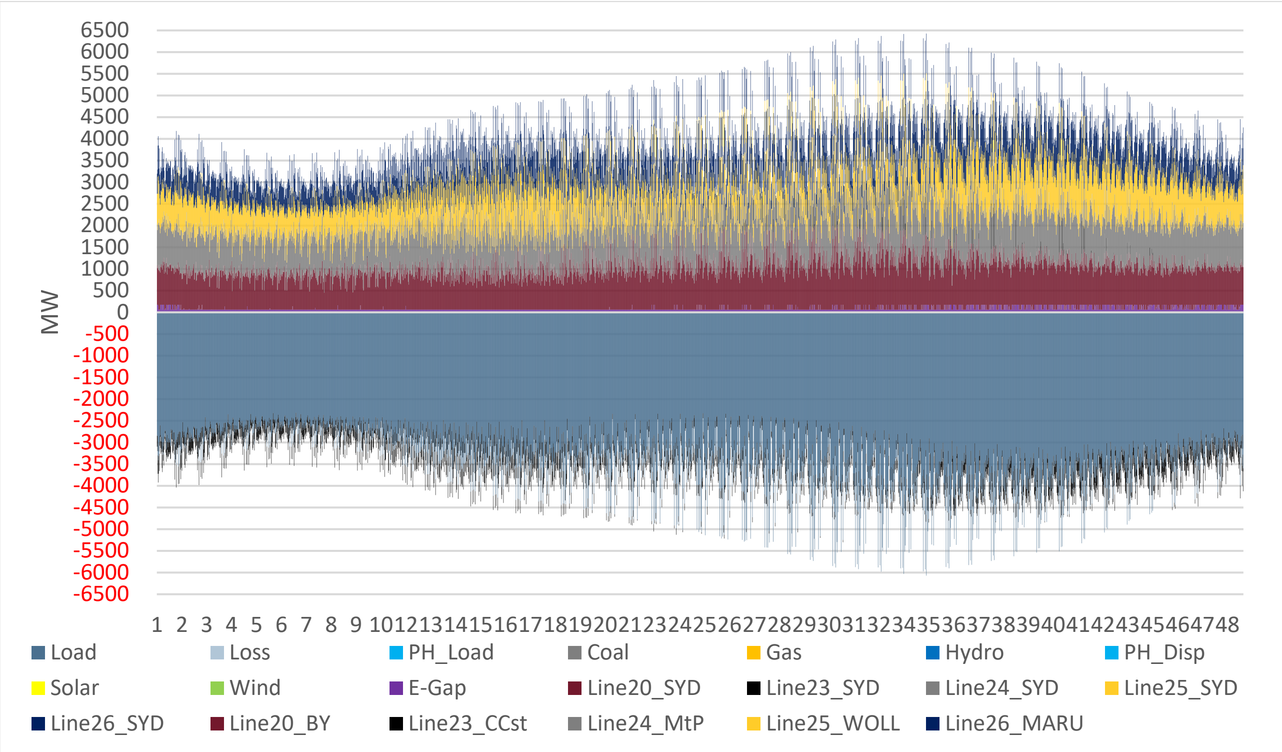

Figure 19: Sydney energy flows for SummWD under sB

Figure 19 provides detail on the flow of energy through SYD node by time-of-day period by type of supply and demand. Of note:

- the maroon coloured series indicates imports from BY

[9] Source: AEMO Generation Information July 2020

- the grey coloured series indicates imports from Mt Piper
- the dark-blue coloured series indicates imports from Marulan node, where there is significant wind and solar capacity
- the steel-blue coloured series indicates SYD load
- the gold coloured series indicates Smithfield generation
- the black coloured series indicates exports to CCST and presumably NEWC
- there is no E-G in SYD
- Table 18 details statistics for SYD energy flows

Table 18: Salient statistics under sB

SYDStatistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(4,883)	(3,952)	(3,391)	(6,071)	56%	(3,287)
Gas	123	116	85	176	48%	62
E-G	0	0	0	0	0%	0
Exports (node)	(388)	(264)	(269)	(587)	46%	(275)
Imports (node)	5,346	4,272	3,712	6,252	59%	3,646

11. MT PIPER details for summer weekdays

Table 19 provides a summary of generating capacity assumptions for Mt Piper (MtP) node

Table 19: Mt Piper capacity assumptions under sB

MtP Capacity assumptions	Current [10] (MW)	2030 (MW)	Notes
Coal	1,320	1,400	Capacity factor: 62%
Solar		120	Capacity factor: 42%
Wind		143	Capacity factor: 36%
Storage/Other/ E-G		-	
TOTAL	1,320	1,663	

Table 20: Mt Piper salient statistics under sB

MtP Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(170)	(137)	(118)	(204)	58%	(114)
Coal	1,250	1,067	868	1,400	62%	573
Solar	73	21	50	120	42%	31
Wind	73	51	51	143	36%	45
E-G	0	0	0	0	12%	0
Exports (node)	(2,965)	(2,216)	(2,059)	(4,487)	46%	(1,988)
Imports (node)	1,865	1,311	1,295	3,576	36%	1,112
Solar spill	0	0	0	16	2%	0

Tables 19 and 20 provide detail on the capacity assumptions and flow of energy through MtP node. Of note:

- MtP node hosts Mt Piper 1.4GW coal generator

[10] Source: AEMO Generation Information July 2020

- Solar and wind generation in the node is assumed to be relatively modest at 120MW and 143MW respectively
- Energy is imported into MtP node from:
  - Wellington node which is assumed to host a large 1.6GW wind capacity by 2030, and
  - BY node which hosts Bayswater coal-fired power station
- Energy is exported from MtP node to SYD and Marulan node in roughly equal measures. Marulan in turn exports to Wollongong, as is discussed in the Wollongong sub-section below
- there is no E-G in MtP

12. WOLLONGONG details for summer weekdays

Table 21 provides a summary of generating capacity assumptions for Wollongong (WOLL) node

Table 21: Wollongong capacity assumptions under sB

WOLL capacity assumptions	Current [11] (MW)	2030 (MW)	Notes
Gas	440	460	Capacity factor: 52%
PHES	240	240	Capacity factor: 14%
Storage/Other/ E-G		240	Capacity factor: 25% Incidences: EvPeak 48 (8%); ONight 930 (86%); Sunlight: 86 (7%)
TOTAL	680	940	

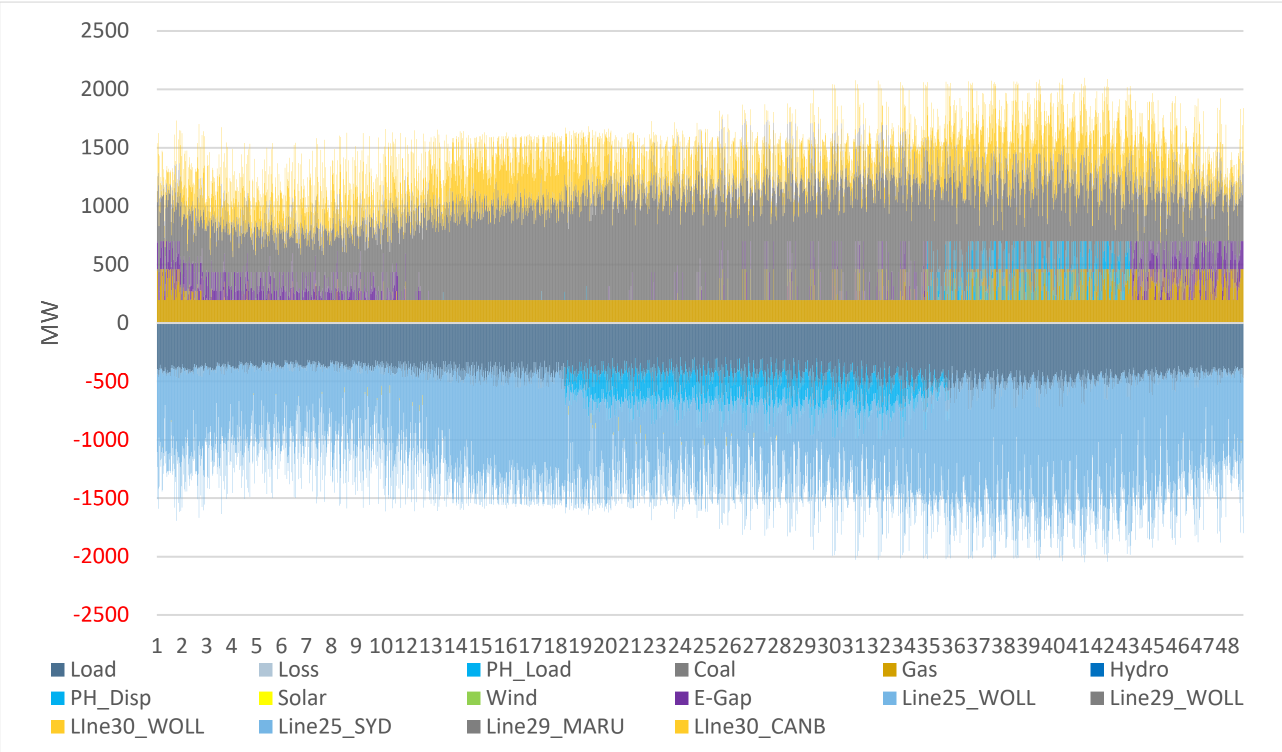

Figure 20: Wollongong energy flows fro SummWD under sB

Figure 20 provides detail on the flow of energy through WOLL node by time-of-day period by type of supply and demand. Of note:

[11] Source: AEMO Generation Information July 2020

- the grey coloured series indicates imports from Marulan node (which is assumed to host 1.6GW of wind generation)
- the gold coloured series indicates imports from Canberra (which is assumed to host 821MW of wind and 133MW of solar generation)
- the light blue coloured series indicates exports to SYD
- the steel-blue coloured series indicates WOLL load
- the dark gold coloured series indicates Tallawarra GT generation
- the cyan coloured series indicates Shoalhaven pump hydro load (if negative) and dispatch (if positive)
- an E-G appears in WOLL node after evening peak until morning peak and sporadically during the day, and reflects dispatch from Shoalhaven (240MW) which is outside of the dispatch strategy and assumed to be E-G because dispatch is only possible at high spot price. The associated reason for classifying this dispatch as E-G, is because all-night dispatch would deplete potential for dispatch during morning and evening peak. However, it is apparent that there is a significantly large requirement for supply overnight (due to the lack of solar energy, and unreliable generation from wind) in addition to evening peak. This implies a greater requirement for storage to meet demand overnight. (New version of ANEM, which pumps based on VRE resource and dispatches based on storage, will provide greater clarity with respect to real E-G). Figure 21 shows detail

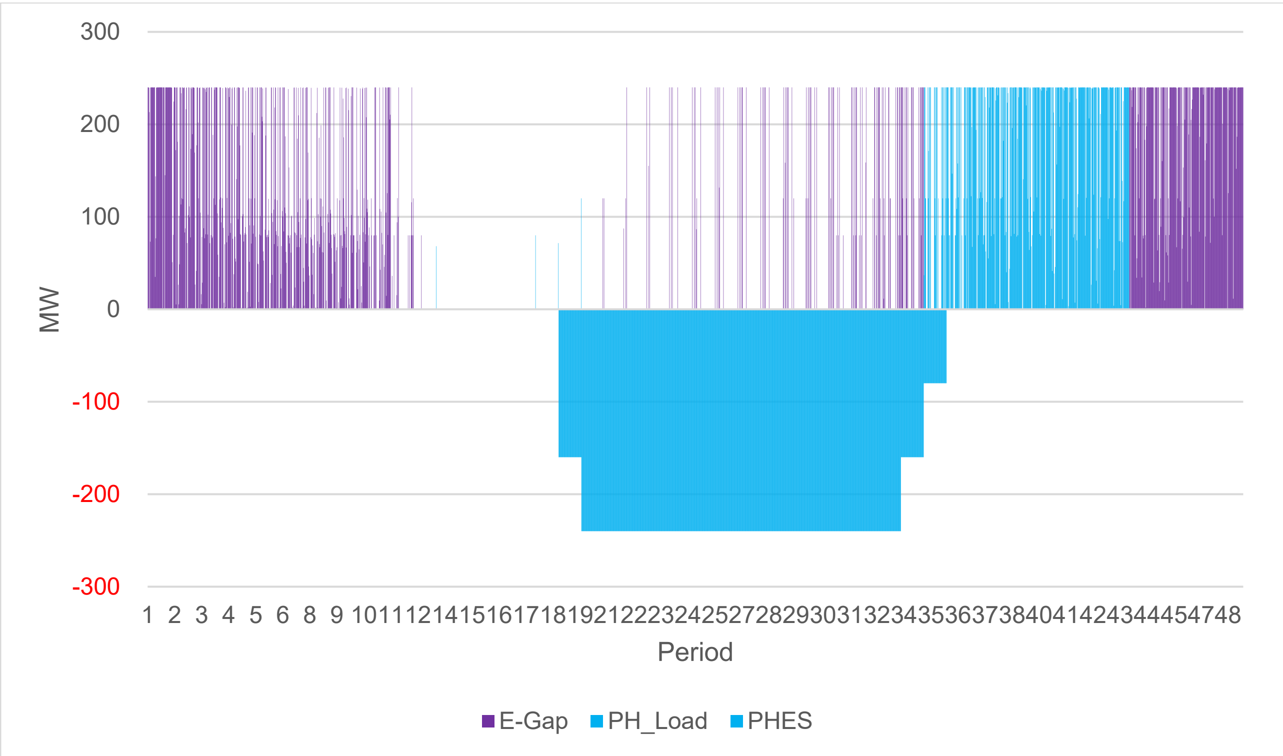

Figure 21: Wollongong energy-gap for SummWD under sB

- Table 22 details statistics for WOLL energy flows

Table 22: Wollongong salient statistics under sB

WOLL Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(641)	(513)	(445)	(760)	59%	(430)
PH Load	(113)	(48)	(78)	(240)	33%	0
Gas	347	289	241	460	52%	196
E-G	85	16	59	240	25%	85
Exports (node)	(1,217)	(1,036)	(845)	(1,462)	58%	(834)
Imports (node)	1,535	1,186	1,066	1,489	72%	1,134
PH_spill	66	49	46	240		0

13. TUMUT details for summer weekdays

Table 23 summarises generating capacity assumptions for Tumut (TUM) node

Table 23: Tumut capacity assumptions under sB

TUM Capacity assumptions	Current [12] (MW)	2030 (MW)	Notes
Hydro	1,669	1,596	Capacity factor: 3%
PHES	616	2,940	Capacity factor: 4%
Storage/Other/ E-G		1,700	Capacity factor: 16% Incidences: EvPeak 28 (5%), ONight 947 (88%), Sunlight 43 (4%)
TOTAL	2,949	6,900	

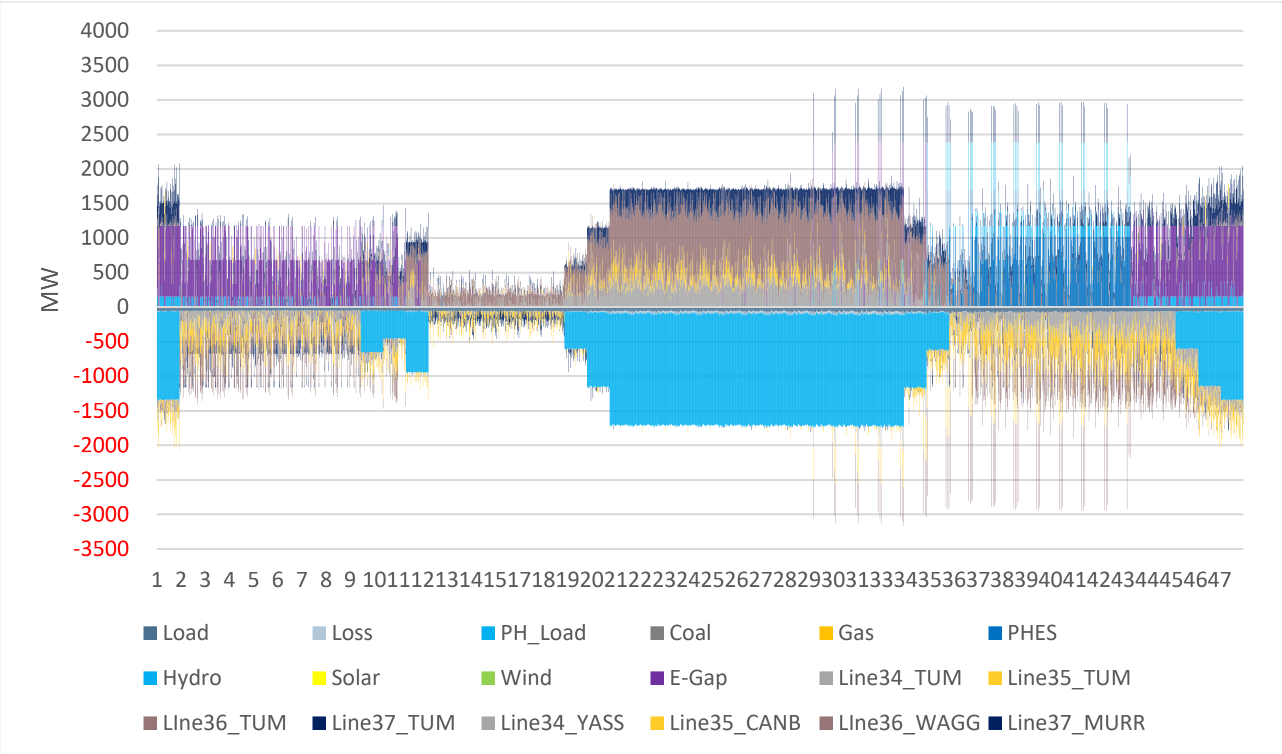

Figure 22: Tumut energy flows for SummWD under sB

Figure 22 provides detail on the flow of energy through TUM node by time-of-day period by type of supply and demand. Of note:

- the grey coloured series indicates imports and exports between TUM and Yass nodes, representing modest flows of energy between the nodes

[12] Source: AEMO Generation Information July 2020

- the light brown coloured series indicates imports and exports between TUM and Wagga nodes. Imports from Wagga result from assumed significant solar generation of 2GW in Wagga node. Significantly elevated exports to Wagga, correspond with periods 42-42 on days 350, 357 and 364, assumed to be Christmas-New Year elevated demand. The energy exported from TUM to Wagga is thereafter exported to VIC.
- the navy-blue coloured series indicates imports/exports from/to Murray node in VIC
- gold coloured series indicates exports to Canberra primarily for evening peak
- the cyan coloured series indicates Tumut 3 and Snowy 2.0 pump hydro load (if negative) and dispatch (if positive)
- a persistent E-G is apparent in TUM node after evening peak and before morning peak, and reflects dispatch from Tumut 3 (900MW) and Snowy 2.0 (2040MW) which is outside of the dispatch strategy and assumed to be E-G because dispatch is only possible at high spot price. The associated reason for classifying this dispatch as E-G, is because all-night dispatch would deplete potential for dispatch during morning and evening peak. However, it is apparent that there is a significantly large requirement for supply overnight (due to the lack of solar energy, and unreliable generation from wind) and sporadically during the day in addition to evening peak. This implies a greater requirement for storage to meet demand overnight. (New version of ANEM, which pumps based on VRE resource and dispatches based on storage, will provide greater clarity with respect to real E-G). Figure 23 shows detail

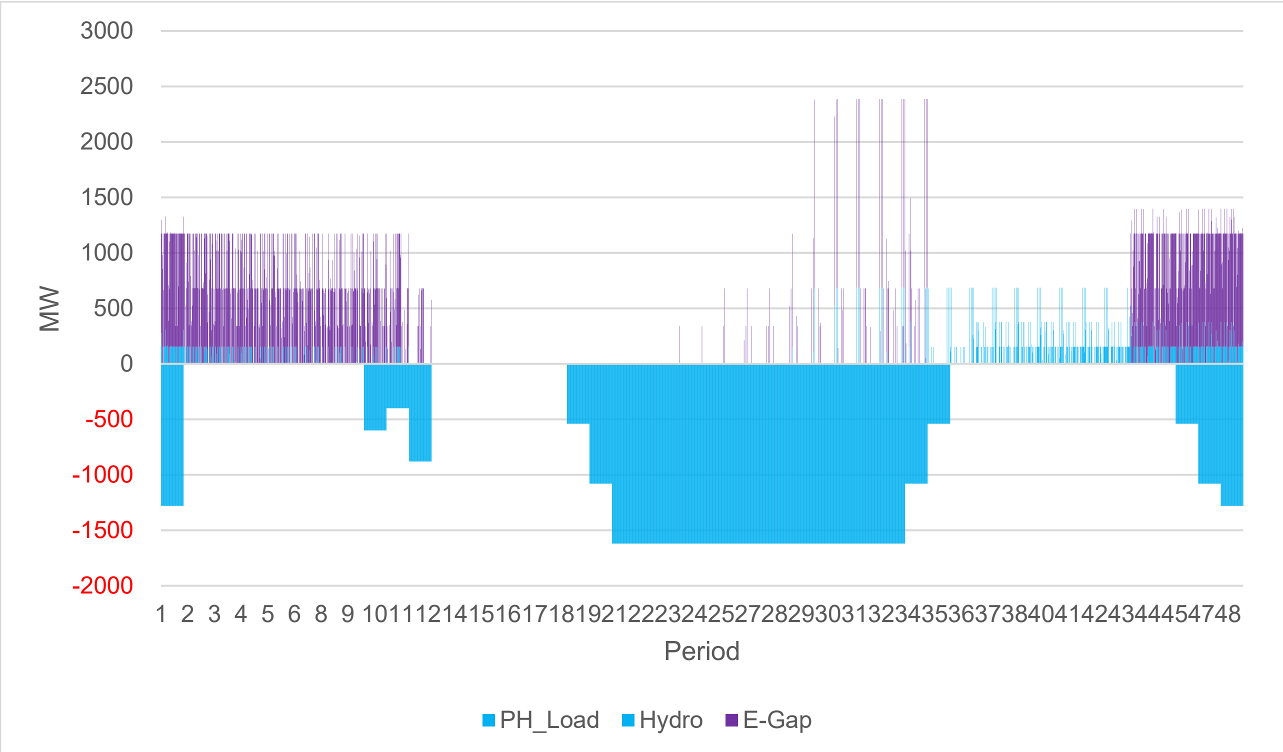

Figure 23: Tumut energy-gap for SummWD under sB

- Table 24 details statistics for Tumut energy flows

Table 24: Tumut salient statistics under sB

TUM Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(86)	(70)	(60)	(106)	56%	(58)
PH Load	(911)	(324)	(633)	(1,620)	39%	(200)
Hydro	73	102	51	686	3%	0
PHES	190	548	132	1,700	4%	0
E-G	379	40	264	1,700	16%	0
Exports (node)	(621)	(764)	(431)	(2,849)	15%	(209)
Imports (node)	998	481	693	1,903	36%	370

14. WELLINGTON details for summer weekdays

Table 25 summarises generating capacity assumptions for Wellington (WELL) node

Table 25: Wellington capacity assumptions under sB

WELL capacity assumptions	Current [13] (MW)	2030 (MW)	Notes
Solar	301	1,659	Capacity factor: 26% Curtailment: 39%, Max curtailment 1398MW
Wind	113	1,621	Capacity factor: 33% Curtailment: 14%, Max curtailment 1164MW
Storage/Other/ E-G		7	Capacity factor: 0%
TOTAL	414	3,287	

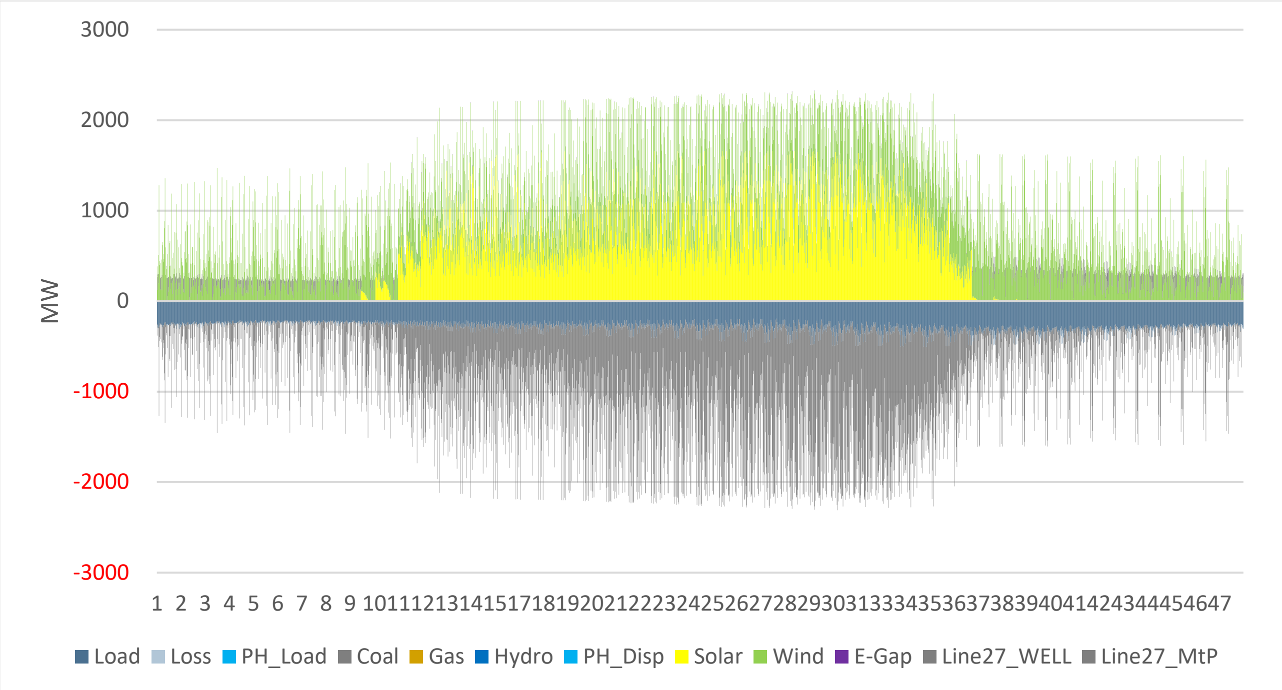

Figure 24: Wellington energy flows for Summer WD under sB

Figure 24 provides detail on the flow of energy through WELL node by time-of-day period by type of supply and demand. Of note:

[13] Source: AEMO Generation Information July 2020

- the grey coloured series indicates exports to MtP node and ultimately to SYD
- the steel-blue coloured series indicates load in WELL
- light green and yellow coloured series indicate dispatch from wind (1,621MW) and solar (1,659MW). Solar dispatch is considerably lower than available resource indicating the over-supply of wind within WELL node but also wind, solar and coal across the NEM during the day. See dispatch and curtailment details in Figures 25 and 26
- E-G in WELL node is negligible
- Table 26 details statistics for WELL energy flows

Table 26: Wellington salient statistics under sB

WELL Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(413)	(335)	(287)	(504)	57%	(276)
Solar	630	313	437	1,659	26%	332
Wind	781	623	542	1,621	33%	503
E-G	0	0	0	7	0%	0
Exports (node)	(1,012)	(614)	(702)	(1,830)	38%	(610)
Imports (node)	29	23	20	384	5%	0

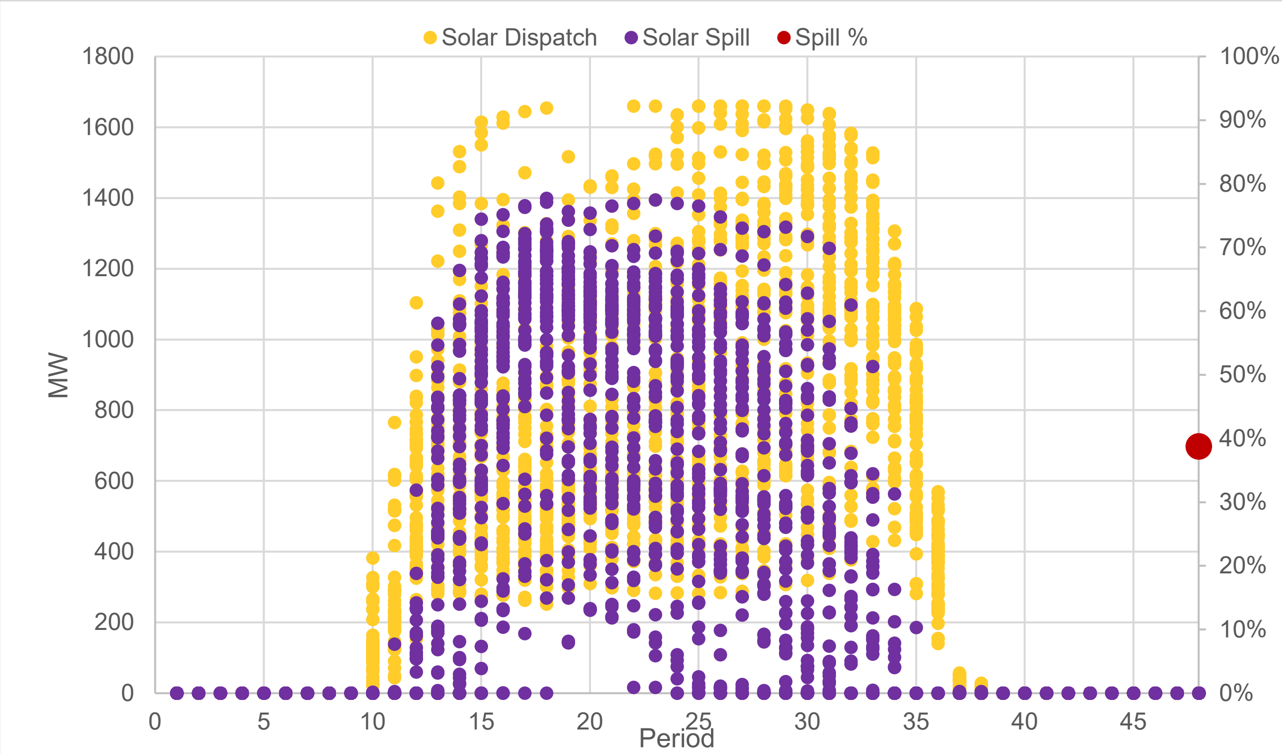

Figure 25: Wellington solar dispatch and curtailment under sB

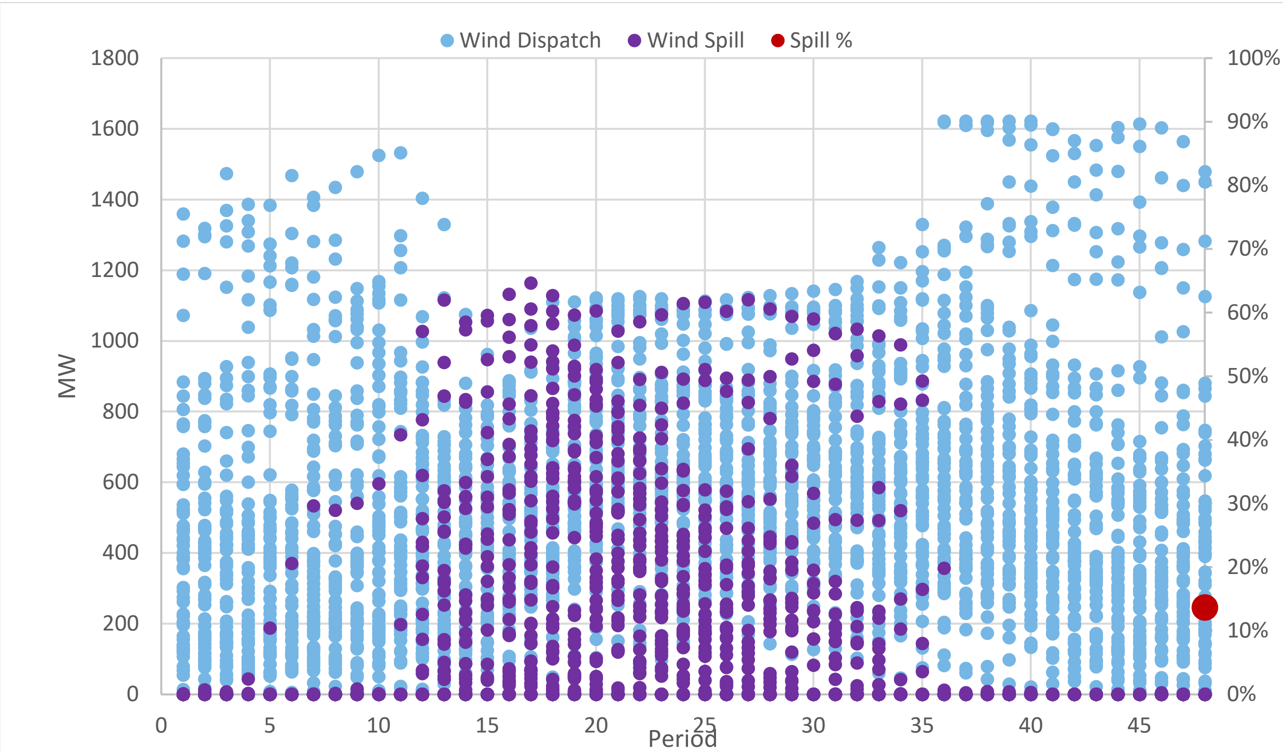

Figure 26: Wellington wind dispatch and curtailment under sB

15. WAGGA details for summer weekdays

Table 27 provides a summary of generating capacity assumptions for Wagga (WAGG) node

Table 27: Wagga capacity assumptions under sB

WAGG Capacity assumptions	Current [14] (MW)	2030 (MW)	Notes
Gas	664	664	Capacity factor: 11%
Solar	343	2,049	Capacity factor: 21% Curtailment: 54%, Max curtailment 2070MW
Storage/Other/ E-G		174	Capacity factor: 0% Incidences: EvPeak 96 (16%), ONight 53 (5%), Sunlight 50 (4%)
TOTAL	343	2,223	

[14] Source: AEMO Generation Information July 2020

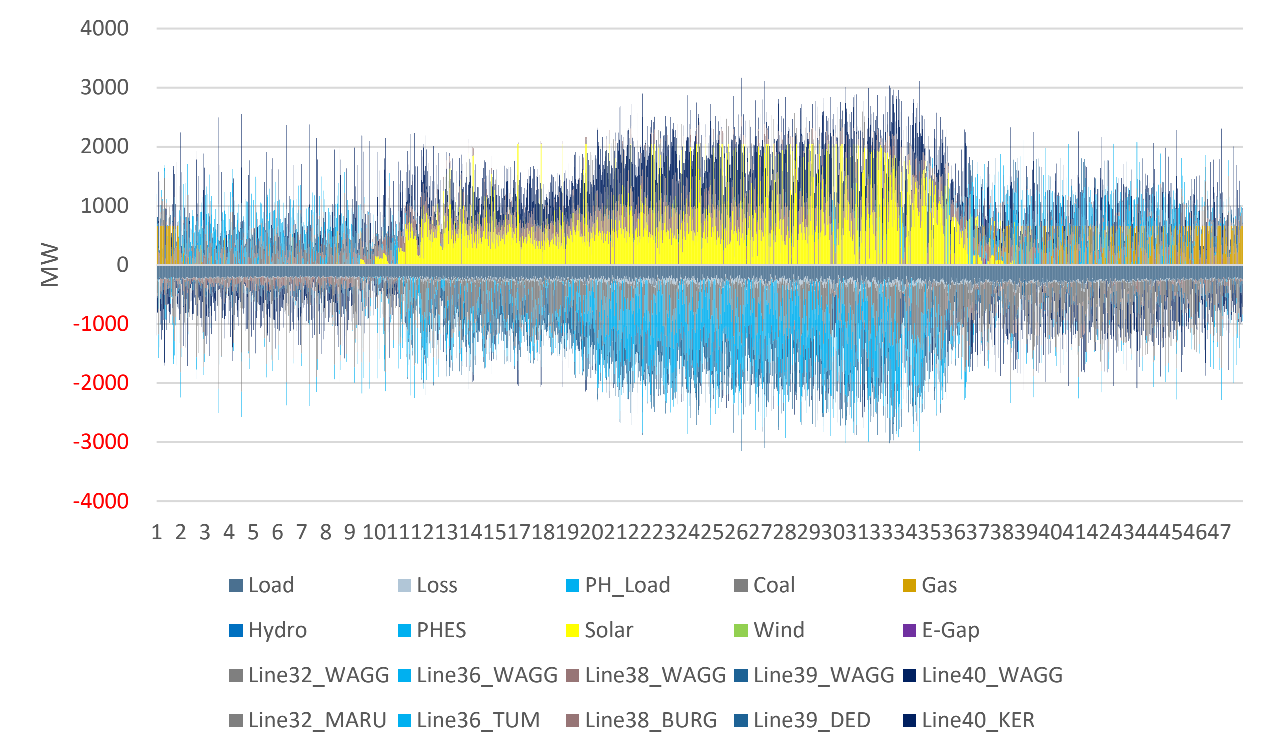

Figure 27: Wagga energy flows for SummWD under sB

Figure 27 provides detail on the flow of energy through WAGG node by time-of-day period by type of supply and demand. Of note:

- the navy blue coloured series indicates imports/exports between WAGG and Kerang node in VIC
- the royal blue coloured series indicates imports/exports (primarily exports) between WAGG and Dederang in VIC
- the cyan coloured series indicates imports/exports between WAGG and TUM node
- the light brown coloured series indicates imports/exports between WAGG and Buronga, where 450MW of solar generation is assumed to be located by 2030
- the yellow coloured series indicates dispatch from solar (2,049MW). Solar dispatch is considerably lower than available resource indicating the over-supply of wind, solar and coal across the NEM during the day. See dispatch and curtailment details in Figure 29
- E-G in Wagga node is small. There are 8 periods when an E-G greater than 20MW occurs. During these periods (during the same period on consecutive days), energy flows reverse from imports from Kerang in VIC to exports to Kerang in VIC. Figure 28 shows detail

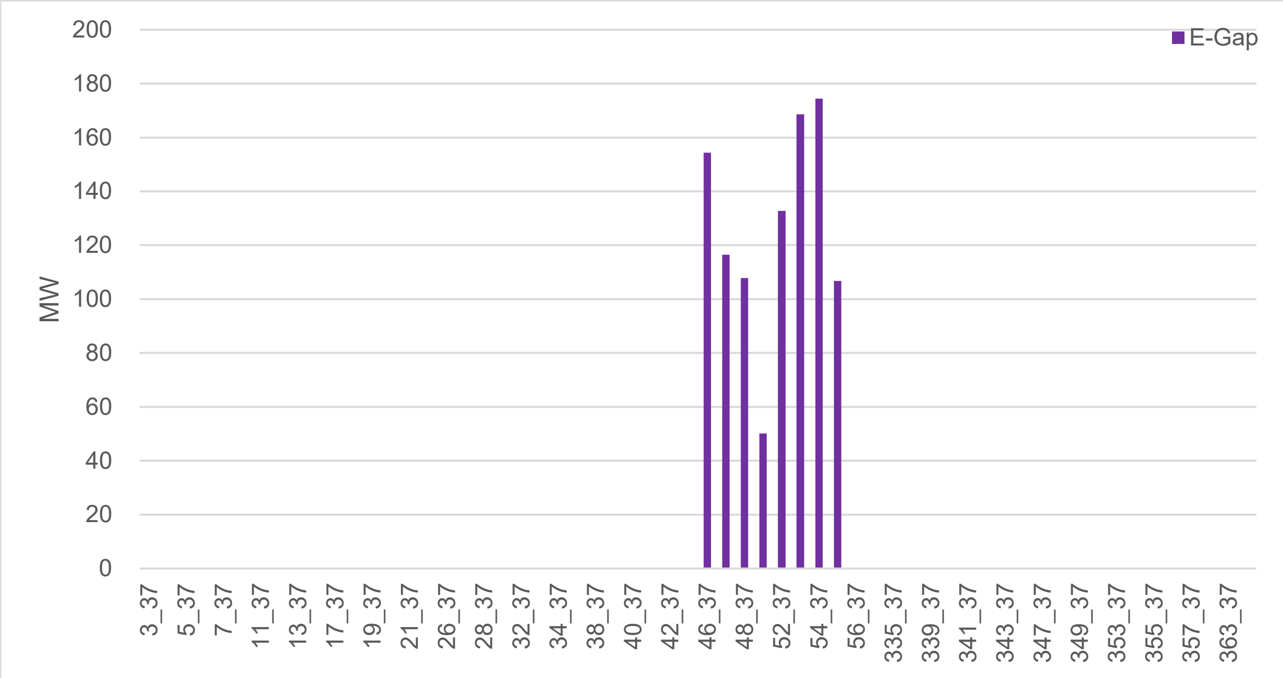

Figure 28: Wagga energy-gap for SummWD under sB

- Table 28 details statistics for Wagga energy flows

Table 28: Wagga salient statistics under sB

WAGGA	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(364)	(294)	(253)	(448)	56%	(243)
Gas	107	118	75	664	11%	0
Solar	611	374	424	2,049	21%	153
E-G	1	2	0	174	0%	0
Exports (node)	(1,582)	(1,088)	(1,099)	(2,847)	39%	(1,027)
Imports (node)	1,271	920	883	2,841	31%	807
Solar spill	727	149	505	2,070	24%	0
Solar spill %	54%	28%	54%	50%		

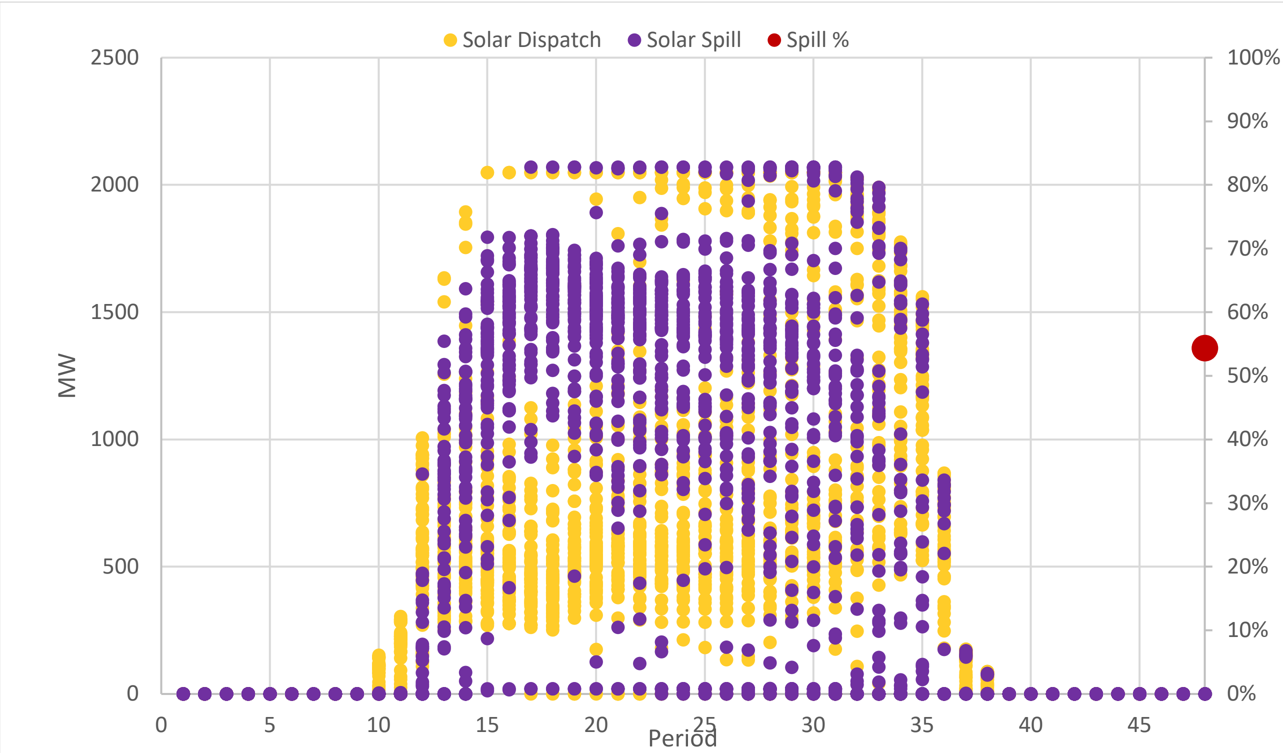

Figure 29: Wagga solar dispatch and curtailment under sB

16. BURONGA details for summer weekdays

Table 29 provides a summary of generating capacity assumptions for Buronga (BURG) node

Table 29: Buronga capacity assumptions under sB

BURG Capacity assumptions	Current [15] (MW)	2030 (MW)	Notes
Solar	29	450	CF (full year) 28%, (SummWD) 35% Curtail (full year) 14%, (SummWD) 24%
Storage/E-G		-	Capacity factor: 0%
TOTAL	29	450	

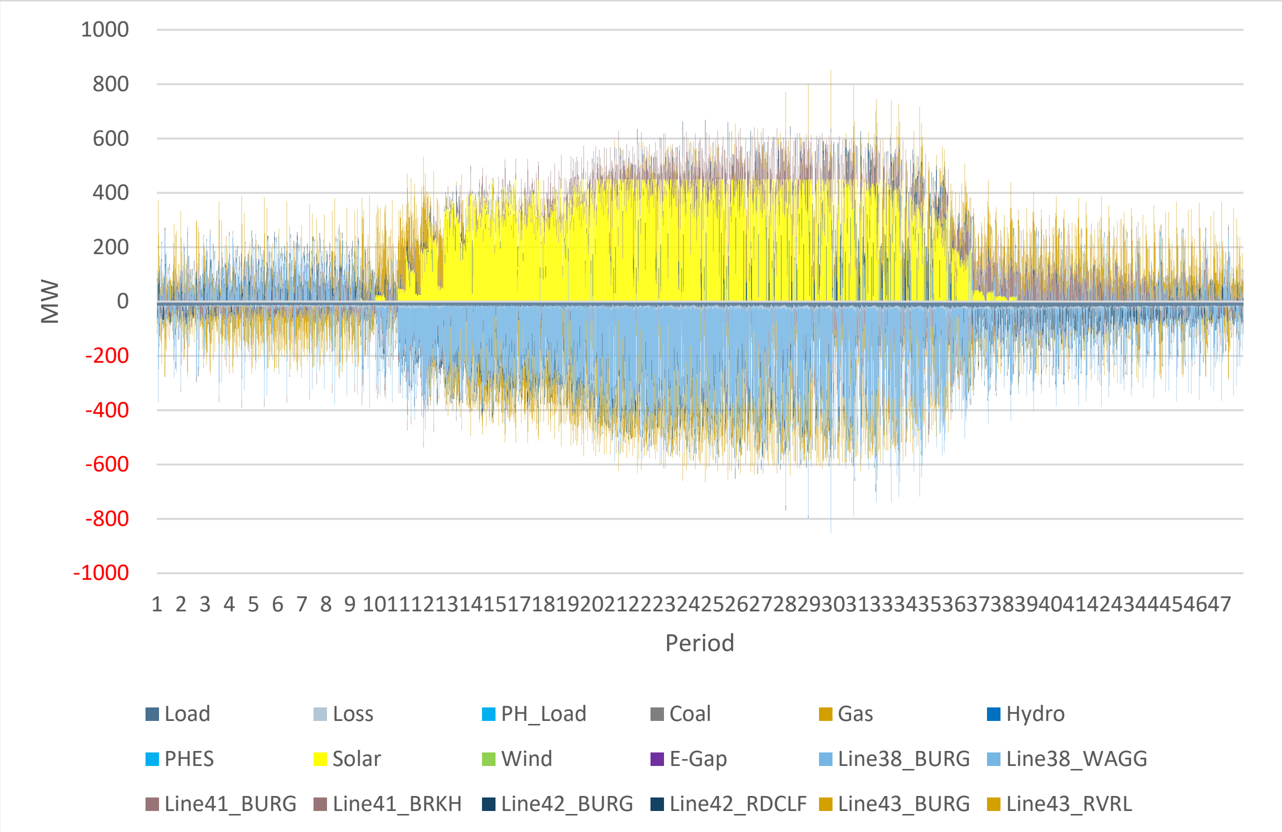

Figure 30: Buronga energy flows for SummWD under sB

Figure 30 provides detail on the flow of energy through BURG node by time-of-day period by type of supply and demand. Of note:

- the navy blue coloured series indicates imports/exports between BURG and Red Cliffs (VIC) nodes, where 1000MW is assumed to be located by 2030

[15] Source: AEMO Generation Information July 2020

- the light blue coloured series indicates imports/exports (primarily exports) between BURG and WAGG nodes, where 2049MW of solar generation is assumed to be located by 2030
- the light brown coloured series indicates imports/exports between BURG and Broken Hill, where 53MW of solar generation and 199MW of wind generation is assumed to be located by 2030
- the dark gold coloured series indicates imports/exports between BURG and Riverlands (SA), where 1230MW of solar generation is assumed to be located by 2030
- the yellow coloured series indicates dispatch from solar (450MW). Potential solar resource in BURG is very high during summer (46% CF) compared to 19% CF during winter, and 33% over the full year. 24% of solar dispatch is curtailed from potential resource indicating the over-supply of energy across the NEM during the day.
- There is no E-G in BURG node.

17. CONCLUDING OBSERVATIONS on NSW nodal supply-demand balance

Curtailment of both wind and solar at WELL and solar at WAGG and BURG, are surprising given the ISP-based transmission augmentations of Energy Connect, Humelink and KerangLink are factored in to the modelling and both nodes are within favoured renewable zones (REZ) supported by the NSW government. The modelling outcomes imply that additional coal closures and/or storage will be needed to uplift the maximum capacity of the VRE resources in the REZ nodes.

3. VICTORIA: Nodal Supply-Demand Balance for Summer Weekdays in 2030

a) Pipeline Scenario B

i. VIC Underlying assumptions

- N transmission network
- Direction of Flow loss method estimation
- Coal power in 2030 will decline to 3,144MW in VIC from 4,775MW currently (NSW 4,040MW from 10,210MW; QLD 4,839MW from 8,059MW)
- Coal unit closures by 2030 include:
  - QLD: Units 1-2 Callide B; Units 1-2 Stanwell; Units 1-2,5-6 Gladstone; Units 1-2 Tarong;
  - NSW: Units 1-4 Liddell; Units 1-4 Eraring; Units 5-6 Vales Point
  - VIC: Units 1-4 Yallourn
- Gas power in 2030 will decline slightly to 2,364MW in VIC from 2,477MW currently (QLD 2,691MW from 3,076MW with closure of Swanbank E; NSW 1,174MW from 2,155MW)
- There is no pump hydro (PHES) in 2030 in VIC (NSW 3,180MW; QLD 2,860MW; SA 610MW)
- Wind power in 2030 will reach 8,470MW in VIC (NSW 5,671MW; QLD 4,820MW; SA 3,652MW; TAS 2,302MW)
- Solar power in 2030 will reach 2,141MW in VIC (NSW 8,021MW; QLD 8,736MW; SA 4,213MW)
- A summary of generation capacity assumptions is provided in Table 31
- Transmission augmentation assumed for:
  - QNI to 5436MW
  - corridor from Armidale to Newcastle and Sydney to accommodate 5+GW of energy flows
  - Energy Connect from NSW to VIC and SA
  - Kerang-Link in Victoria
  - Battery of the Nation augmentation VIC to TAS

ii. VIC ANEM nodal structure for sB

Figure 31 provides a graphic representation of the generation capacity at each node and transmission corridors between each node in Victoria, for the ANEM model to balance supply and demand for each of 17520 periods in the given year.

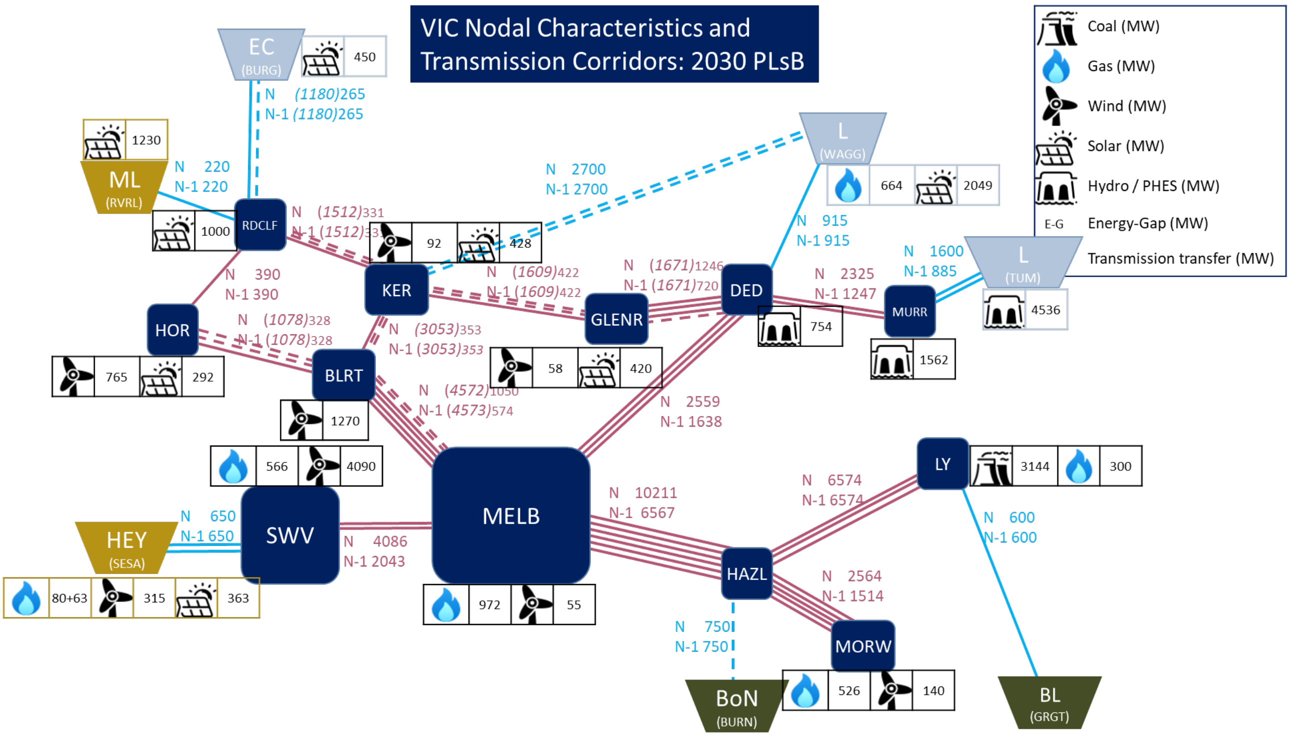

Figure 31: VIC ANEM nodal structure for sB

iii. VIC transmission corridors for sB

Table 30 provides a summary of the ANEM network transmission corridors used to determine intra-regional and inter-state trade (by reactance and thermal ratings) for co-optimisation of Optimal Power Flow (OPF) and competitive dispatch of identified generation.

Table 30: VIC ANEM transmission corridors for sB

Nodes	Transmission routes	N (MW)	N-1 (MW)
MURR - DED	Murray - Dederang	2325	1247
DED - MELB	Dederang – S. Morang Eildon – Thomas Town	2559	1638
DED - GLENR	***(KerangLink, 1 x 330kV)*** Dederang – Glenrowan Dederang - Shepparton	***(1671)*** 1246	***(1671)*** 720
MELB - HAZL	S. Morang – Hazelwood Rowville – Hazelwood Cranbourne –Hazelwood Yallourn–Rowville-Hazel	10211	6567
MELB - SWV	Moorabool – Heywood	4086	2043
MELB - BLRT	***(Western VIC, 1 x 500kV)*** Moorabool – Ballarat Moorabool -Elaine-Ballarat Moorabool-Terang-Ballarat Melbourne – N.Ballarat	***(4572)*** 1050	***(4572)*** 1050
HAZL - MOR	Hazelwood – TEE1 Hazelwood - Jeeralang	2564	1514
HAZL - LY	Hazelwood – Loy Yang	6574	6574
BLRT - KER	***(KerangLink)*** Ballarat-Bendigo-Kerang	***(3053)*** 353	***(3053)*** 353
BLRT - HOR	***(KerangLink)*** N.Ballarat-Waubra-Bulgana Ballarat-Waubra-Horsham	***(1078)*** 328	***(1078)*** 328
KER - GLENR	***(KerangLink)*** Bendigo-Fosterville-Shepparton	***(1609)*** 422	***(1609)*** 422
KER - RDCLF	***(KerangLink)*** Kerang-Wemen-Red Cliffs	***(1512)*** 331	***(1512)*** 331
HOR - RDCLF	Horsham – Red Cliffs	390	390
BURG – BRKH	Burong – Broken Hill	252	252
Interconnection			
TUM - MURR	Upper Tumut – Murray Lower Tumut – Murray	1600	885
WAGG - DED	Wagga – Jindera – Wodonga	915	915
WAGG - KER	***(Kerang Link)***	***(2700)***	***(2700)***

Nodes	Transmission routes	N (MW)	N-1 (MW)
BURG - RDCLF	***(Energy Connect)***	***(1180)*** 265	***(1180)*** 265
SWV - SESA	Heywood	650	650
RDCLF - RVRL	Red cliffs - Riverlands	220	220
HAZL - BURN	***(Battery of the Nation S2 – ISP 2040C only)*** ***(Battery of the Nation S1)***	***(1500)*** ***(750)***	***(1500)*** ***(750)***
LY - GRGT	Basslink	480-600	480-600

iv. VIC ANEM generation capacity assumptions for sB

Table 31: VIC capacity assumptions under sB

VIC Capacity assumptions	Current [16] (MW)	2030 (MW)	Notes
Coal	4,775	3,144	Closures: Yallourn 1450MW Capacity factor: 76% (full year); 79% (Summ WD)
Gas	2,477	2,364	Closures: No Capacity factor: 7% (full year); 6% (Summ WD)
Hydro	2,292	2,316	Closures: No Capacity factor: 10% (full year); 9% (Summ WD)
Solar	478	2,141	Capacity factor: 26% (full year); 34% (Summ WD) Curtailment: 17%, Max curtailment 2141MW
Wind	2,693	8,470	Capacity factor: 25% (full year); 21% (Summ WD) Curtailment: 14%, Max curtailment 6459MW
Storage/Other	115	405	Capacity factor: 0% (full year); 0% (SummWD)
TOTAL	12,830	18,840	

[16] Source: AEMO Generation Information July 2020

v. VIC modelling outcomes for Summer Weekdays in 2030

1. VIC Fuel share (Summer Weekdays)

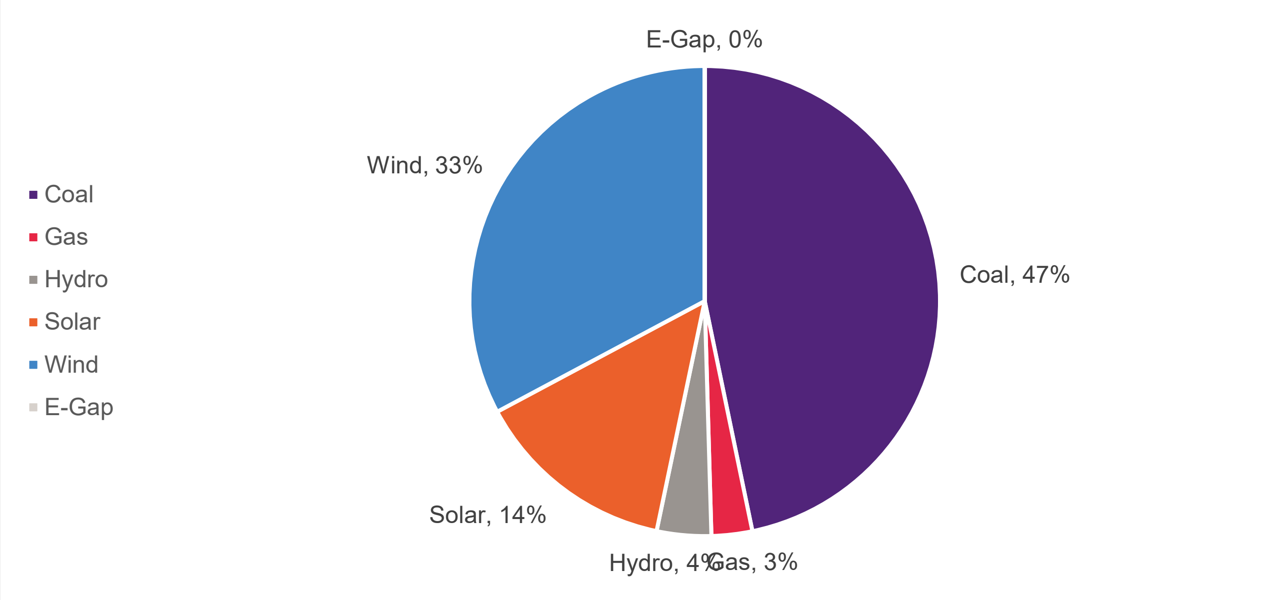

Figure 32: VIC fuel share during SummerWD under sB

Modelling outcomes predict that 47% of electricity generated in VIC in 2030 should be sourced from coal, 33% from wind, 14% from solar, 4% from hydro, and 3% from gas as shown in Figure 32. E-G is shown to be negligible.

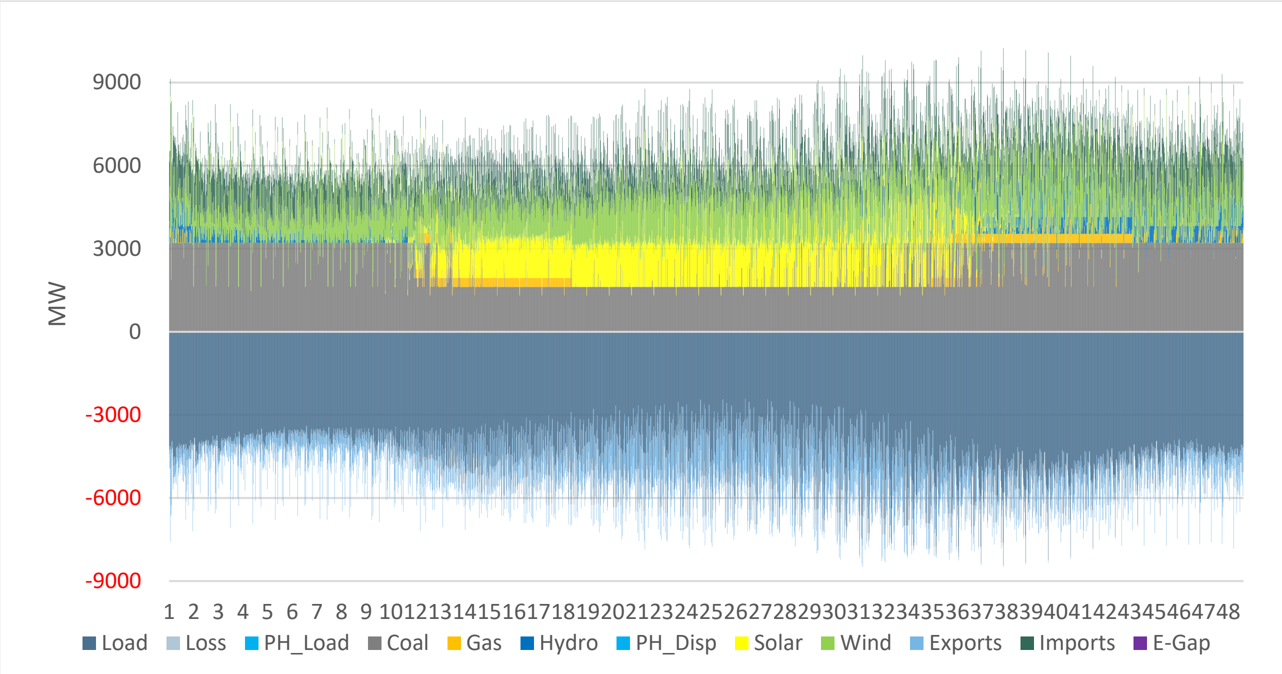

Figure 33: VIC energy flows for SummWD under sB

Figure 33 provides detail on the flow of energy through VIC by time-period according to source. Of note:

- the light blue coloured series indicates exports to NSW (predominantly) which are ongoing all day but increase during daylight hours
- the dark green coloured series indicates imports from Tasmania, South Australia and NSW (in roughly equal measures) which occur generally throughout the day but are smaller than the exports to NSW
- the grey coloured series indicates coal generation within VIC which declines during sunlight hours
- the gold coloured series indicates gas generation within VIC which tends to dispatch during morning and evening peaks
- the light green and yellow coloured series indicate solar and wind generation, which are lower than expected due to significant levels of curtailment, especially for solar. Further details in Figures 34 and 35
- the grey-blue coloured series indicates VIC load
- the purple coloured series indicates E-G

Table 32 provides totals and averages of the summer weekday energy flows. Coal generation across the state, with the removal of 1.6GW of capacity, achieves 79% capacity factor. Gas and hydro generation show low capacity factors at 6 and 9% respectively. Even with 24% curtailment of solar energy from potential dispatch, solar generation achieves a capacity factor of 34%. This is as a result of high dispatch during Summer Weekdays – capacity factors drop significantly during winter months. Curtailment of wind energy from potential dispatch is lower than solar at 15%, ensuring that wind generation state-wide achieves 32% capacity factor. As mentioned previously, E-G is negligible. VIC imports 1,752GWh in relatively equal measures from TAS, SA and NSW during Summer Weekdays. It exports 1,394 GWh primarily to NSW (937GWh), which highlights the important role that interconnection with NSW, SA and TAS plays in supporting energy flows as large quantities of VRE enter the system.

Table 32: VICTORIA salient statistics under sB

VIC Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(6,543)	(5,342)	(4,544)	(8,431)	54%	(4,366)
PH_Load	-					
Coal	3,573	2,794	2,481	3,210	77%	3,043
Gas	214	350	148	2,290	6%	1
Hydro	286	367	198	2,147	9%	0
PH_Disp		0	0	0	0%	0
Solar	1,063	512	738	2,141	34%	507
Wind	2,507	2,066	1,741	5,494	32%	1,567
E-G	0			51	0%	0
Exports	(1,394)	(847)	(968)	(3,450)	28%	(906)
Imports	1,752	1,274	1,217	3,192	38%	1,178
Solar_spill	337	33	234			0
Wind_spill	436	33	303			3
Solar spill %	24%	15%	24%			
Wind spill %	15%	5%	15%			

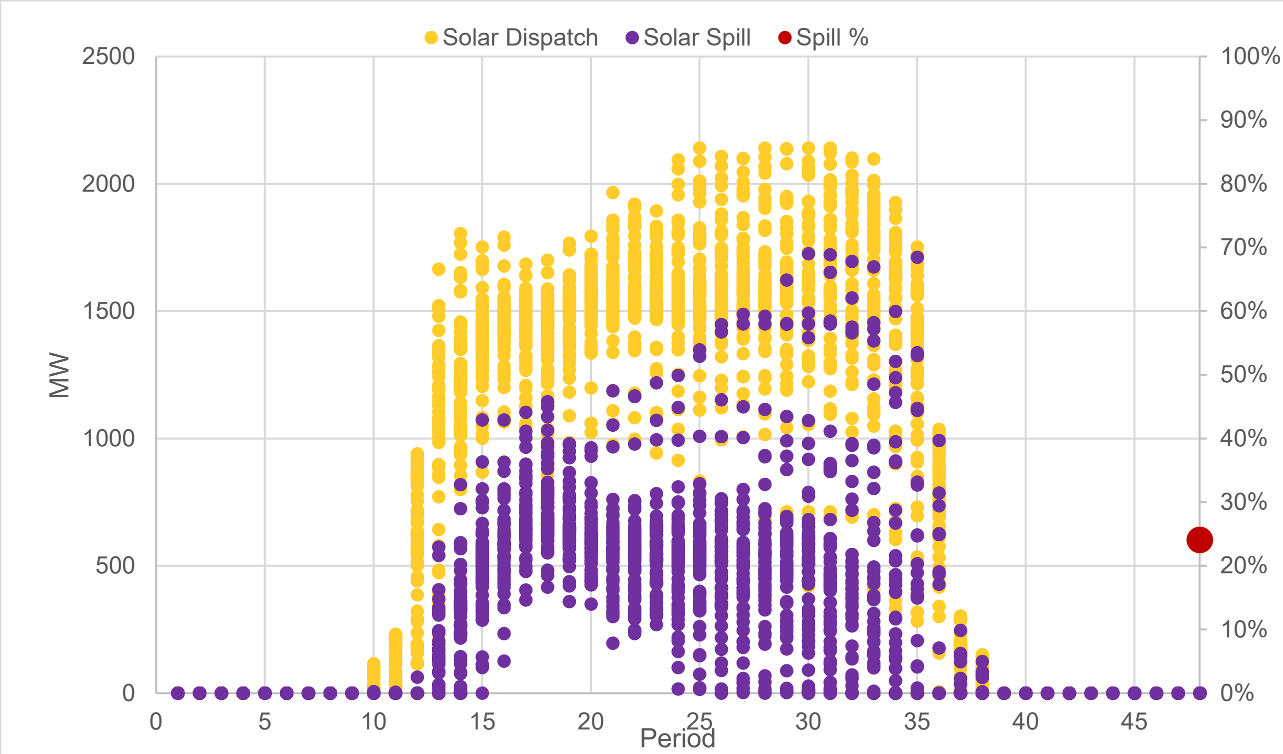

Figure 34: VIC coincident solar dispatch and curtailment under sB

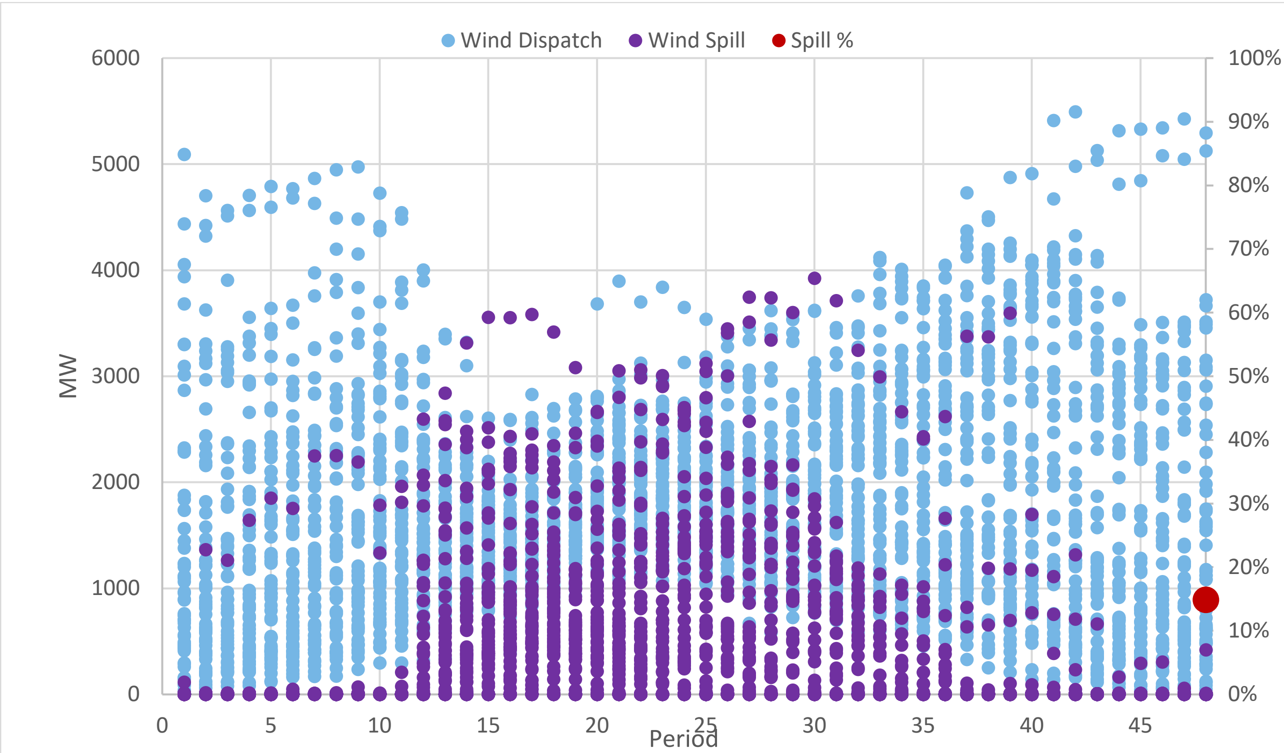

Figure 35: VIC coincident wind dispatch and curtailment under sB

2. MELBOURNE details for summer weekdays

Table 33 provides a summary of generating capacity assumption for Melbourne (MELB) node

Table 33: MELBOURNE capacity assumptions under sB

MELBOURNE Capacity assumptions	Current [17] (MW)	2030 (MW)	Notes
Gas	982	972	Capacity Factor: 13%
Wind		55	Capacity Factor: 33%, Max dispatch: 55MW
Storage/Other		-	
TOTAL	982	1,027	

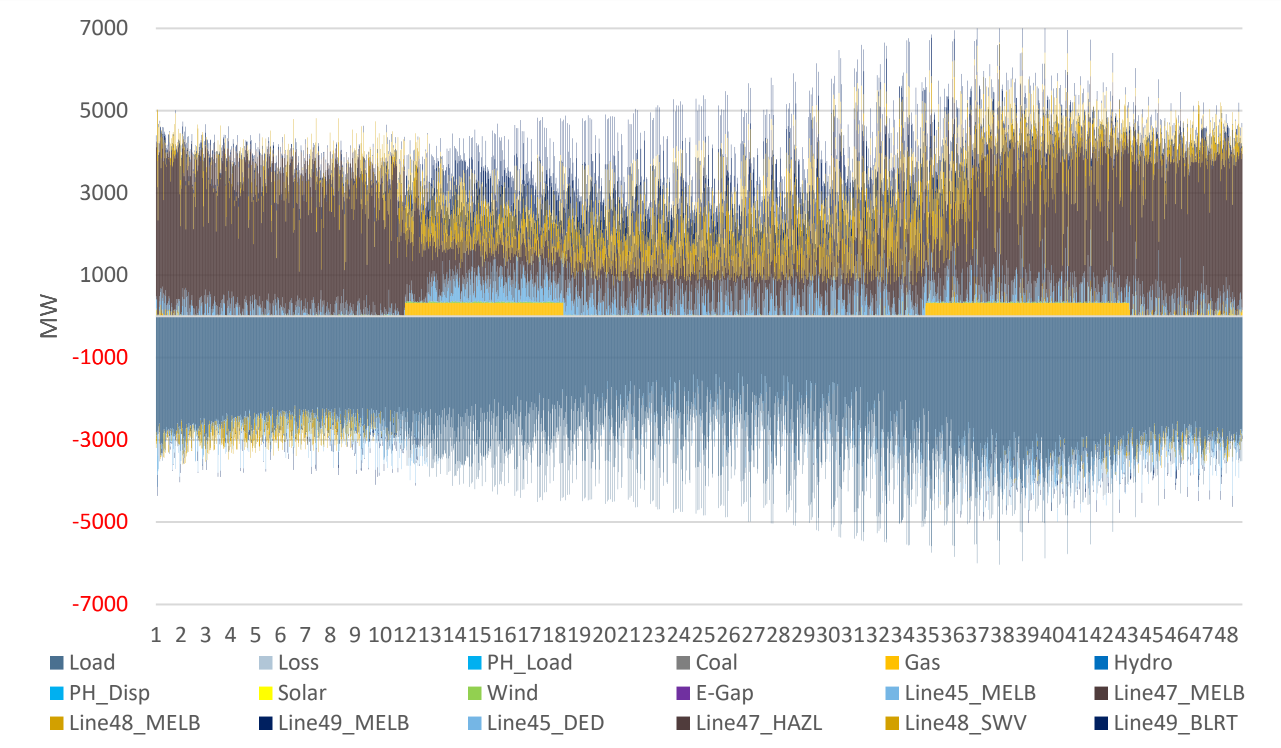

Figure 36: MELBOURNE energy flows for SummWD under sB

Figure 36 provides detail on the flow of energy through MELB node by time-of-day period by type of supply and demand. Of note:

- the brown coloured series indicates imports from Hazelwood node, which transfers energy from Loy Yang (coal), imports from Tasmania and gas from Morwell

[17] Source: AEMO Generation Information July 2020

- the dark gold coloured series indicates imports from SW Victoria node, where there is significant wind capacity (4,090MW)
- the navy-blue coloured series indicates imports from Ballarat node, where there is significant wind capacity (1,270MW)
- the steel-blue coloured series indicates MELB load
- the gold coloured series indicates generation from gas including Somerton, Newport and Laverton North
- the light blue coloured series indicates exports (primarily) to Dederang node
- E-G in the MELB node is negligible
- Table 34 details statistics for MELB energy flows

Table 34: MELBOURNE salient statistics under sB

MELB SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(4,471)	(3,738)	(3,105)	(6,031)	51%	(2,973)
Gas	174	283	121	966	13%	0
Wind	26	16	18	55	33%	15
E-G	0	0	0	0	9%	0
Exports	(256)	(160)	(178)	(1,578)	11%	0
Imports	5,320	4,264	3,694	6,691	55%	3,781
Wind_spill	1	0	0	10	4%	0
Wind spill %	2%	3%	2%			

3. SOUTH WEST VICTORIA details for summer weekdays

Table 35 provides a summary of South West Victoria (SWV) generating capacity assumptions

Table 35: SOUTH WEST VICTORIA capacity assumptions under sB

SWV Capacity assumptions	Current [18] (MW)	2030 (MW)	Notes
Gas	584	566	Capacity Factor: 4%
Wind	862	4,090	Capacity Factor: 23%, Max dispatch 3865MW Curtailment: 21%, Max curtailment 2844MW
Storage/Other		-	
TOTAL	1,446	4,656	

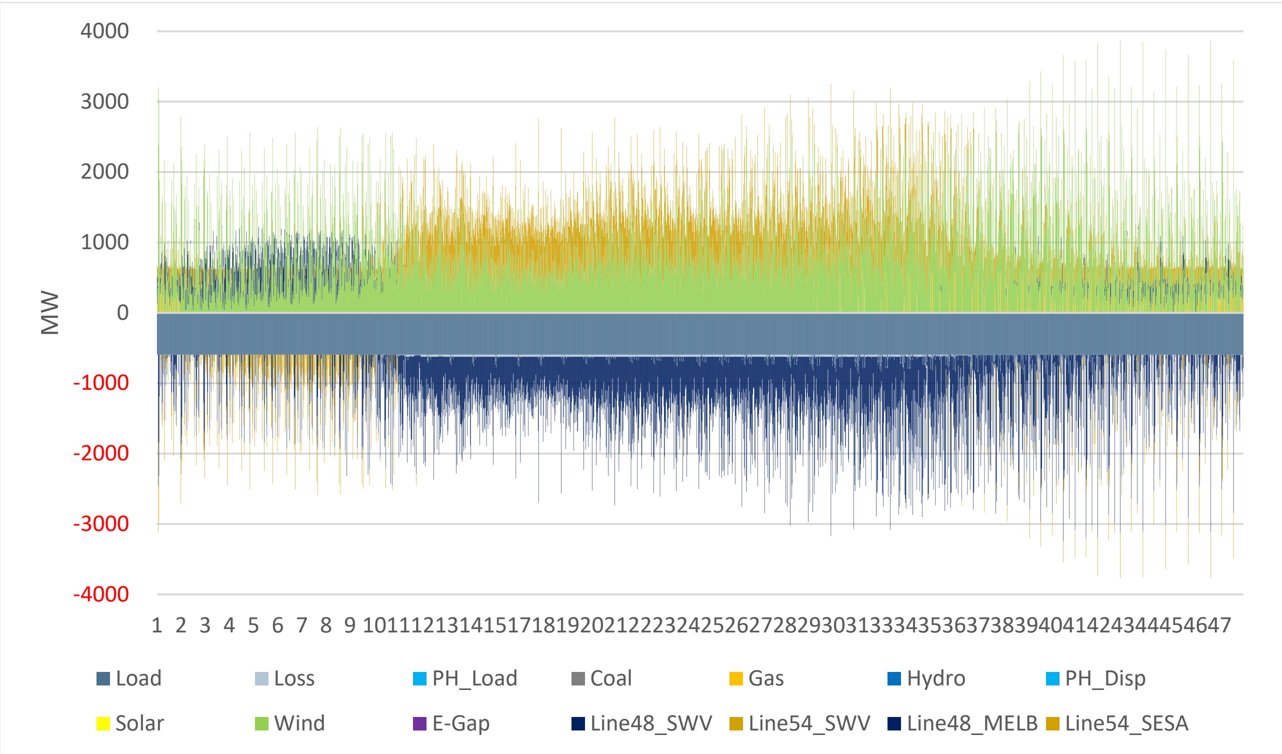

Figure 37: SW VICTORIA energy flows for SummWD under sB

Figure 37 provides detail on the flow of energy through SWV node by time-of-day period by type of supply and demand. Of note:

[18] Source: AEMO Generation Information July 2020

- the dark gold coloured series indicates imports (primarily) from SE South Australia node, where there is solar (363MW) and wind (315MW) capacity
- the navy-blue coloured series indicates exports (primarily) to MELB node
- the steel-blue coloured series indicates SWV load - primarily Portland aluminium smelter
- the gold coloured series indicates generation from gas, Mortlake (566MW), which dispatches only at evening peak and overnight and makes up a small proportion of generation in SWV node
- the light green coloured series indicates generation from 4,090MW of wind capacity. Wind resource for SWV is poor over summer, showing potential dispatch of only 29% (increasing to 50% during winter). Coupled with 21% curtailment, wind dispatched in SWV node during summer only achieves only 23% capacity factor. Figure 38 shows detail
- E-G in the SWV node is negligible
- Table 36 details statistics for SWV energy flows

Table 36: SOUTH WEST VICTORIA salient statistics under sB

SWV STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(870)	(620)	(604)	(866)	70%	(594)
Gas	29	49	20	566	4%	0
Wind	1,365	1,224	948	3,865	23%	757
E-G	0	0	0	0	5%	0
Exports	(1,036)	(888)	(720)	(3,175)	23%	(633)
Imports	603	300	419	877	48%	544
Wind_spill	352	38	244	2,844	9%	0
Wind spill %	21%	3%	21%			

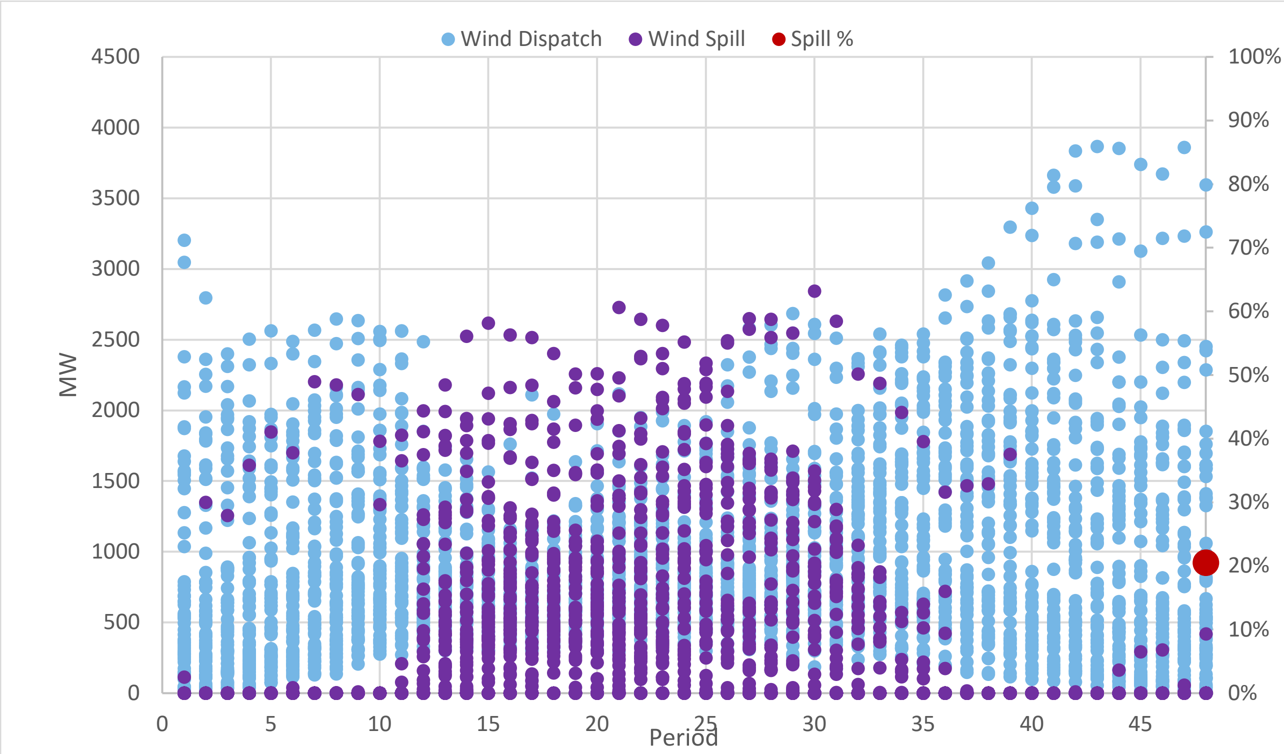

Figure 38: SW VICTORIA wind dispatch and curtailment under sB

4. BALLARAT details for summer weekdays

Table 37 details generating capacity assumptions for Ballarat (BLRT) node

Table 37: BALLARAT capacity assumptions under sB

BLRT Capacity assumptions	Current [19] (MW)	2030 (MW)	Notes
Wind	644	1,270	Capacity Factor: 31%, Max dispatch 1259MW Curtailment: 8%, Max curtailment 1098MW
Storage/Other	30	-	
TOTAL	674	1,270	

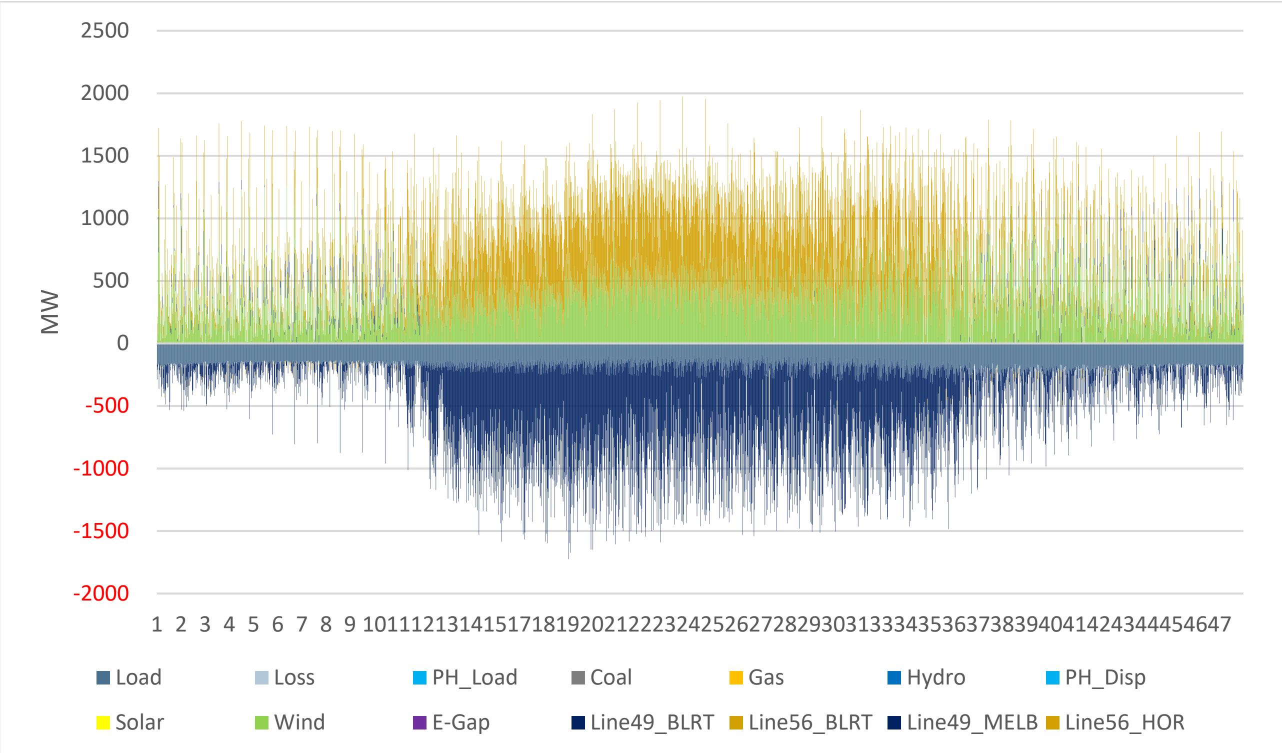

Figure 39: BALLARAT energy flows for SummWD under sB

Figure 39 provides detail on the flow of energy through BLRT node by time-of-day period by type of supply and demand. Of note:

- the dark gold coloured series indicates imports (primarily) from Horsham node, where there is solar (292MW) and wind (765MW) capacity
- the navy-blue coloured series indicates exports (primarily) to MELB node

[19] Source: AEMO Generation Information July 2020

- the steel-blue coloured series indicates BLRT load
- the light green coloured series indicates generation from 1,270MW of wind capacity. Figure 40 shows detail highlighting that the wind resource seldom results in maximum output out of sunlight hours and is in conflict with solar dispatch during sunlight hours, resulting in a capacity factor of 31%
- E-G in the BLRT node is negligible
- Table 38 details statistics for BLRT energy flows

Table 38: BALLARAT salient statistics under sB

BLRT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(260)	(213)	(180)	(339)	53%	(173)
Wind	564	460	392	1,259	31%	370
E-G	0	0	0	0	7%	0
Exports	(908)	(605)	(630)	(1,640)	38%	(666)
Imports	763	479	530	1,292	41%	522
Wind_spill	48	36	33	1,098	3%	0
Wind spill %	8%	7%	8%			

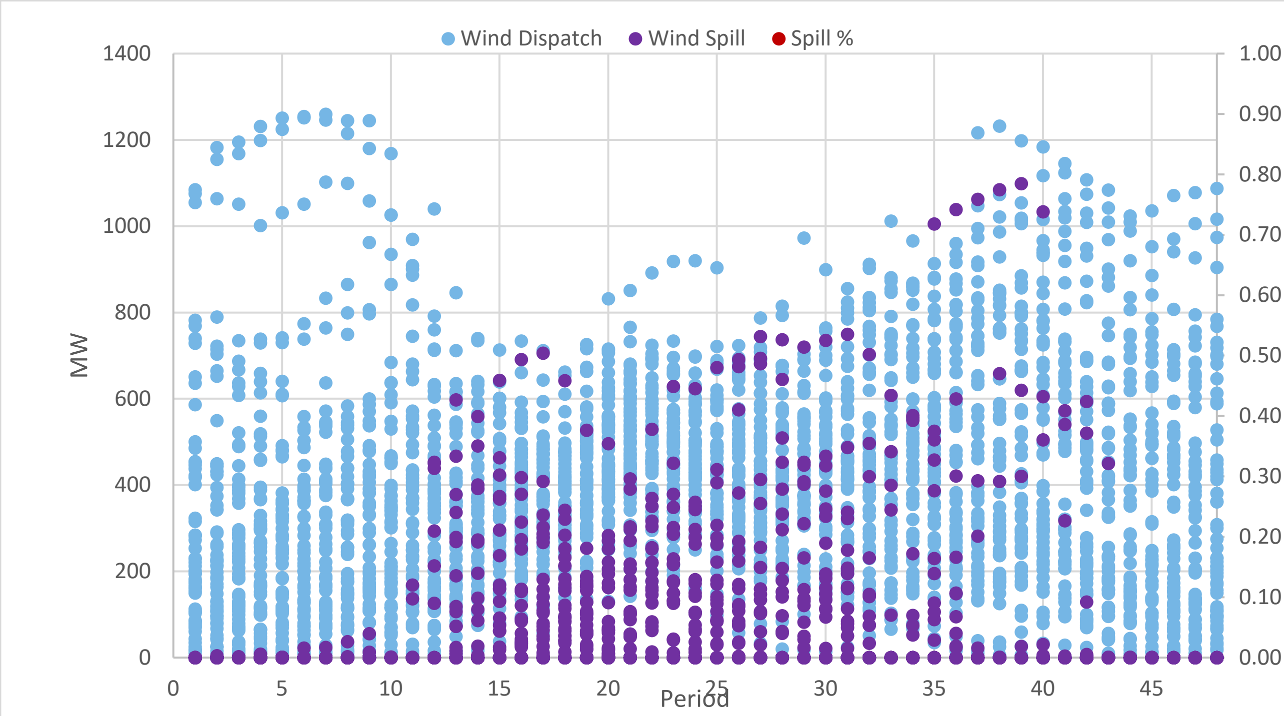

Figure 40: BALLARAT wind dispatch and curtailment under sB

5. HORSHAM details for summer weekdays

Table 39 summarises generating capacity assumptions for Horsham (HOR) node

Table 39: HORSHAM capacity assumptions under sB

HOR Capacity assumptions	Current [20] (MW)	2030 (MW)	Notes
Solar		292	Capacity Factor: 45%, Max dispatch 292MW Curtailment: 2%, Max curtailment 292MW
Wind	31	765	Capacity Factor: 38%, Max dispatch765MW Curtailment: 7%, Max curtailment 754MW
Storage/Other		-	
TOTAL	31	1,057	

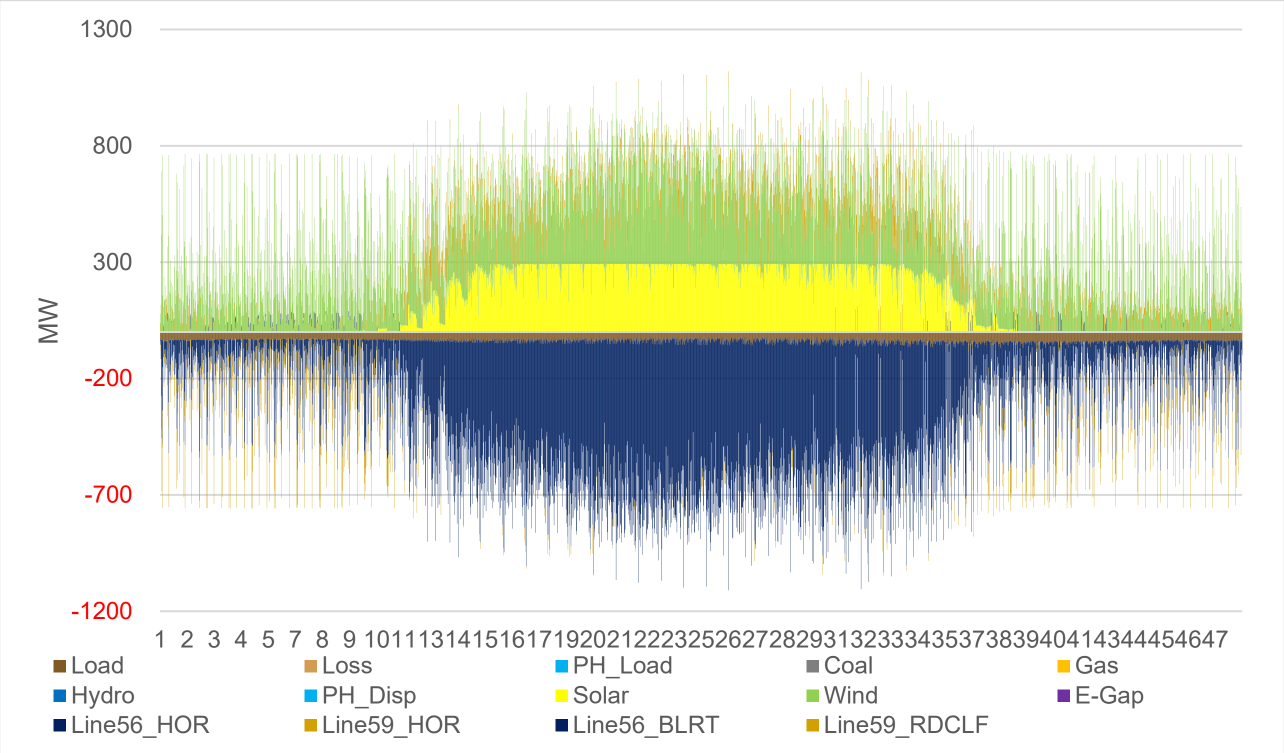

Figure 41: HORSHAM energy flows for SummWD under sB

Figure 41 provides detail on the flow of energy through HOR node by time-of-day period by type of supply and demand. Of note:

[20] Source: AEMO Generation Information July 2020

- the dark gold coloured series indicates imports and exports from and to Red Cliffs node, where there is solar (1000MW) capacity
- the navy-blue coloured series indicates exports (primarily) to BLRT and ultimately to MELB node
- the steel-blue coloured series indicates HOR load which is very small
- the light green coloured series indicates generation from 765MW of wind capacity. Figure 43 shows detail showing relatively good wind resource in HOR, resulting in a capacity factor of 38%
- the yellow coloured series indicates generation from 292MW of solar capacity. Potential solar resource in HOR is very high during summer (45% CF) compared to 15% CF during winter, and 30% over the full year. Figure 42 gives detail indicating excellent dispatch from the solar resource during Summer WD with little curtailment
- E-G in the HOR node is negligible
- Table 40 details statistics for HOR energy flows

Table 40: HORSHAM salient statistics under sB

HOR STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(53)	(44)	(37)	(69)	53%	(36)
Solar	187	86	130	292	45%	77
Wind	420	272	292	765	38%	267
E-G	0	0	0	0	9%	0
Exports	(611)	(361)	(425)	(1,065)	40%	(454)
Imports	65	52	45	254	18%	25
Solar_spill	3	5	2	295	1%	0
Solar spill %	2%	5%	2%			
Wind_spill	32	24	22	754	3%	32
Wind spill %	7%	8%	7%			

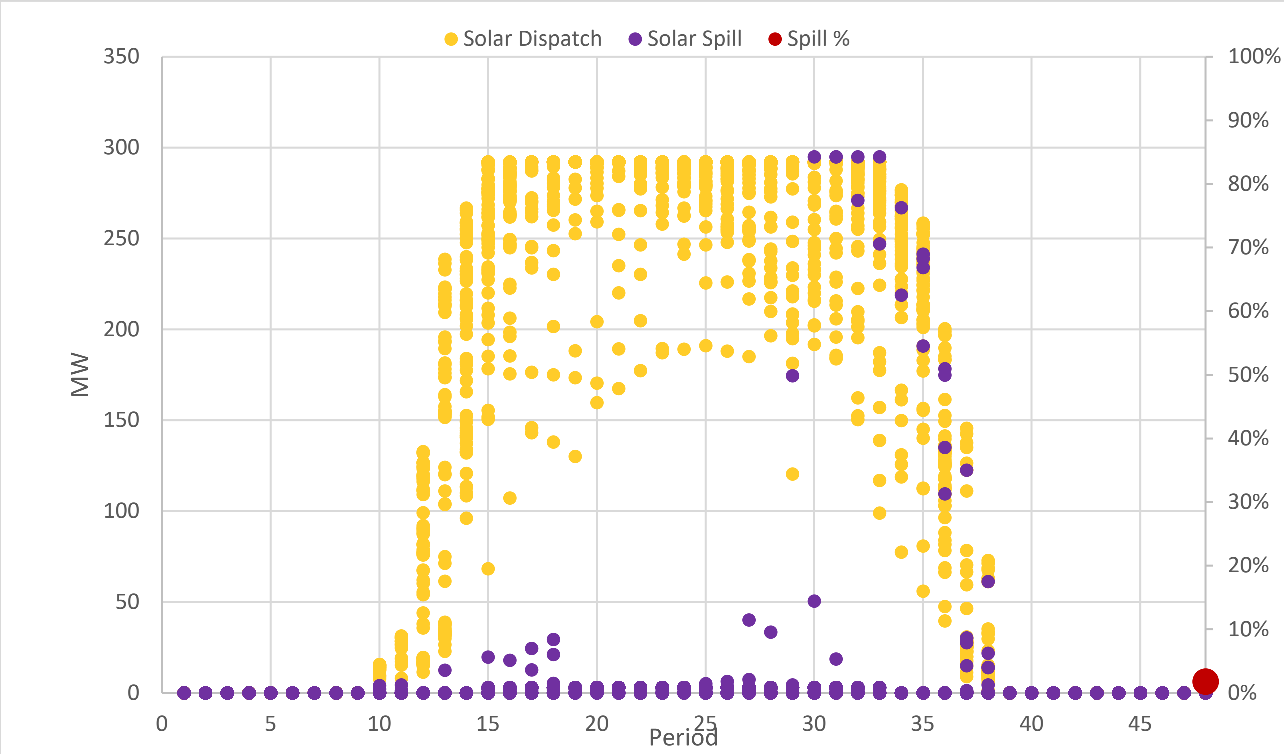

Figure 42: HORSHAM solar dispatch and curtailment under sB

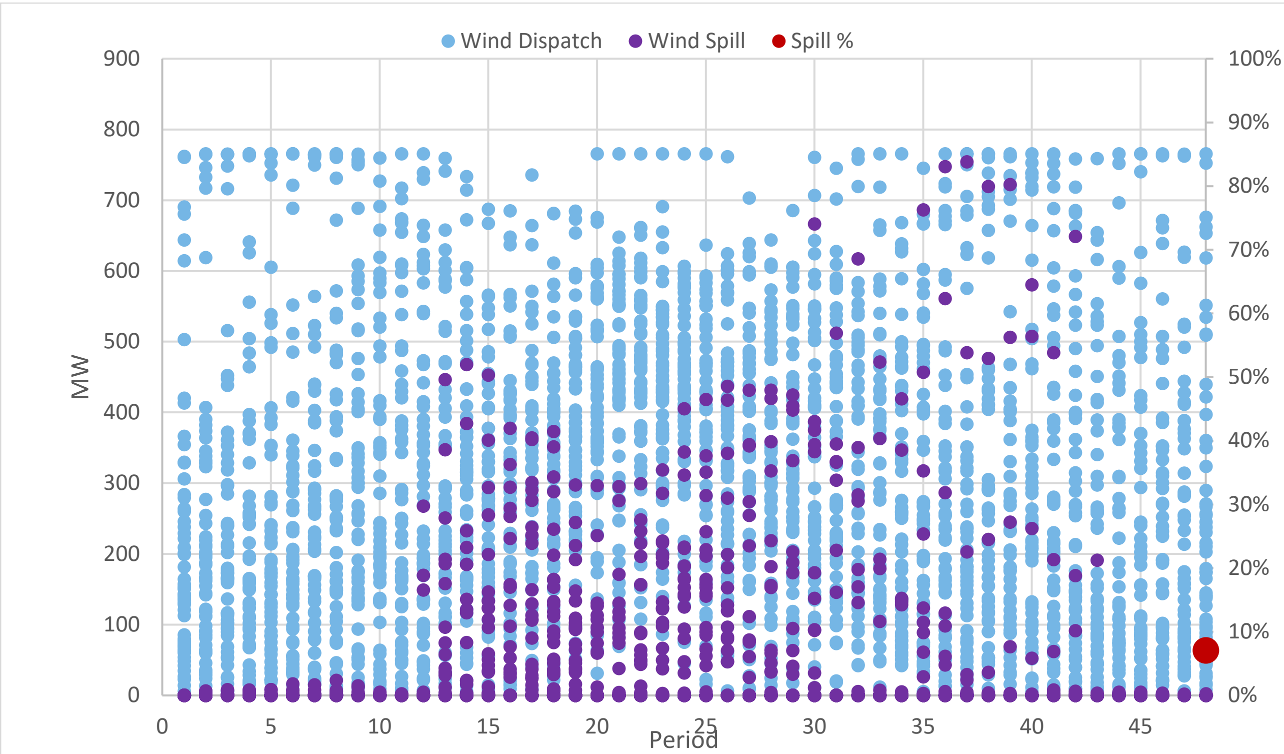

Figure 43: HORSHAM wind dispatch and curtailment under sB

6. RED CLIFFS details for summer weekdays

Table 41 summarises generating capacity assumptions for Red Cliffs (RDCLF) node

Table 41: RED CLIFFS capacity assumptions under sB

RDCLF Capacity assumptions	Current [21] (MW)	2030 (MW)	Notes
Solar	294	1,000	Capacity Factor: 24%, Max dispatch 1000MW Curtailment: 47%. Max curtailment 1000MW
Storage/Other		-	
TOTAL	294	1,000	

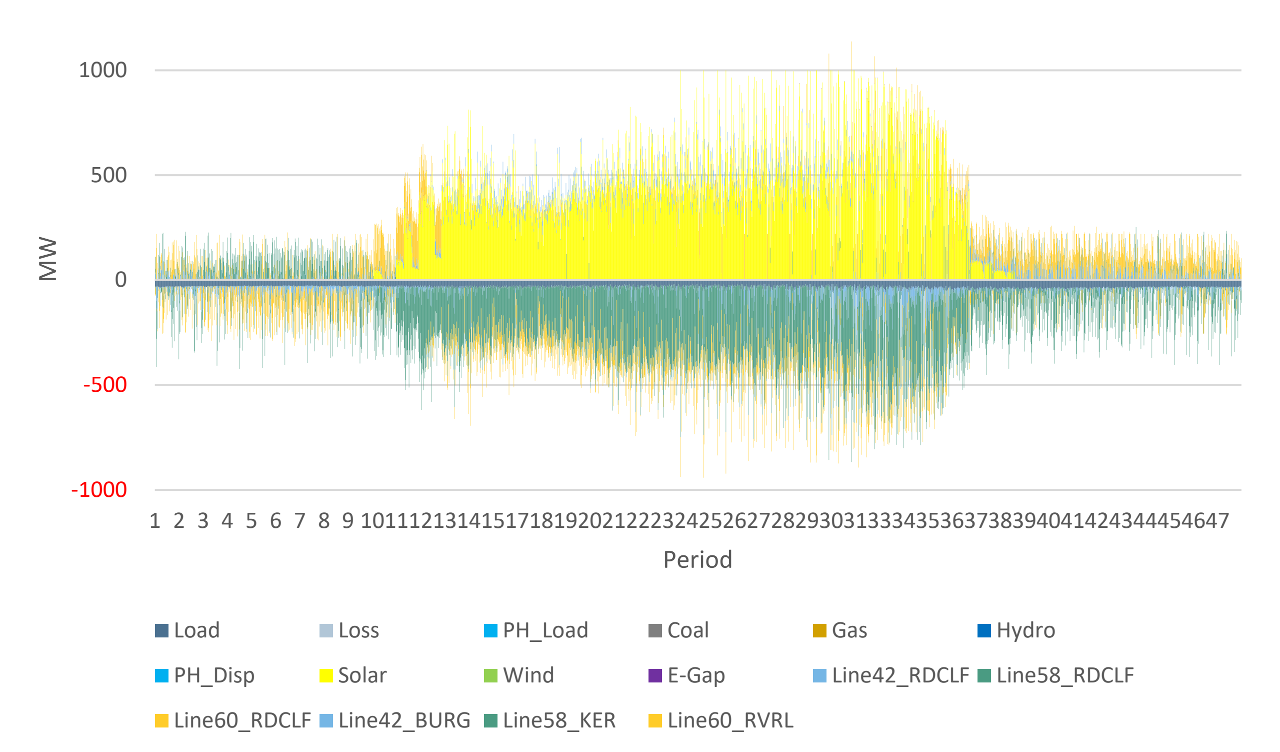

Figure 44: RED CLIFFS energy flows for SummWD under sB

Figure 44 provides detail on the flow of energy through RDCLF node by time-of-day period by type of supply and demand. Of note:

- the gold coloured series indicates imports and exports from and to Riverlands node, where there is solar (1230MW) capacity
- the green-blue coloured series indicates exports (primarily) to Kerang node

[21] Source: AEMO Generation Information July 2020

- the steel-blue coloured series indicates RDCLF load which is very small
- the yellow coloured series indicates generation from 1000MW of solar capacity. Potential solar resource in RDCLF is very high during summer (45% CF) compared to 18% CF during winter, and 32% over the full year. Figure 45 gives detail indicating limited dispatch and high curtailment from the solar resource resulting in a capacity factor of 24% despite excellent solar resource
- E-G in the RDCLF node is negligible
- Table 42 details statistics for RDCLF energy flows

Table 42: RED CLIFFS salient statistics under sB

RED CLIFFS SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(49)	(40)	(34)	(64)	53%	(33)
Solar	345	216	240	1,000	24%	95
E-G	0	0	0	0	2%	0
Exports	(450)	(304)	(313)	(1,087)	29%	(291)
Imports	163	135	113	452	25%	91
Solar_spill	308	68	214	1,000	21%	0
Solar spill %	47%	24%	47%			

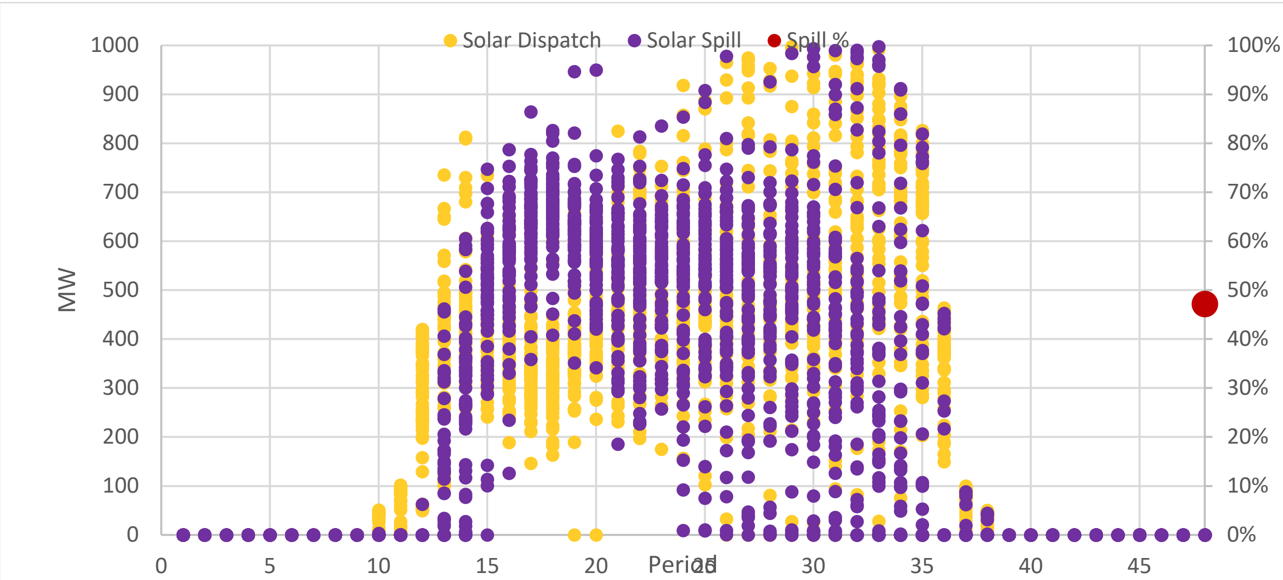

Figure 45: RED CLIFFS solar dispatch and curtailment under sB

7. MURRAY details for summer weekdays

Table 43 provides a summary of generating capacity assumptions for Murray (MURR) node

Table 43: MURRAY capacity assumptions under sB

MURR Capacity assumptions	Current [22] (MW)	2030 (MW)	Notes
Hydro	1,531	1,562	Capacity factor: 10%, Max dispatch 1467MW
Storage/Other/ E-G		-	
TOTAL	1,531	1,562	

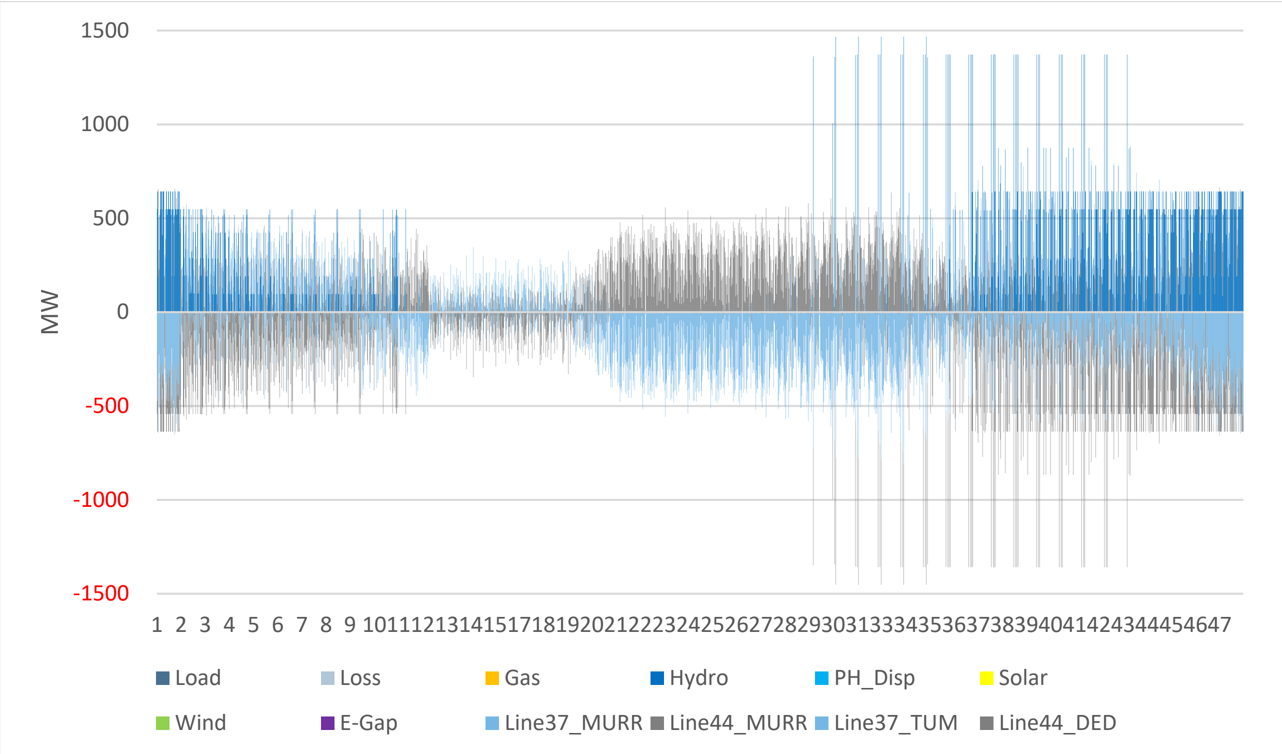

Figure 46: MURRAY energy flows for SummWD under sB

Figure 46 provides statistics on the flow of energy through MURR node by time-of-day period by type of supply and demand. Of note:

- Murray hydro, dark blue coloured series, is generally dispatched from 5pm through to morning peak, although seldom at maximum capacity. The periods of very high dispatch correspond with the high demand periods over Christmas – New Year.

[22] Source: AEMO Generation Information July 2020

- the light blue coloured series indicates the imports-exports from-to TUM node in NSW;
- the grey coloured series indicates the imports-exports from-to Dederang node
- E-G is non-existent in MURR node
- Table 44 details statistics for MURR energy flows

Table 44: MURRAY salient statistics under sB

MURR Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	0	0	0	0	0%	0
Hydro	227	277	158	1,467	11%	0
E-G	0	0	0	0	0%	0
Exports (node)	(419)	(376)	(291)	(1,453)	20%	(244)
Imports (node)	197	103	137	638	21%	95

8. CONCLUDING OBSERVATIONS for VIC nodal supply-demand balance

There is evidence of significant curtailment of solar in VIC, indicative of over-supply during the day during Summer WD. Surprisingly wind resource in VIC is fairly low during summer months, averaging 29% CF in SWV and 32% in BLRT. The concerns for low wind resource during summer would be that expectations of high wind resource outside of sunlight hours may not be met.

4. SOUTH AUSTRALIA: Nodal Supply-Demand Balance for Summer Weekdays in 2030

a) Pipeline Scenario B

i. SA Underlying assumptions

- N transmission network
- Direction of Flow loss method estimation
- There will be no coal generation in SA Coal power in 2030. In the other states, coal generation will decline (VIC 3,144MW from 4,775MW; NSW 4,040MW from 10,210MW; QLD 4,839MW from 8,059MW)
- Coal unit closures by 2030 include:
    - QLD: Units 1-2 Callide B; Units 1-2 Stanwell; Units 1-2,5-6 Gladstone; Units 1-2 Tarong;
    - NSW: Units 1-4 Liddell; Units 1-4 Eraring; Units 5-6 Vales Point
    - VIC: Units 1-4 Yallourn
- Gas power in 2030 will increase to 2,785MW in SA from 2,368MW currently. Gas generation in other states will total NSW 3,048MW; VIC 2,364MW; QLD 2,691MW
- Pump hydro (PHES) in 2030 will be 610MW including Baroota (240MW), Goats Hill (240MW) and Middleback Ranges (110MW). PHES in other states will total (QLD 2,860MW; NSW 3,180MW)
- Wind power in 2030 will reach 3,652MW in SA (VIC, 8,470MW; NSW 5,671MW; QLD 4,820MW, TAS 2,302MW)
- Solar power in 2030 will reach 4,213MW in SA (VIC 2,141MW; NSW 8,021MW; QLD 8,736MW)
- A summary of the generating capacity assumptions for SA is detailed in Table 46
- Transmission augmentation assumed for:
    - QNI to 5436MW
    - corridor from Armidale to Newcastle and Sydney to accommodate 5+GW of energy flows
    - Energy Connect from NSW to VIC and SA
    - Kerang-Link in Victoria
    - Battery of the Nation augmentation VIC to TAS

ii. SA ANEM nodal structure for sB

Figure 47 provides a graphic representation of the generation capacity at each node and transmission corridors between each node in South Australia, for the ANEM model to balance supply and demand for each of 17520 periods in the given year.

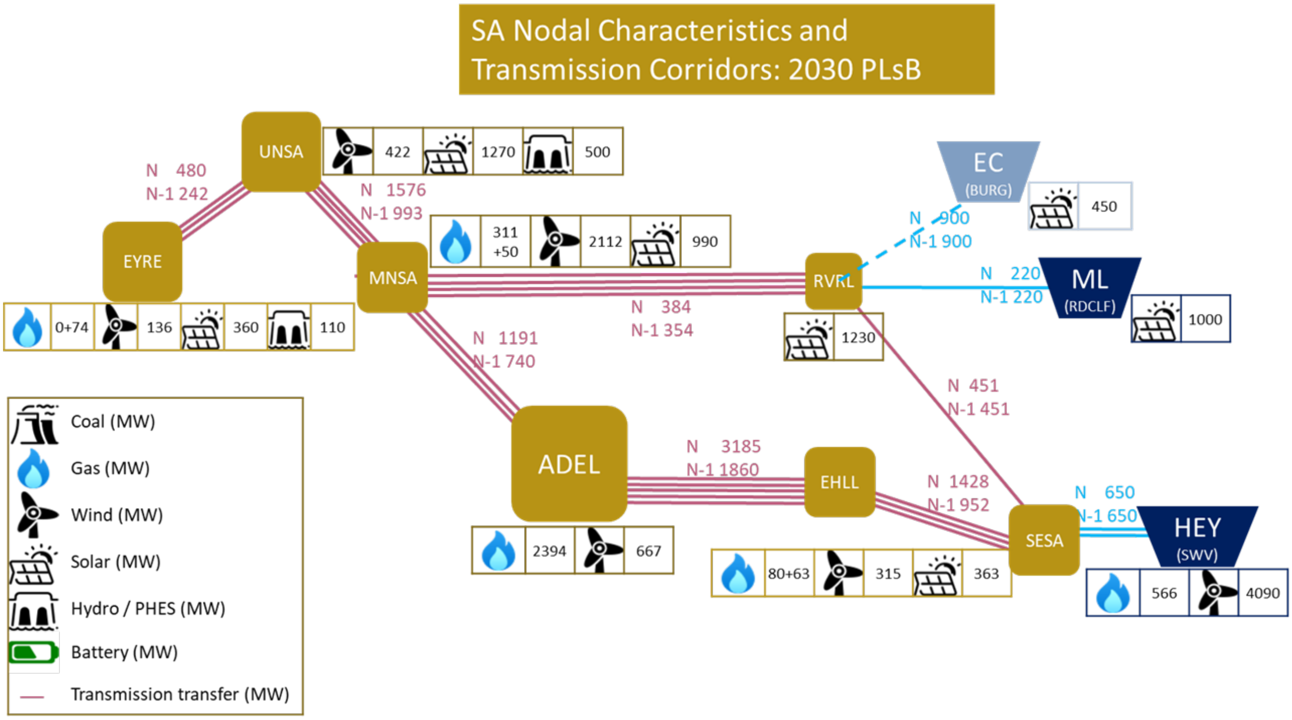

Figure 47: SA ANEM nodal structure for sB

iii. SA ANEM transmission corridors for sB

Table 45 provides a summary of the ANEM network transmission corridors used to determine intra-regional and inter-state trade (by reactance and thermal ratings) for co-optimisation of Optimal Power Flow (OPF) and competitive dispatch of identified generation.

Table 45: SA ANEM transmission corridors for sB

Nodes	Transmission routes	N (MW)	N-1 (MW)
SESA – EHLL	SESA – Tallem Bend Tallem Bend – Cherry Gr	1428	952
SESA - RVRl	Tallem Bend – Tungkillo – Robertstown	451	451
EHLL - ADEL	MtBaker.S-Tungkillo-Para-Millbrook Cherry Gardens – Happy Valley Cherry Grdns – Morphett Vales E Cherry Gardens – Torrens Island B	3185	1860
ADEL - MNSA	Para – Bungama Para – Brinkworth Para - Robertstown	1191	740
RVRL - MNSA	WaterlooE –Robertstown NWBend – Robertstown	384	354
MNSA - UNSA	Robertstown–Canowie-Davenport Brinkworth – Davenport Bungama – Davenport Robertstown - Davenport	1576	993
UNSA - EYRE	Davenport – Cultana Davenport - Whyalla	480	242
Interconnection			
SWV - SESA	Heywood	650	650
RDCLF - RVRL	Red cliffs - Riverlands	220	220
BURG RVRL	***(Energy Connect)*** ***Robertstown – Buronga*** ***Buronga – Darlington Pt*** ***Darlington Pt - Wagga***	***(900)***	***(900)***

iv. SA ANEM generation capacity assumptions for sB

Table 46: SOUTH AUSTRALIA capacity assumptions under sB

SA Capacity assumptions	Current [23] (MW)	2030 (MW)	Notes
Gas	2,368	2,785	Additions: Barkers Inlet 210MW; TGN 226MW; TGS 120MW Capacity factor: 15% (full year); 16% (Summ WD)
Diesel	609	207	
Hydro	3	-	
Solar	366	4,213	Capacity factor: 14% (full year); 17% (Summ WD) Curtailment: 56%, Max curtailment 3547MW
Wind	2,053	3,652	Capacity factor: 28% (full year); 27% (Summ WD) Curtailment: 28%, Max curtailment 2789MW
PHES	-	610	Capacity factor: 6% (full year); 3% (SummWD)
Storage/Other	890	1,296	Capacity factor: 10% (full year); 10% (SummWD)
TOTAL	6,289	12,762	

[23] Source: AEMO Generation Information July 2020

v. SA modelling outcomes for Summer Weekdays in 2030

1. SA Fuel share (Summer Weekdays)

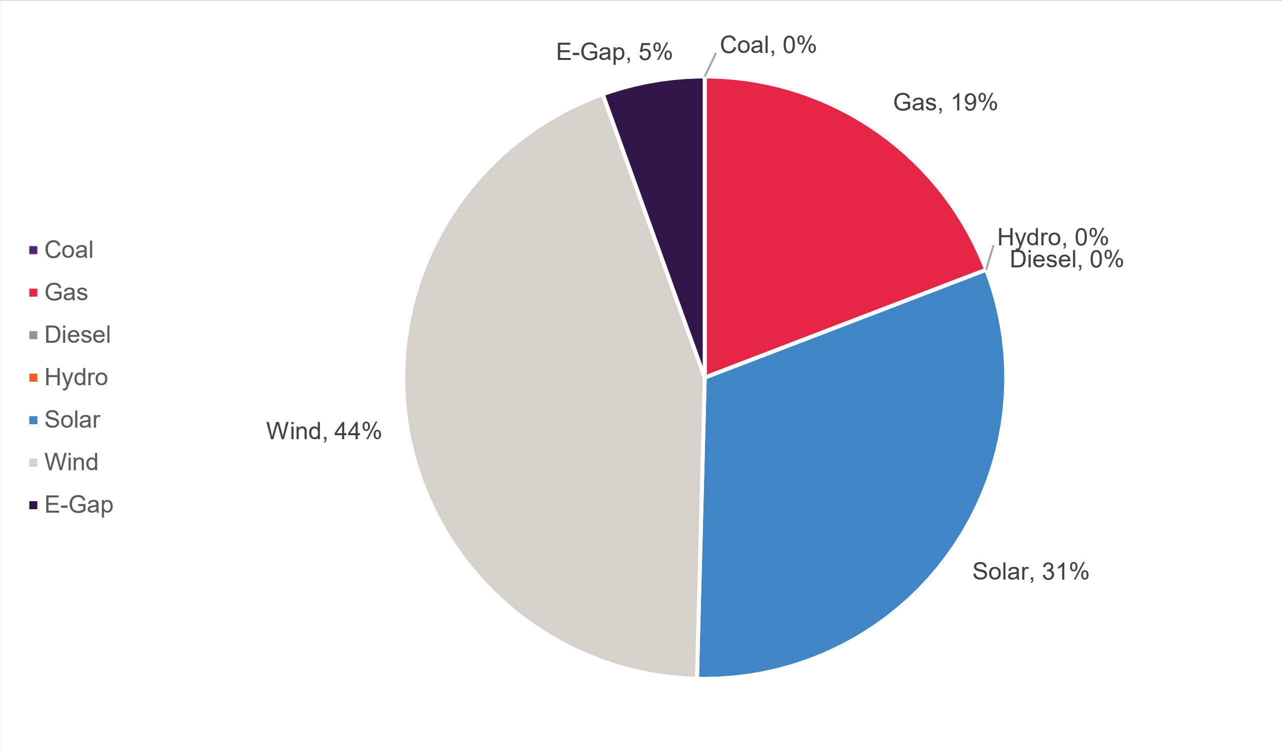

Figure 48: SA fuel share during SummerWD under sB

Modelling outcomes predict that 44% of electricity generated in SA in 2030 will be sourced from wind, 31% from solar, and 19% from gas as shown in Figure 48. Five percent of energy generated comes from the E-G which is persistent overnight, with a handful of highly elevated levels during evening peak, resulting in an overall capacity factor of 10%. The max capacity of E-G required in Upper North SA node is 500MW, Mid North SA node is 245MW, Eyre Peninsula is 110MW, and Riverlands is 101MW.

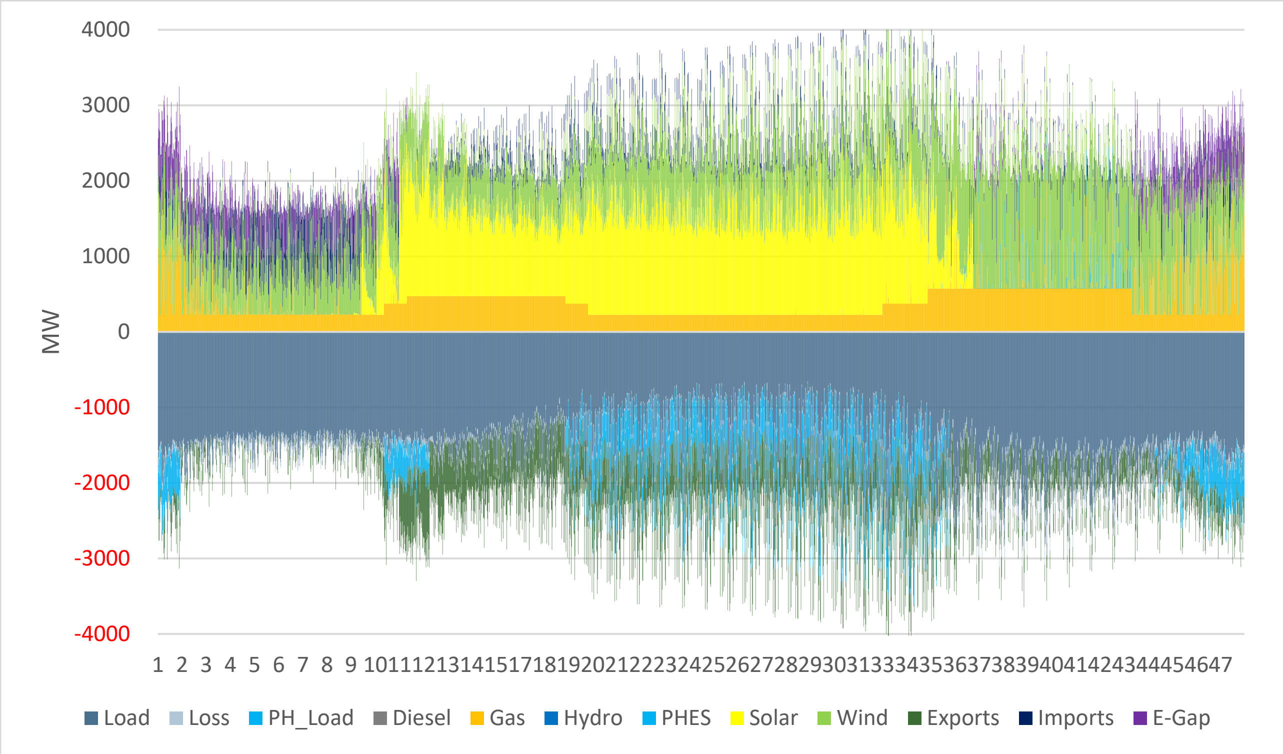

Figure 49: SA energy flows for SummWD under sB

Figure 49 provides detail on the flow of energy through SA by time-period according to source. Of note:

- the dark green coloured series indicates exports to SWV node in VIC (predominantly) which are ongoing all day but increase during daylight hours. Flows of energy between NSW and SA are not large – exports of 66GWh from Riverlands to BURG with corresponding imports of 73GWh from BURG to Riverlands. Transfers are maximised at 335MW for exports and 274MW for imports, which is considerably lower than the transfer capacity. This depressed level of activity results in significant curtailment of wind and solar
- the dark blue coloured series indicates imports from VIC which are small and scattered throughout the day and night
- the gold coloured series indicates gas generation within SA which tends to dispatch during morning and evening peaks
- the light green and yellow coloured series indicate solar and wind generation, which are lower than expected due to significant levels of curtailment, especially for solar. Figures 50 and 51 show detail
- the grey-blue coloured series indicates SA load
- the purple coloured series indicates E-G which occurs predominantly overnight

Table 47 provides totals and averages of the summer weekday energy flows. Wind is the source of the largest proportion of generation in SA (3,652MW) and achieves a 42% capacity factor, even with 33% curtailment from potential generation. Solar is the next largest source of generation in SA (4,213MW), achieving 27% capacity factor after 63% curtailment from potential generation - a remarkable result due to excellent solar resource during Summer. Gas generation of 2.8GW across the state, achieves 21% capacity factor. SA imports 264GWh mainly from VIC (173GWh) during Summer Weekdays and exports 716 GWh primarily to VIC (599GWh), which highlights the important role that interconnection with VIC plays in supporting energy flows as large quantities of VRE enter the system.

E-G is large (1,296MW) relative to the fleet capacity of 11,466MW. It maximises at 500MW in Upper North SA which hosts Baroota (240MW) and Goats Hill (240MW) PHES and is relatively persistent with a capacity factor of 17%. Although the E-G in Eyre Peninsula is smaller at 110MW it is also relatively persistent with a capacity factor of 20%. The cause of the E-G will be discussed in greater detail below.

Table 47: SOUTH AUSTRALIA salient statistics under sB

SA STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(2,197)	(1,798)	(1,526)	(2,901)	53%	(1,478)
PH_Load	(378)	(153)	(263)	(590)	45%	(55)
Gas	625	583	434	2,086	21%	373
Diesel	0	0	0	1	2%	0
PH_Disp	25	61	17	610	3%	0
Solar	1,018	445	707	2,623	27%	867
Wind	1,437	1,440	998	2,392	42%	891
E-G	179	28	124	610	20%	0
Exports	(665)	(439)	(461)	(1,187)	39%	(563)
Imports	246	96	171	1,038	16%	84
Solar_spill	1,759	323	1,222	3,547	34%	81
Wind_spill	716	661	497	2,789	18%	282
Solar spill %	63%	42%	63%			
Wind spill %	33%	31%	33%			

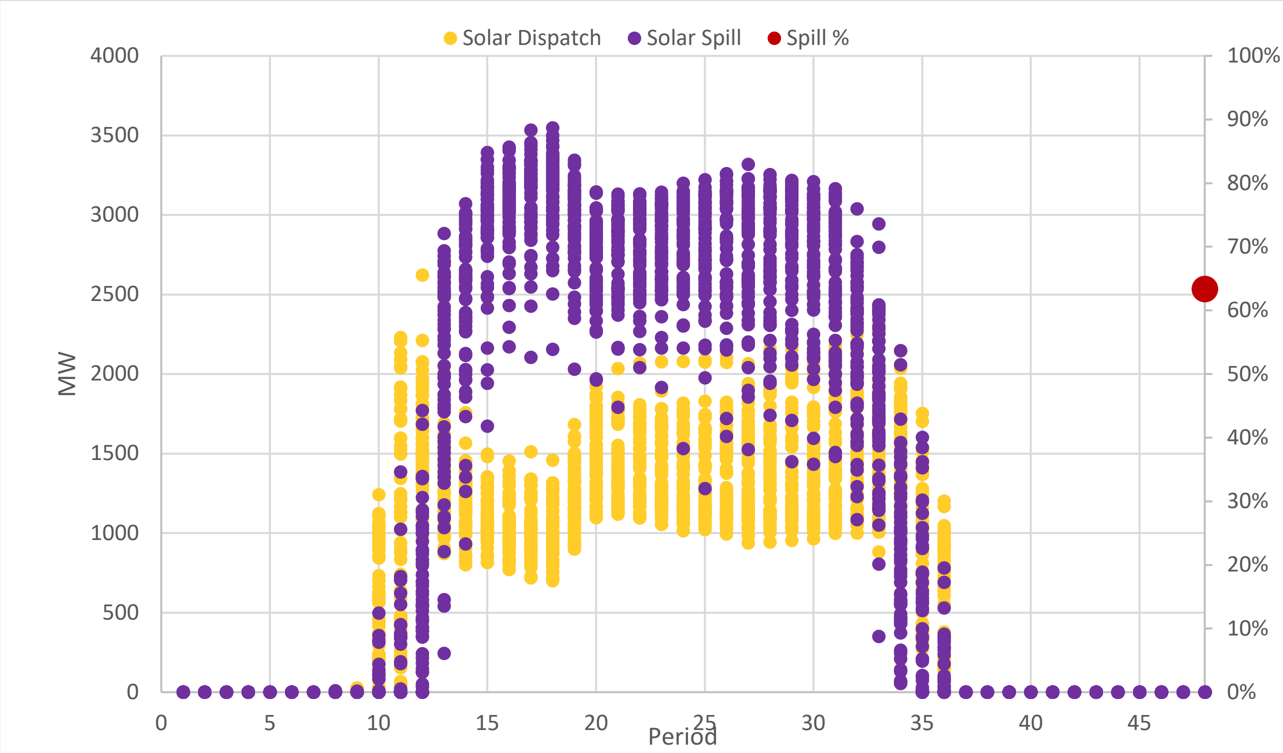

Figure 50: SA coincident solar dispatch and curtailment under sB

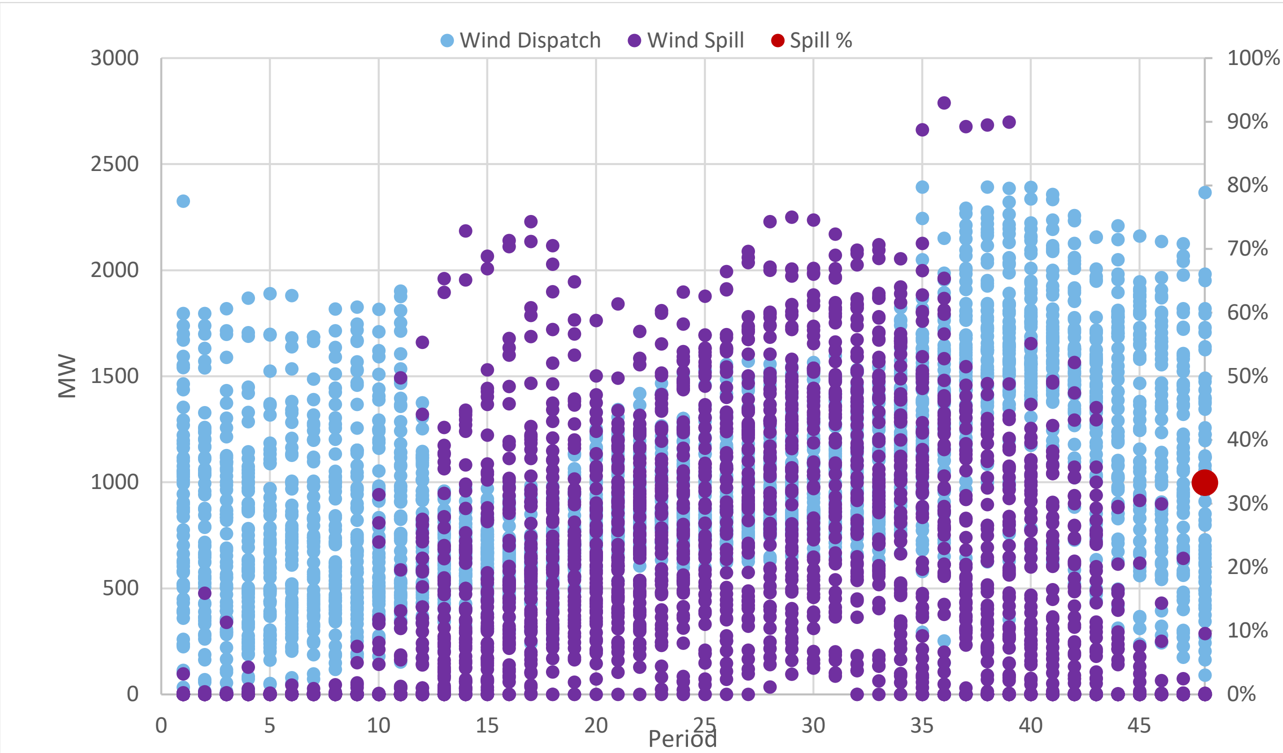

Figure 51: SA coincident wind dispatch and curtailment under sB

2. ADELAIDE details for summer weekdays

Table 48 provides a summary of generating capacity assumptions for Adelaide (ADEL) node

Table 48: ADELAIDE capacity assumptions under sB

ADEL Capacity assumptions	Current [24] (MW)	2030 (MW)	Notes
Gas	2,201	2,394	Capacity factor: 18%
Diesel	22	20	Capacity factor: 2%
Wind	33	667	Capacity factor: 36%, Curtailment 13%
Storage/Other	30	12	Capacity factor: 0%
TOTAL	2,285	3,093	

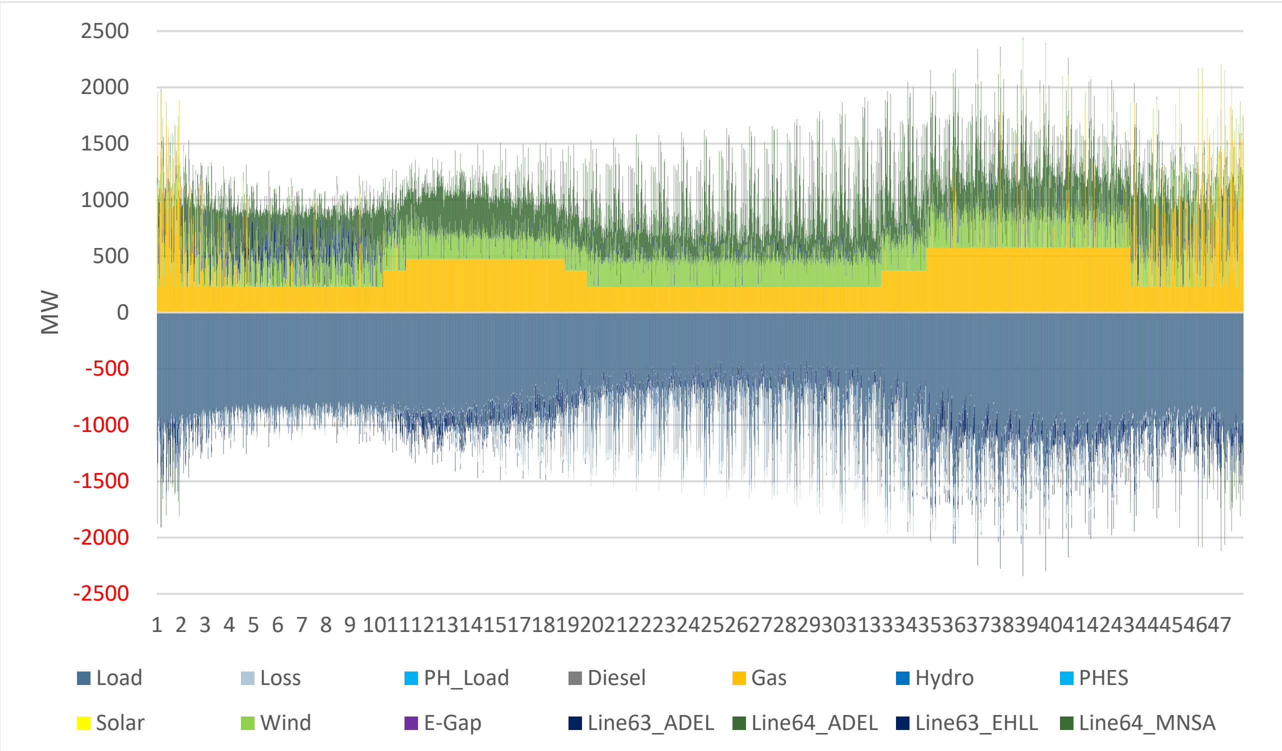

Figure 52: ADELAIDE energy flows for SummWD under sB

Figure 52 provides detail on the flow of energy through ADEL node by time-of-day period by type of supply and demand. Of note:

[24] Source: AEMO Generation Information July 2020

- the dark green coloured series indicates imports from Mid North SA node, where there is significant wind (2,112MW), solar (990MW) and gas (311MW) generation capacity.
- the navy-blue coloured series indicates exports from ADEL node to Eastern Hills node, where there is no generation capacity (1,270MW). Energy flows are small but generally flow onwards from Eastern Hills to South East South Australia and then into SWV node
- the steel-blue coloured series indicates ADEL load
- the gold coloured series indicates generation from gas including Pelican Point (478MW), Quarantine (224MW), New Osborne (180MW), Torrens Island B (800MW) and Dry Creek (156MW). With the quantity of wind and solar available from Mid North SA, gas generators dispatch primarily at morning and evening peak
- the light green coloured series indicates generation from wind (667MW) within the ADEL node. 13% of potential wind generation is curtailed resulting in a capacity factor for SummWD of 36%. Figure 53 shows detail
- E-G in the ADEL node is negligible
- Table 49 details statistics for ADEL energy flows

Table 49: ADELAIDE salient statistics under sB

ADELAIDE Statistics	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(1,407)	(1,168)	(977)	(1,891)	52%	(937)
Gas	622	577	432	2,074	18%	373
Diesel	0	0	0	0	2%	0
Wind	343	266	238	591	36%	240
E-G	0	0	0	12	0%	0
Exports	(120)	(117)	(83)	(950)	9%	(54)
Imports	633	512	440	1,483	30%	409
Wind_spill	52	10	36	453	8%	0
Wind spill %	13%	4%	13%			

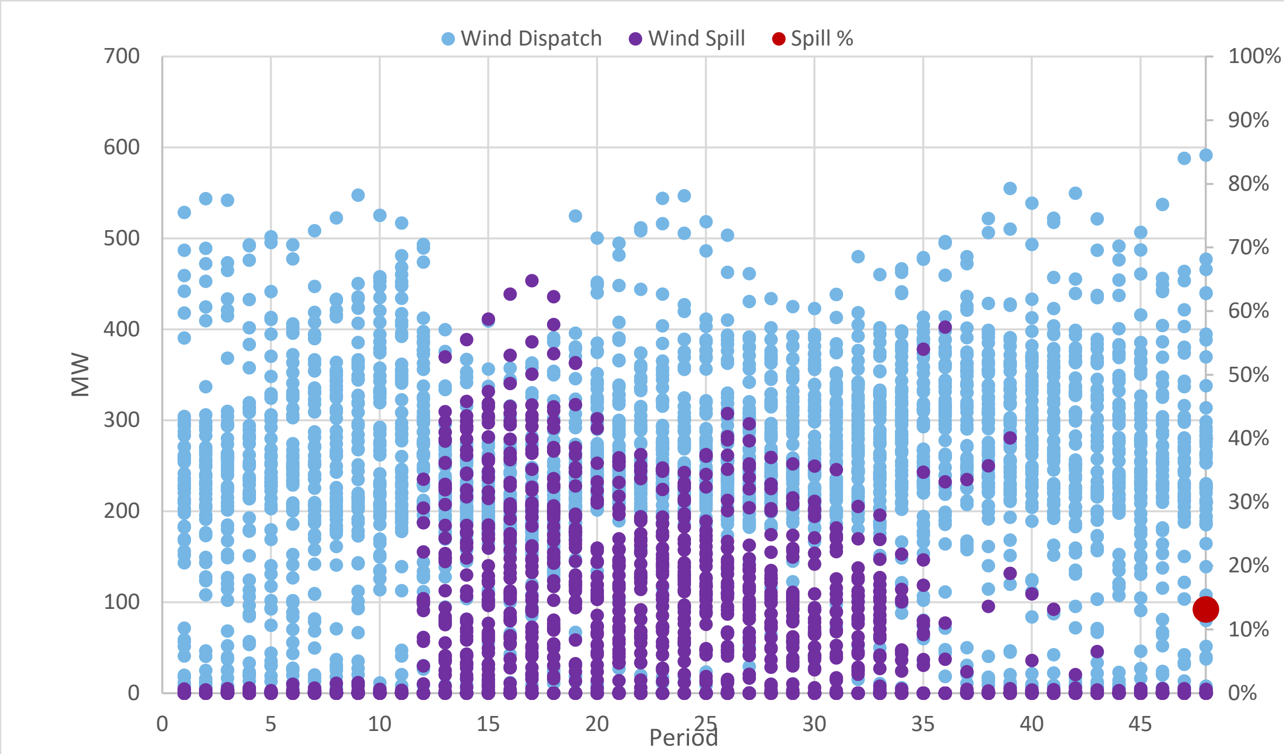

Figure 53: ADELAIDE wind dispatch and curtailment under sB

3. SOUTH EAST SOUTH AUSTRALIA details for summer weekdays

Table 50 provides a summary of generating capacity assumptions for South East South Australia (SESA) node

Table 50: SOUTH EAST SOUTH AUSTRALIA capacity assumptions under sB

SESA Capacity assumptions	Current [25] (MW)	2030 (MW)	Notes
Gas/Diesel	164	143	Capacity factor: 2%
Wind	325	315	CF (full year) 32%, (SummWD) 26%; Curtail (full year) 4% , (SummWD) 2%
Solar	108	363	CF (full year): 35%; (SummWD) Curtail (full year) 19%GWh, (SummWD) 22%
Storage/Other	25	3	Capacity factor: 0%
TOTAL	622	824	

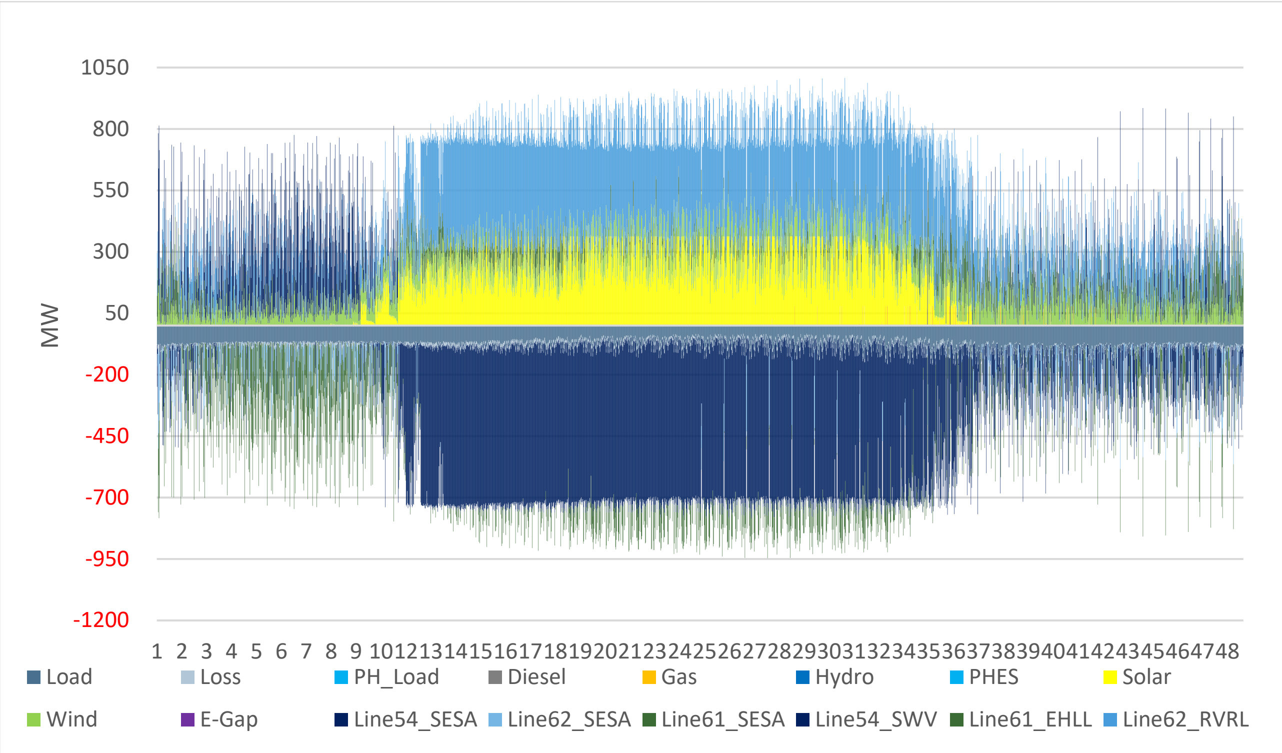

Figure 54: SE SOUTH AUSTRALIA energy flows for SummWD under Sb

Figure 54 provides detail on the flow of energy through SESA node by time-of-day period by type of supply and demand. Of note:

[25] Source: AEMO Generation Information July 2020

- the dark green coloured series indicates exports (mainly) to Eastern Hills node, where there is no generation capacity.
- the navy-blue coloured series indicates exports to SWV node, even though there is 4GW of wind generation capacity in SWV
- the light blue coloured series indicates imports (primarily) from Riverlands node in SA where there is 1,230MW of solar capacity
- the steel-blue coloured series indicates SESA load
- the light green coloured series indicates generation from wind (315MW) within the SESA node. Potential dispatch has CF of 27% during summer (42% in winter and 31% over the year). 2% of potential wind generation is curtailed resulting in a capacity factor for SummWD of 26%. Figure 56 shows detail
- the yellow coloured series indicates generation from solar (363MW) within the SESA node. Potential dispatch has CF of 45% during summer (16% in winter and 31% over the year), but 22% of potential solar generation is curtailed resulting in a capacity factor for SummWD of 35%. Figure 55 shows detail
- E-G in the SESA node is negligible
- Table 51 details statistics for SESA energy flows

Table 51: SOUTH EAST SOUTH AUSTRALIA salient statistics under sB

SESA STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(111)	(92)	(77)	(154)	50%	(73)
Gas	2	5	1	80	2%	0
Diesel	0	0	0	0	2%	0
Solar	184	60	128	363	35%	102
Wind	118	91	82	246	26%	78
E-G	0	0	0	3	0%	0
Exports	(671)	(356)	(466)	(834)	56%	(534)
Imports	529	331	367	692	53%	433
Solar_spill	52	5	36	281	13%	0
Wind_spill	2	3	2	238	1%	0
Solar spill %	22%	8%	22%			
Wind spill %	2%	3%	2%			

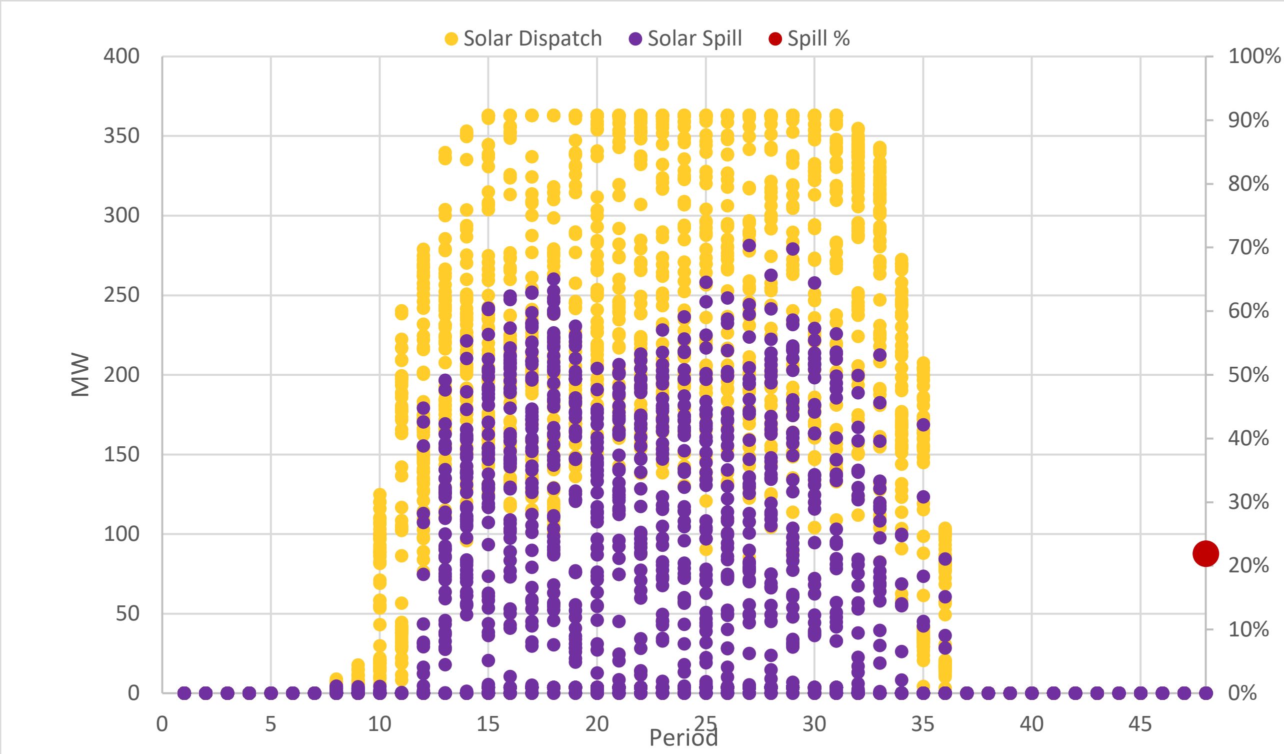

Figure 55: SE SOUTH AUSTRALIA solar dispatch and curtailment under sB

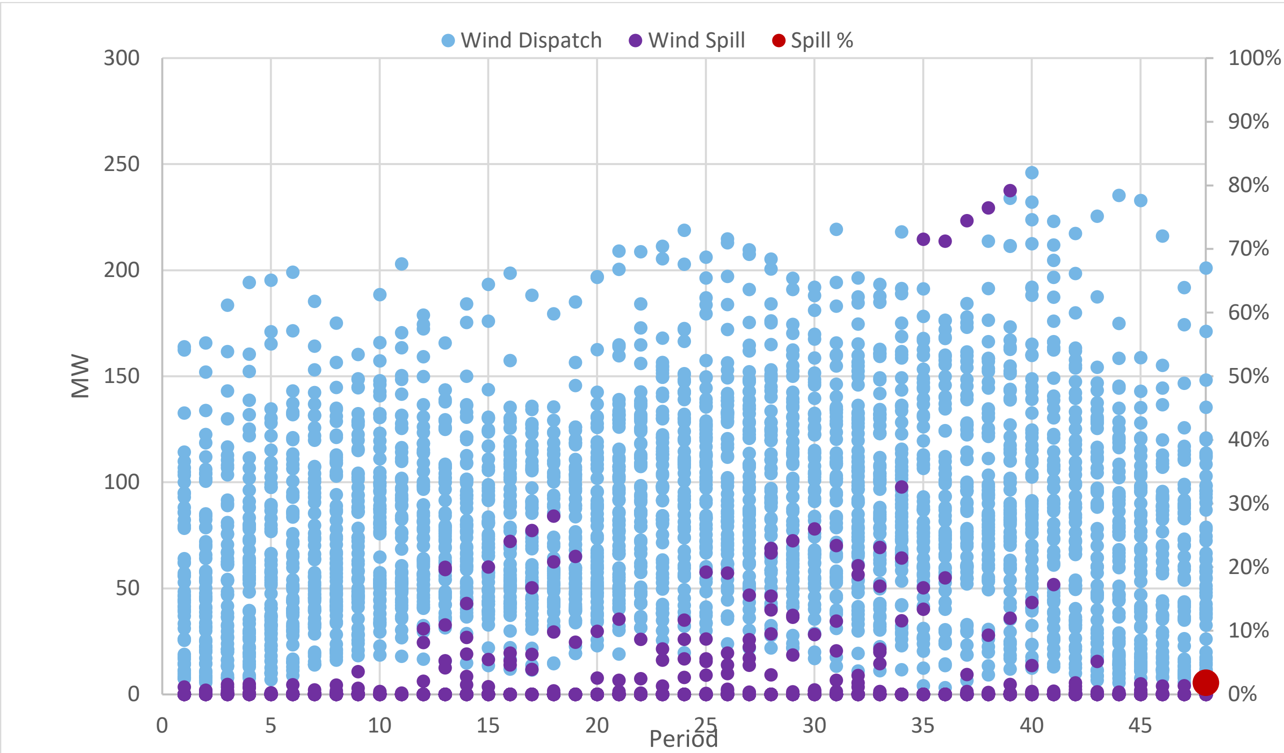

Figure 56: SE SOUTH AUSTRALIA wind dispatch and curtailment under sB

4. MID NORTH SOUTH AUSTRALIA details for summer weekdays

Table 52 provides a summary of the generating capacity assumptions for Mid North South Australia (MNSA) node

Table 52: MID NORTH SOUTH AUSTRALIA capacity assumptions under sB

MNSA Capacity assumptions	Current [26] (MW)	2030 (MW)	Notes
Gas/Diesel	391	361	Capacity factor: -%
Solar	-	990	CF (full year) 15%, (SummWD) 17% Curtail (full year) 54%, (SummWD) 64%
Wind	1,414	2,112	CF (full year) 24%, (SummWD) 23% Curtail (full year) 42%, (SummWD) 48%
Storage/Other	100	245	Capacity factor; 2%
TOTAL	1,905	3,708	

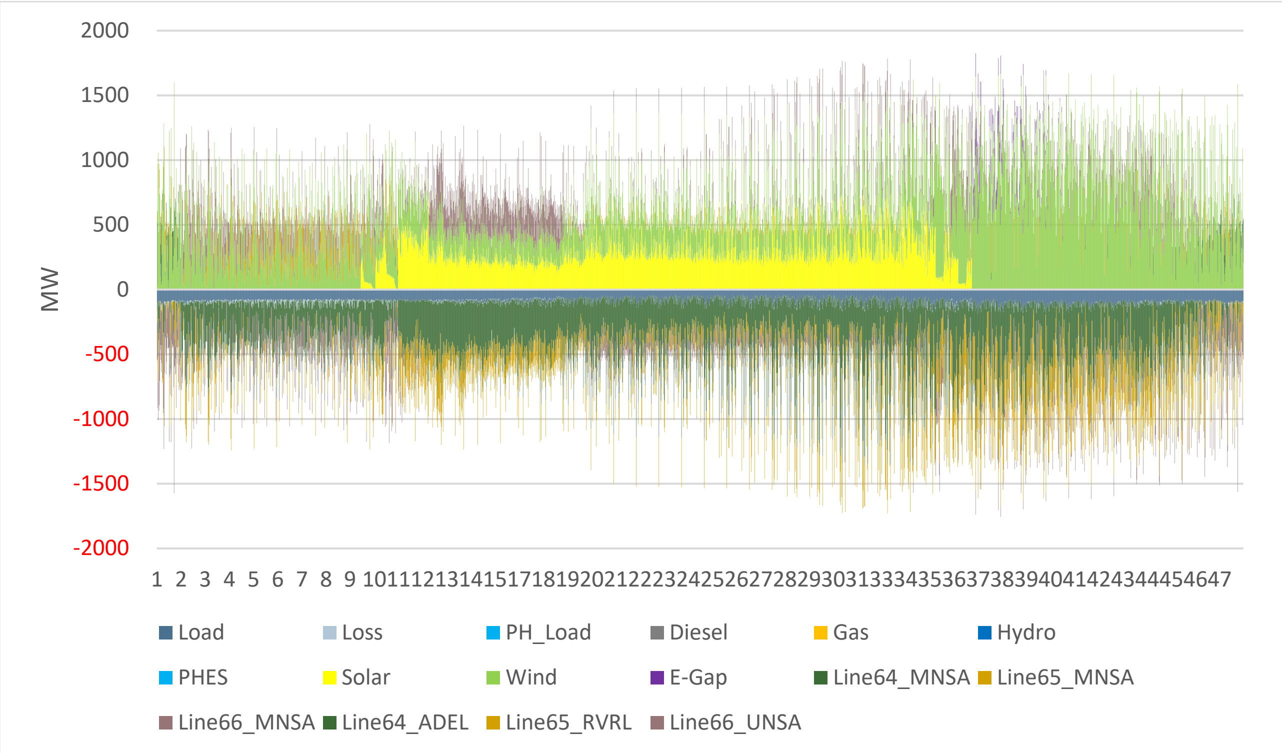

Figure 57: MID NORTH SOUTH AUSTRALIA energy flows for SummWD under sB

Figure 57 provides detail on the flow of energy through MNSA node by time-of-day period by type of supply and demand. Of note:

[26] Source: AEMO Generation Information July 2020

- the dark green coloured series indicates exports (mainly) to ADEL node, the primary load centre
- the dark gold coloured series indicates exports to Riverlands node, even though there is 1.2GW of solar generation capacity in Riverlands. Exports to Riverlands occur primarily during the day (178GWh) with 84GWh exported overnight as Riverlands has no wind generation
- the light brown coloured series indicates exports and imports to and from Upper North SA node in SA where there is 1,270MW of solar, 422MW of wind and 500MW of PHES capacity
- the steel-blue coloured series indicates MNSA load which is modest
- the light green coloured series indicates generation from wind (2,112MW) within the MNSA node. Potential dispatch has CF of 44% during summer (34% in winter and 41% over the year). 48% of potential wind generation is curtailed resulting in a capacity factor for SummWD of 23%. Figure 60 shows detail
- the yellow coloured series indicates generation from solar (990MW) within the MNSA node. Potential dispatch has CF of 46% during summer (18% in winter and 32% over the year). 64% of potential solar generation is curtailed resulting in a capacity factor for SummWD of 17%. Figure 59 shows detail
- E-G in the MNSA node is maximised at 245MW, and is persistent during evening peak, periods 37-41 during SummWD. Figure 58 gives detail

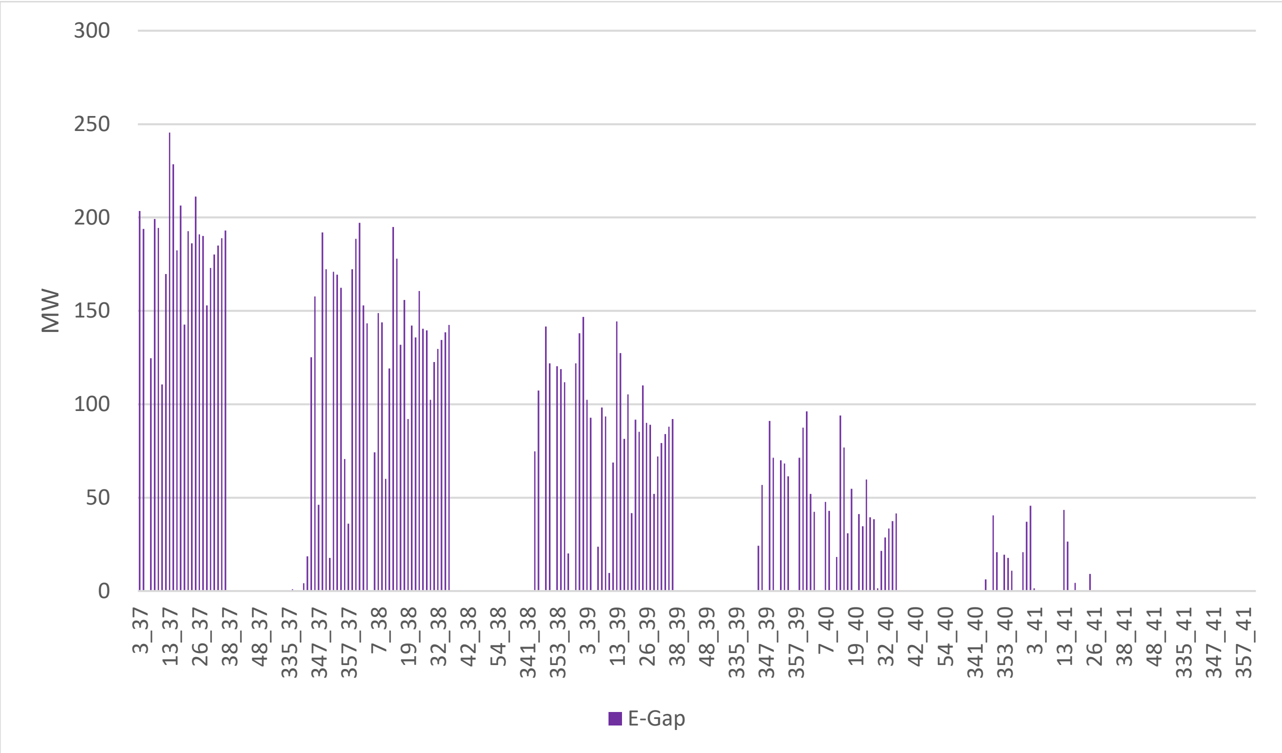

Figure 58: MNSA Energy-Gap during SummWD under sB

- Table 53 details statistics for MNSA energy flows

Table 53: MID NORTH SOUTH AUSTRALIA salient statistics under sB

MNSA Statistics SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(129)	(108)	(90)	(182)	49%	(86)
Gas	0	0	0	3	-%	0
Diesel	0	0	0	0	-%	0
Solar	238	124	166	808	17%	184
Wind	688	788	478	1,670	23%	336
E-G	7	24	5	245	2%	0
Exports	(935)	(867)	(649)	(1,591)	41%	(563)
Imports	195	94	135	659	21%	90
Solar_spill	415	61	288	874	33%	0
Wind_spill	640	621	444	1,927	23%	246
Solar spill %	64%	33%	64%			
Wind spill %	48%	44%	48%			

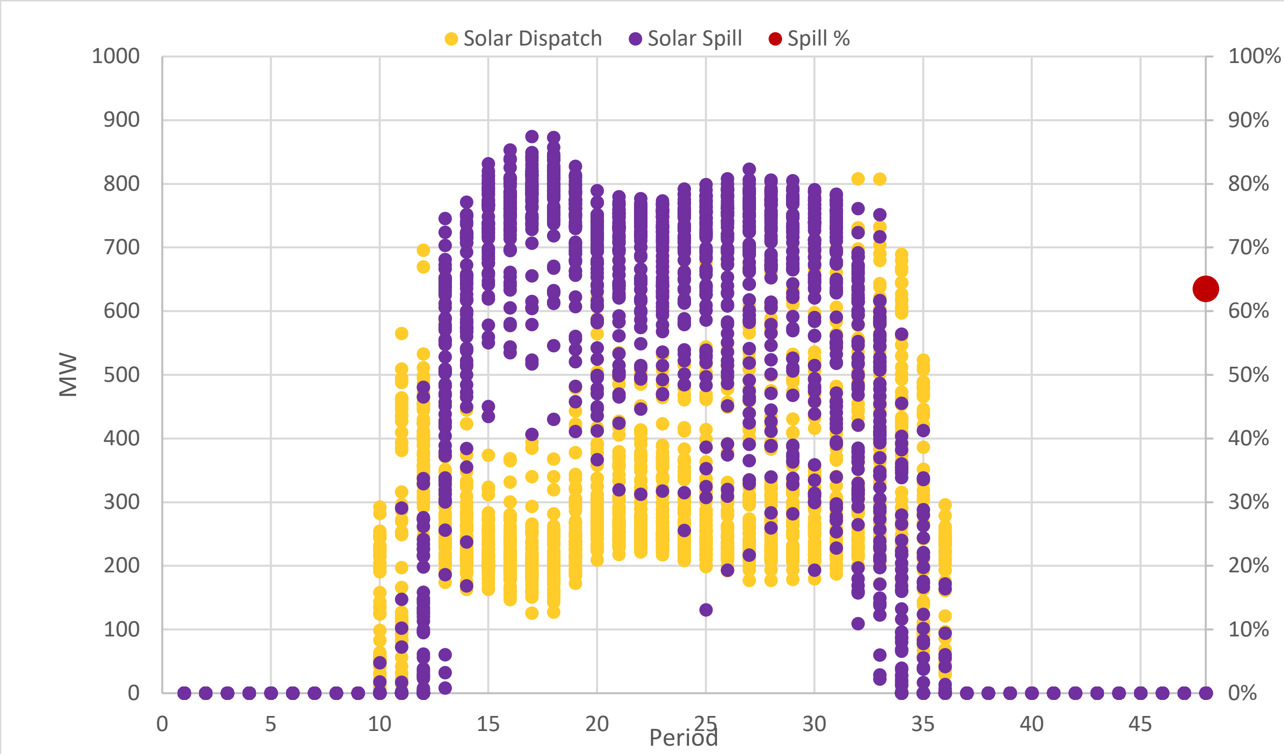

Figure 59: MID NORTH SOUTH AUSTRALIA solar dispatch and curtailment under sB

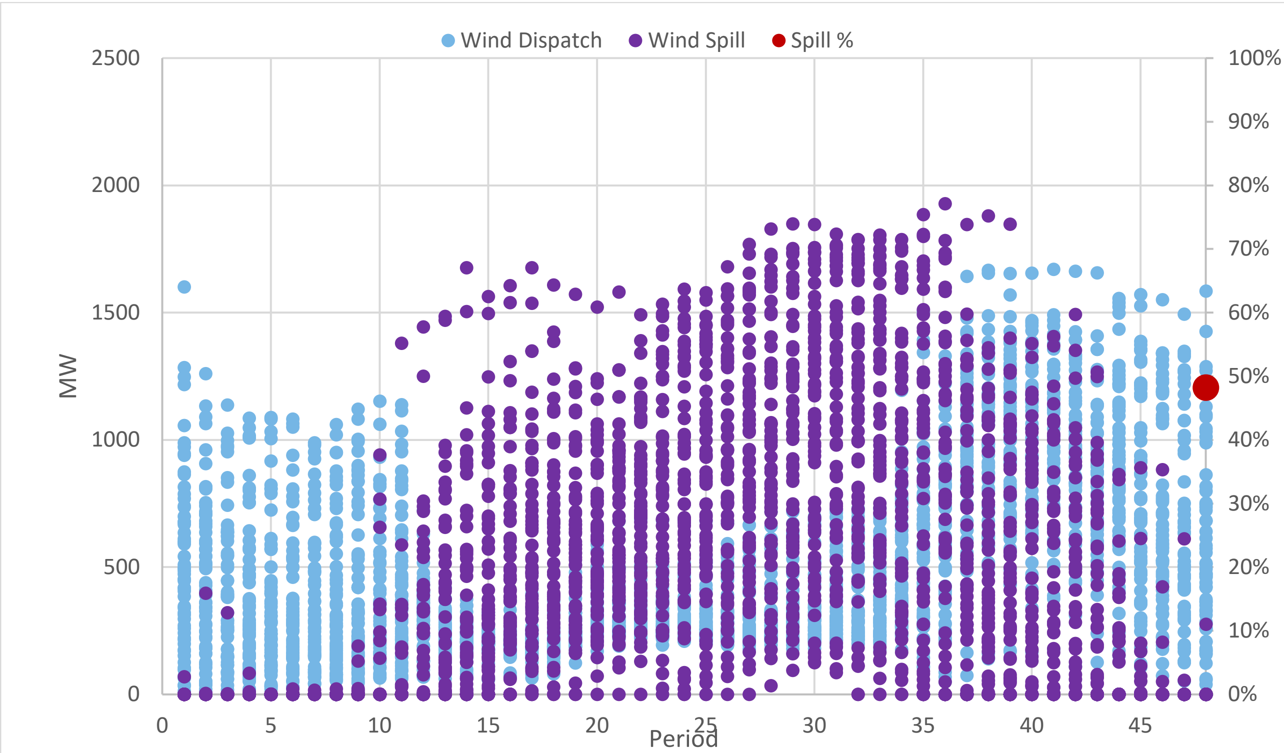

Figure 60: MID NORTH SOUTH AUSTRALIA wind dispatch and curtailment under sB

5. UPPER NORTH SOUTH AUSTRALIA details for summer weekdays

Table 54 provides a summary of generating capacity assumptions for Upper North SA (UNSA) node

Table 54: UPPER NORTH SOUTH AUSTRALI capacity assumptions under sB

UNSA Capacity assumptions	Current [27] (MW)	2030 (MW)	Notes
Solar	135	1,270	Capacity factor: 13%, curtailment: 71%
Wind		422	Capacity factor: 39%; curtailment: 8%
PHES		500	Capacity factor: 3%
Storage/Other		500	Capacity factor: 19%
TOTAL	135	2,692	

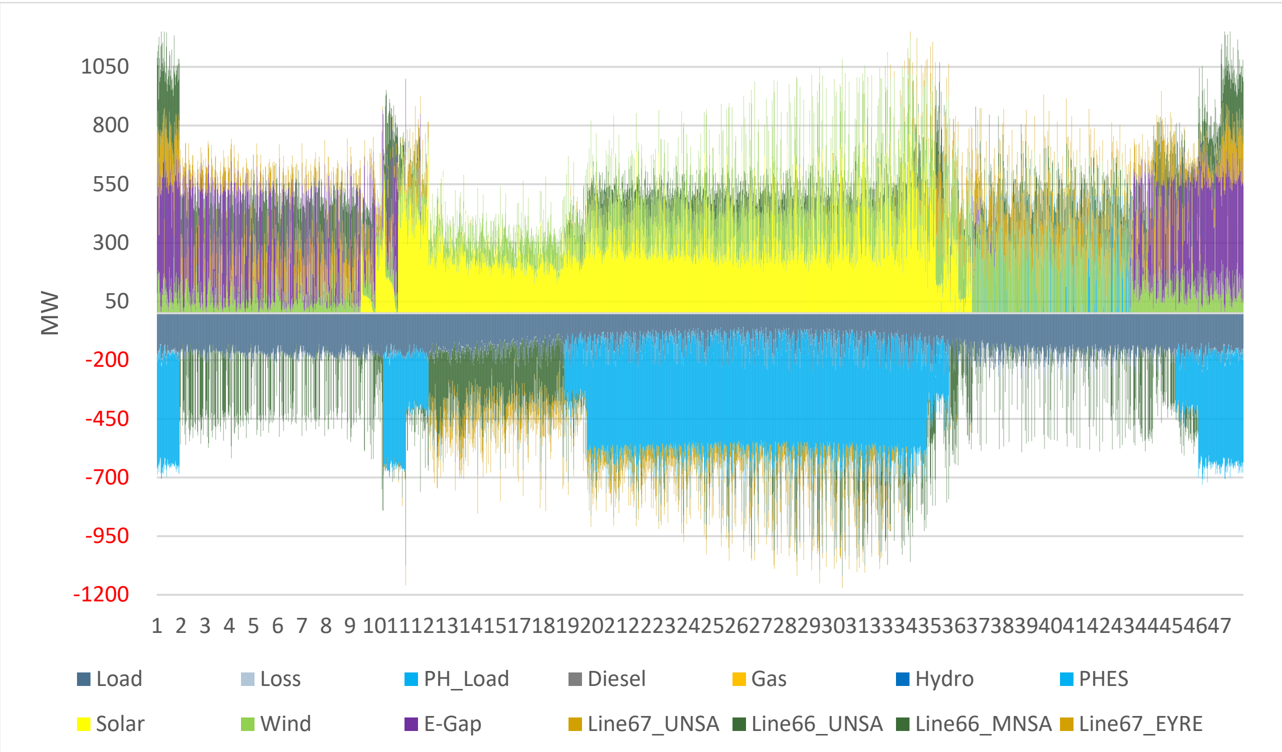

Figure 61: UPPER NORTH SOUTH AUSTRALIA energy flows for SummWD under sB

Figure 61 provides detail on the flow of energy through UNSA node by time-of-day period by type of supply and demand. Of note:

- the dark green coloured series indicates exports and imports between UNSA and MNSA nodes.

[27] Source: AEMO Generation Information July 2020

- the dark gold coloured series indicates imports and exports between UNSA and Eyre Peninsula.
- the light green coloured series indicates wind dispatched from 422MW in UNSA. Curtailment of wind generation is 8% during SummWD, resulting in a capacity factor of 39% for wind generation. Figure 64 shows detail
- the yellow coloured series indicates solar dispatched from 1,270MW in UNSA. Solar dispatch is maximised at 868MW during SummWD which is significantly lower than full capacity, resulting in very high (71%) curtailment of solar in the node from potential dispatch. Figure 63 shows detail.
- the cyan coloured series indicates PHES (500MW) pumping load if negative and dispatch if positive
- UNSA has high levels of solar (1,270MW) and 422MW of wind within the node and MNSA has high levels of solar (990MW) and 2,112MW of wind within its node, resulting in significant transfer between the nodes as resources vary in each node, but also significant curtailment of both wind and solar.
- the steel-blue coloured series indicates UNSA load which is modest at an average of 159MW over SummWD
- there is evidence of a persistent E-G overnight. Figure 62 shows detail. The E-G is, in effect, dispatch from Baroota (250MW) and Goats Hill (250MW) which is outside of the dispatch strategy and assumed to be E-G because dispatch is only possible at high spot price. The associated reason for classifying this dispatch as E-G, is because night-time dispatch would deplete potential for dispatch during morning and evening peak. However, it is apparent that there is a significantly large requirement for supply overnight (due to the lack of solar energy, and unreliable generation from wind) in addition to evening peak. This implies a greater requirement for storage to meet demand overnight. (New version of ANEM, which pumps based on VRE resource and dispatches based on storage, will provide greater clarity with respect to real E-G).

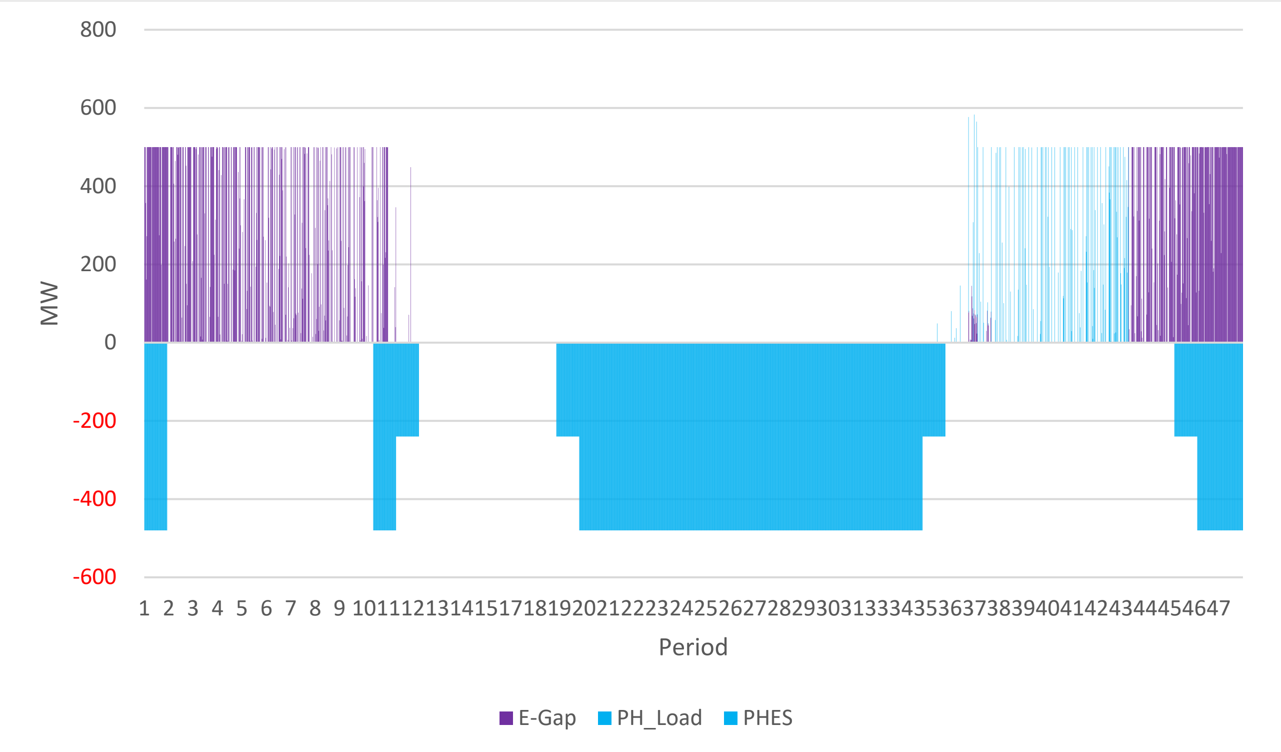

Figure 62: Upper North South Australia Energy-Gap for SummWD under sB

- Table 55 details statistics for UNSA energy flows

Table 55: UPPER NORTH SOUTH AUSTRALIA salient statistics under sB

UNSA STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(223)	(169)	(155)	(283)	55%	(160)
PH_Load	(302)	(120)	(210)	(480)	44%	0
PHES	20	50	14	500	3%	0
Solar	244	134	170	868	13%	185
Wind	238	252	165	422	39%	157
E-G	140	3	97	500	19%	0
Exports	(248)	(207)	(172)	(659)	26%	(167)
Imports	141	62	98	808	12%	81
Solar_spill	593	102	412	1,157	36%	0
Wind_spill	20	23	14	378	4%	0
Solar spill %	71%	43%	71%			
Wind spill %	8%	8%	8%			

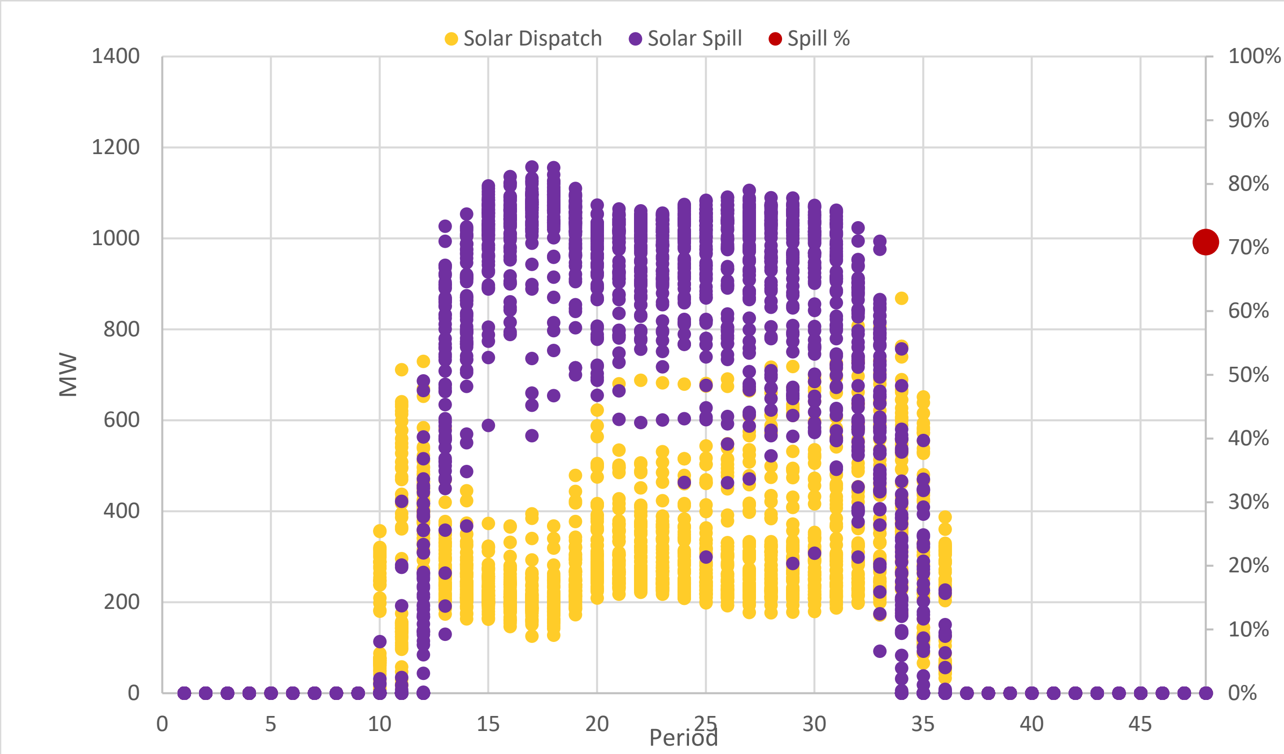

Figure 63: UPPER NORTH SOUTH AUSTRALIA solar dispatch and curtailment under sB

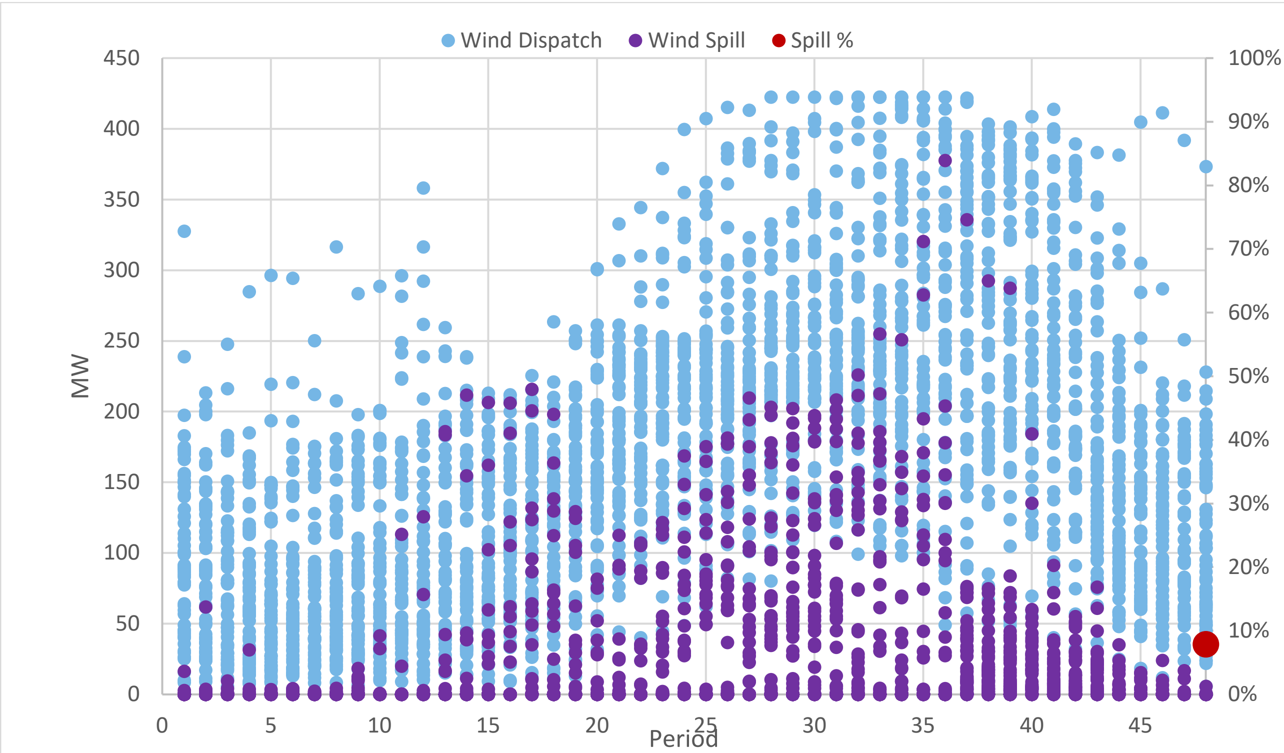

Figure 64: UPPER NORTH SOUTH AUSTRALIA wind dispatch and curtailment under sB

6. RIVERLANDS details for summer weekdays

Table 56 provides a summary of generating capacity assumptions for Riverlands (RVRL) node

Table 56: RIVERLANDS capacity assumptions under sB

RVRL Capacity assumptions	Current [28] (MW)	2030 (MW)	Notes
Solar	-	1,230	Capacity factor: 9%; curtailment: 80%
Storage/Other		101	Capacity factor: 0%
TOTAL	-	1,331	

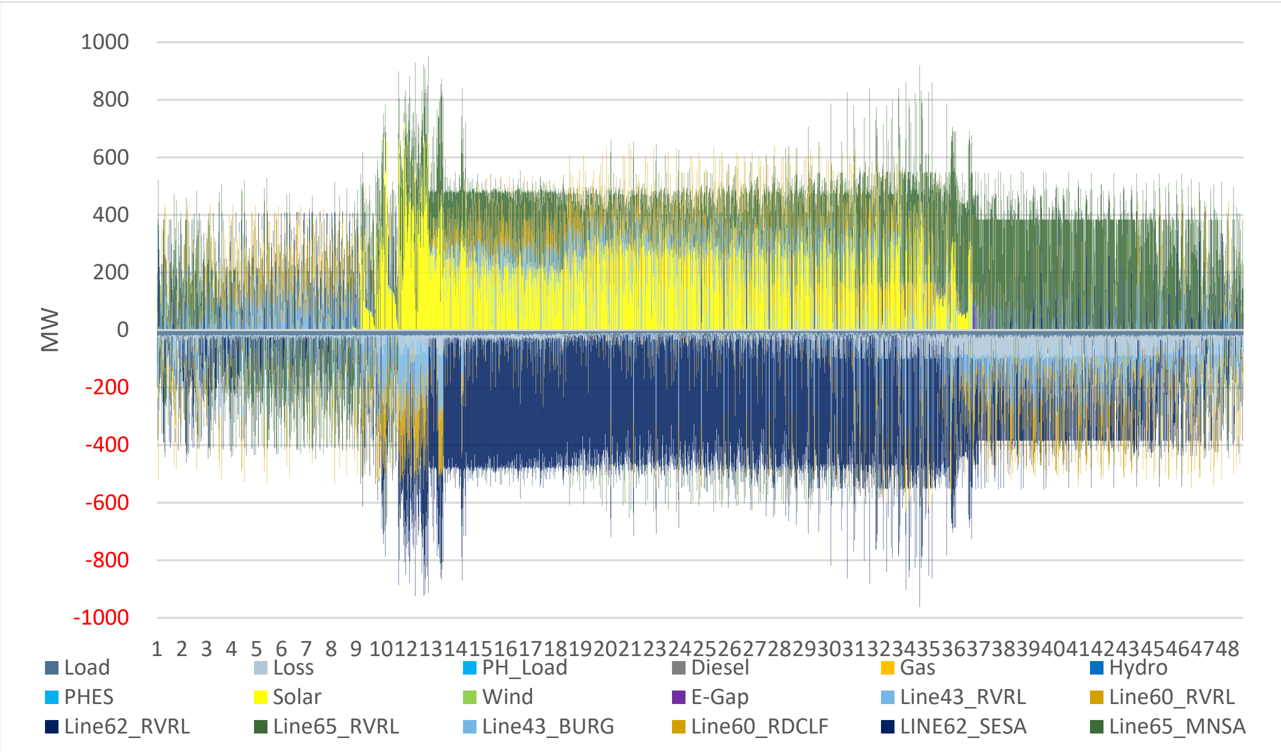

Figure 65: RIVERLANDS energy flows for SummWD under sB

Figure 65 provides detail on the flow of energy through RVRL node by time-of-day period by type of supply and demand. Of note:

- the dark green coloured series indicates exports and imports between RVRL and MNSA nodes.
- the dark gold coloured series indicates imports and exports between RVRL and RDCLF nodes.
- the yellow coloured series indicates solar dispatched from 1,230MW in RVRL. Solar dispatch is maximised at 722MW during SummWD which is significantly lower than full capacity, resulting in very high (80%) curtailment of solar in the node from potential dispatch. Figure 67 shows detail.

[28] Source: AEMO Generation Information July 2020

- the navy blue coloured series indicates exports (primarily) to SESA node
- the light blue coloured series indicates imports and exports between RVRL and Buronga in NSW
- RVRL has 1,273MW of solar within the node, connecting nodes MNSA and RDCLF (VIC) have high levels of solar 990MW and 1000MW respectively in addition to wind capacity of 2112MW in MNSA, resulting in significant surplus capacity during the day for RVRL but also MNSA and RDCLF
- there is evidence of an incidental E-G during evening peak, specifically during period 37. Figure 66 shows detail.

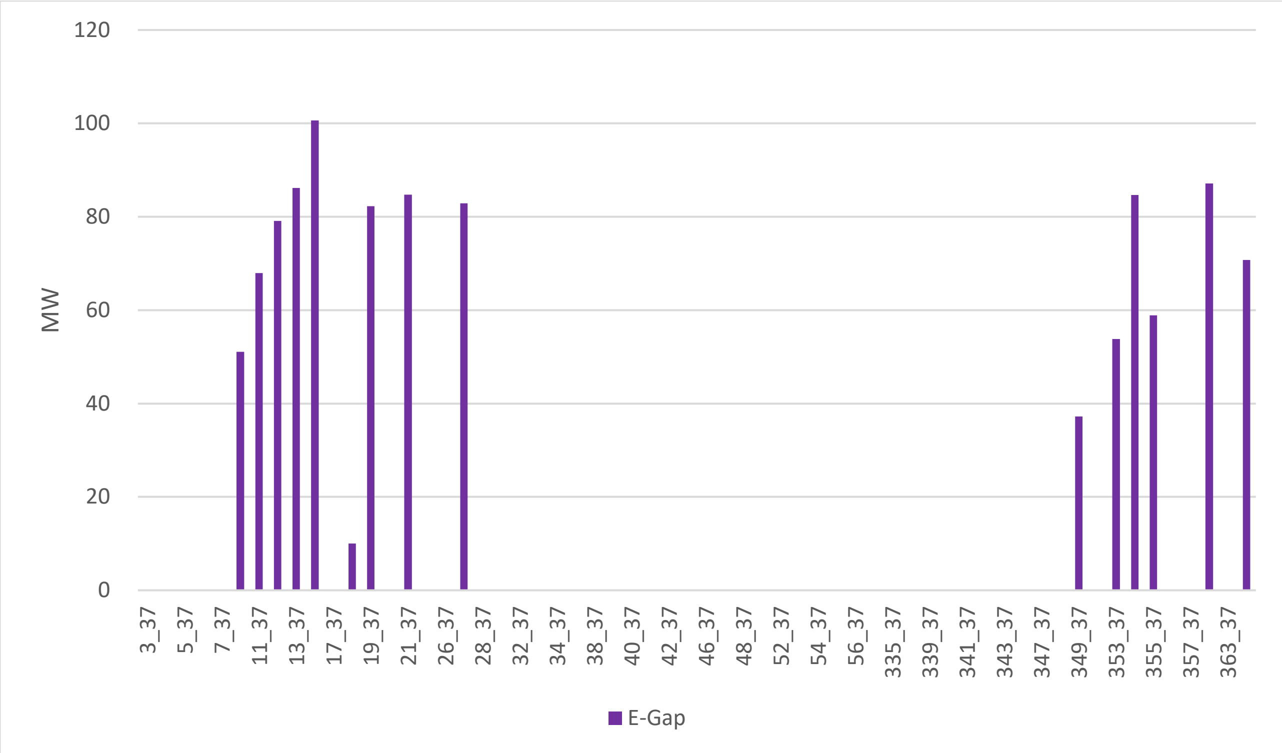

Figure 66: Riverlands Energy Gap during SummWD under sB

- Half of the incidence of E-G is during the Christmas-New Year period. The remaining E-Gs are related to periods of low wind resource in VIC and TAS, 15% and 12% respectively, of nameplate capacity, which result in energy flows away from SA towards VIC.
- Table 57 details statistics for RVRL energy flows

Table 57: RIVERLANDS salient statistics under sB

RVRL SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(27)	(21)	(19)	(36)	52%	(18)
Solar	161	59	112	722	9%	0
E-G	1	2	0	101	0%	0
Exports	(548)	(384)	(381)	(887)	43%	(416)
Imports	448	395	311	567	55%	314
Solar_spill	650	151	452	1,242	36%	25
Solar spill %	80%	72%	80%			

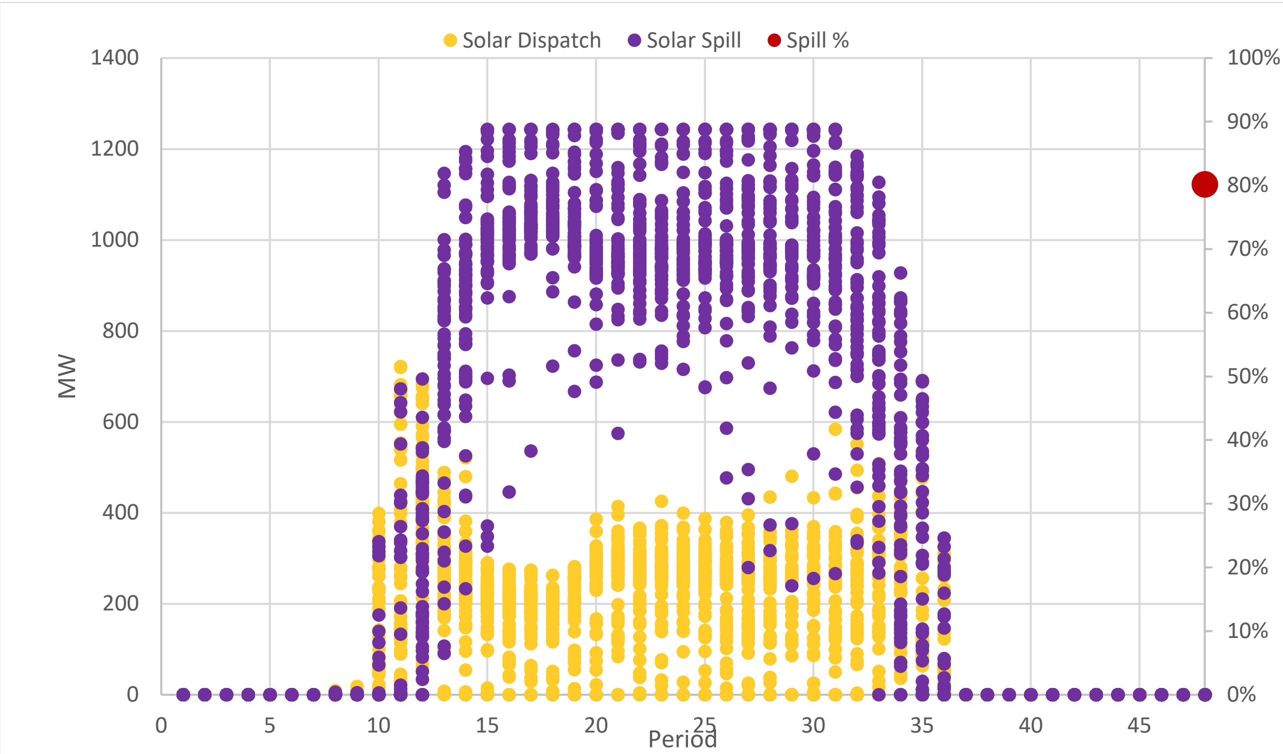

Figure 67: RIVERLANDS solar dispatch and curtailment under sB

7. EYRE PENINSULA details for summer weekdays

Table 58 provides a summary of generating capacity assumptions for Eyre Peninsula (EYRE) node

Table 58: EYRE PENINSULA capacity assumptions under sB

EYRE Capacity assumptions	Current [29] (MW)	2030 (MW)	Notes
Diesel	74	74	Capacity factor: -%
PHES		110	Capacity factor: 3%
Solar		360	CF(full year) 27%, (SummWD) 36% Curtail (full year) 18%, (SummWD) 21%
Wind	136	136	CF (full year) 26%, (SummWD) 26% Curtail (full year) 8%, (SummWD) 4%
Storage/Other		110	Capacity factor: 20%
TOTAL	210	790	

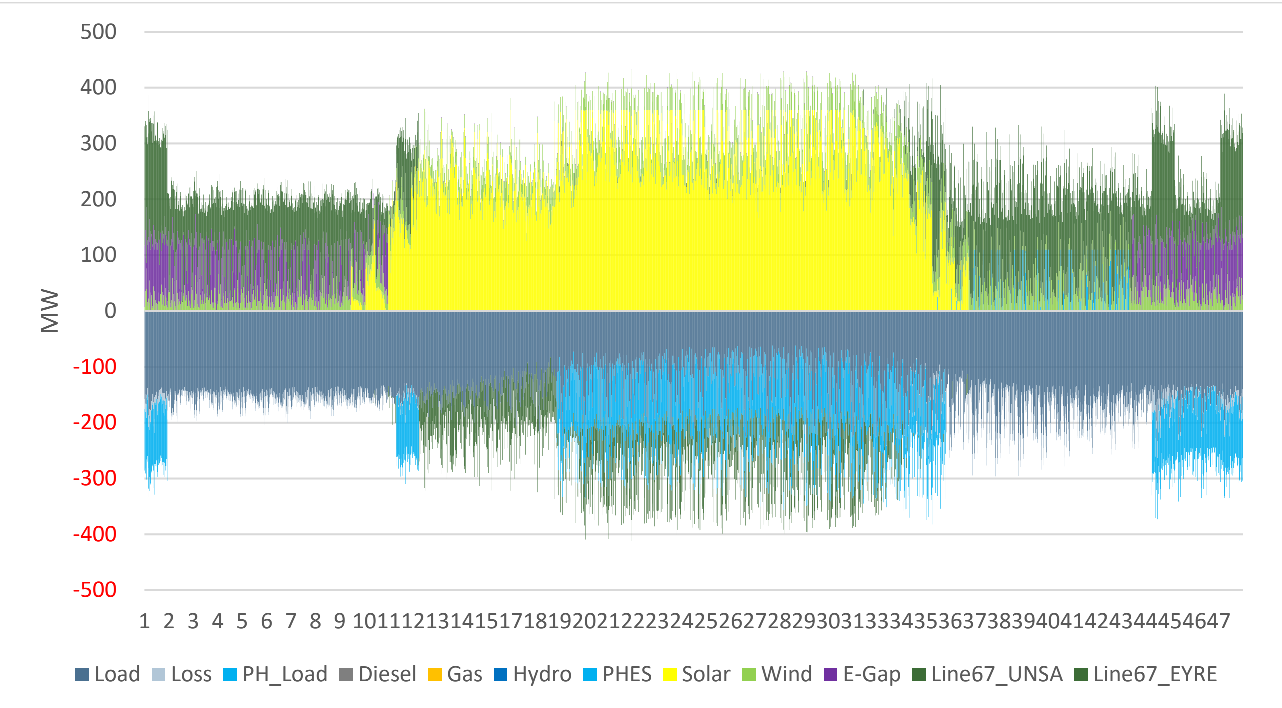

Figure 68: Eyre Peninsula energy flows for SummWD under sB

Figure 68 details the flow of energy through EYRE node by time-of-day period by type of supply and demand. Of note:

[29] Source: AEMO Generation Information July 2020

- EYRE has a single transmission link to UNSA. The dark green coloured series indicates the flow of energy between EYRE and UNSA
- the yellow coloured series indicates solar dispatched from 360MW in EYRE. Potential dispatch has CF of 46% during summer (20% in winter and 33% over the year). With 21% curtailment of potential dispatch, capacity factor for solar dispatch reduces to 37%.
- the steel blue coloured series indicates load in EYRE, in average 148MW
- there is evidence of a persistent E-G after evening peak and before morning peak. Figure 69 shows detail.

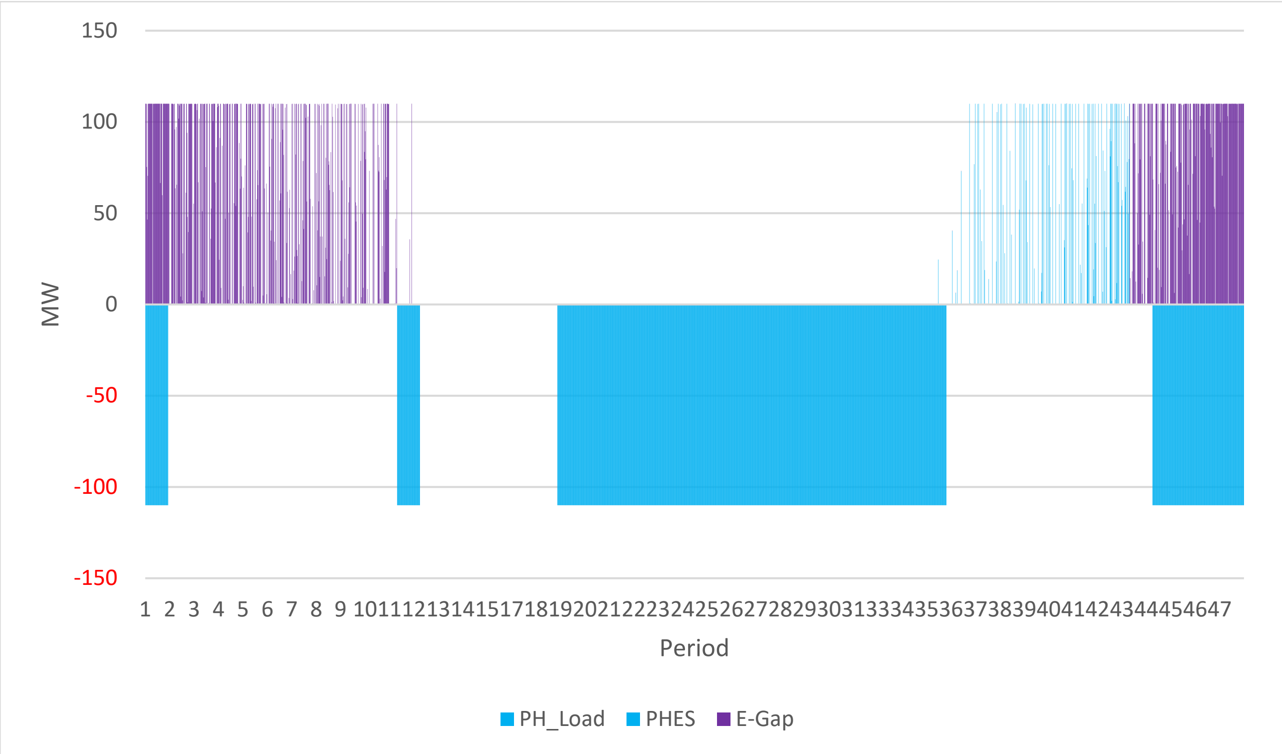

Figure 69: Eyre Peninsula energy-gap for SummWD under sB

Similar to the E-G in UNSA, the E-G in EYRE is, in effect, dispatch from Middleback Ranges (110MW) which is outside of the dispatch strategy and assumed to be E-G because dispatch is only possible at high spot price. The associated reason for classifying this dispatch as E-G, is because night-time dispatch would deplete potential for dispatch during morning and evening peak. However, it is apparent that there is a significantly large requirement for supply overnight (due to the lack of solar energy, and unreliable generation from wind) in addition to evening peak. This implies a greater requirement for storage to meet demand overnight

- Table 59 details statistics for EYRE energy flows

Table 59: EYRE PENINSULA salient statistics under sB

EYRE SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(213)	(167)	(148)	(268)	55%	(148)
PH-Load	(76)	(33)	(53)	(110)	48%	0
Diesel	0	0	0	0	-%	0
PHES	5	12	3	110	3%	0
Solar	189	68	131	360	37%	106
Wind	50	42	35	107	26%	31
E-G	31	0	22	110	20%	0
Exports	(42)	(5)	(29)	(171)	17%	0
Imports	104	124	72	346	21%	56
Solar_spill	49	3	34	236	14%	0
Wind_spill	2	5	1	45	3%	0
Solar spill %	21%	4%	21%			
Wind spill %	4%	10%	4%			

8. CONCLUDING OBSERVATIONS for SA nodal supply-demand balance

There is significant curtailment for both wind and solar in SA, particularly in MNSA, UNSA and Riverlands. Energy Connect augmentation, 800MW of transfer capacity, and only marginal expansion of Heywood interconnection, does not appear to be sufficient to prevent high levels of curtailment in SA. Over the full year, 328GWh of energy flows from NSW to SA compared to 582GWh from SA to NSW. The interconnection results in exports from SA to NSW 57% of the time, and imports from NSW to SA 43% of the time. Energy Connect is providing opportunities for export of SA surplus VRE, but the interconnection is insufficient to avert very high levels of over-supply and curtailment. Consideration should be given to further transmission augmentation to avoid the wholescale curtailment predicted by the modelling.

5. TASMANIA: Nodal Supply-Demand Balance for Summer Weekdays in 2030

a) Pipeline Scenario B

i. TAS Underlying assumptions

- N transmission network
- Direction of Flow loss method estimation
- There will be no coal generation in TAS in 2030. In the other states, coal generation will decline (VIC 3,144MW from 4,775MW; NSW 4,040MW from 10,210MW; QLD 4,839MW from 8,059MW)
- Coal unit closures by 2030 include:
    - QLD: Units 1-2 Callide B; Units 1-2 Stanwell; Units 1-2,5-6 Gladstone; Units 1-2 Tarong;
    - NSW: Units 1-4 Liddell; Units 1-4 Eraring; Units 5-6 Vales Point
    - VIC: Units 1-4 Yallourn
- Gas power in 2030 will remain at current capacity of 372MW in TAS. Gas generation in other states will total NSW 3,048MW; VIC 2,364MW; QLD 2,691MW; SA 2,368MW
- Wind power in 2030 will reach 2,302MW in TAS (SA 3,652MW; VIC 8,470MW: NSW 5,671MW; QLD 4,820MW;)
- There will be little solar power in 2030 in TAS (SA 4,213MW, VIC 2,141MW; NSW 8,021MW; QLD 8,736MW)
- Transmission augmentation assumed stage 1 of battery of the nation – 750MW line from Burnie (TAS) to HAZL (VIC)
- Table 61 provides a summary of generating capacity assumptions for TAS

ii. TAS ANEM nodal structure for sB

Figure 70 provides a graphic representation of the generation capacity at each node and transmission corridors between each node in Tasmania, for the ANEM model to balance supply and demand for each of 17520 periods in the given year.

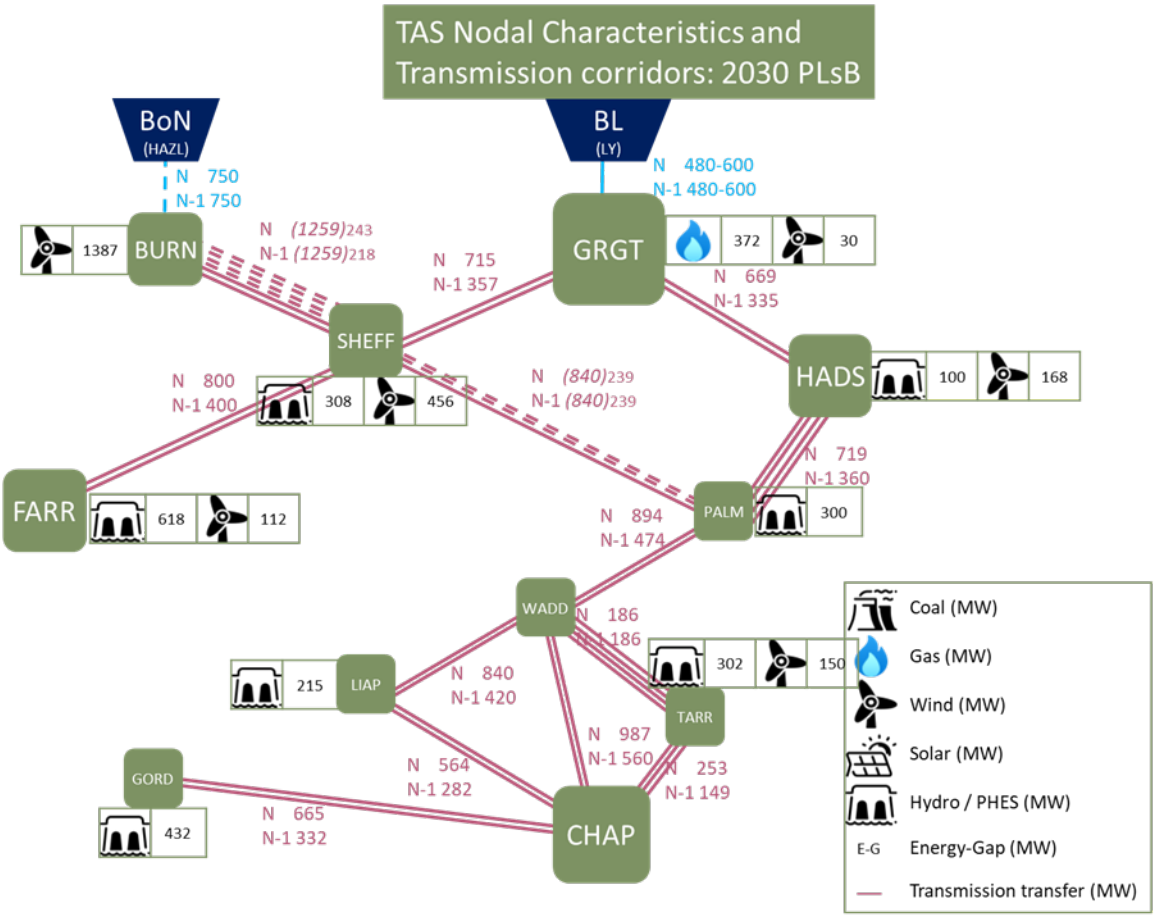

Figure 70: TAS ANEM nodal structure for sB

iii. TAS ANEM transmission corridors for sB

Table 60 provides a summary of the ANEM network transmission corridors used to determine intra-regional and inter-state trade (by reactance and thermal ratings) for co-optimisation of Optimal Power Flow (OPF) and competitive dispatch of identified generation.

Table 60: TAS ANEM transmission corridors for sB

Nodes	Transmission routes	N (MW)	N-1 (MW)
GRGT – SHEFF	2 X 220kV	715	357
GRGT - HADS	2 X 220kV	669	335
SHEFF - BURN	***(Battery of the Nation augmentation, 2 x 220kV)*** 2 X 220kV	***(1259)*** 243	***(1259)*** 218
SHEFF - FARR	2 X 220kV	800	400
SHEFF - PALM	***(Battery of the Nation augmentation)*** 2 X 198kV	***(840)*** 239	***(840)*** 239
HADS - PALM	2 X 220kV	719	360
PALM - WADD	2 X 220kV	894	474
WADD - LIAP	2 X 220kV	840	420
WADD - TARR	Waddamana-LakeEcho-Tungatinah-Tarraleah	186	186
WADD - CHAP	Waddamana-Lindisfarme Waddamana-Bridgewater	987	560
LIAP - CHAP	2 X 220kV	564	282
TARR - CHAP	Tarraleah – N.Norfolk Meadowbank – N.Norfolk	253	149
CHAP - GORD	2 X 220kV	665	332
Interconnection			
HAZL - BURN	***(Battery of the Nation Stage 2 – ISP 2040C only)*** ***Battery of the Nation Stage 1***	***(1500)*** ***(750)***	***(1500)*** ***(750)***
LY - GRGT	Basslink	480-600	480-600

iv. TAS ANEM generation capacity assumptions for sB

Table 61: TASMANIA capacity assumptions under sB

TAS Capacity assumptions	Current [30] (MW)	2030 (MW)	Notes
Gas	386	372	Capacity factor: 19% (full year); 20% (Summ WD)
Hydro	2,289	2,275	Capacity factor: 32% (full year); 32% (Summ WD)
Wind	573	2,302	Capacity factor: 39% (full year); 31% (Summ WD) Curtailment: 5%, Max curtailment 885MW
Storage/Other	7	65	Capacity factor: 0%
TOTAL	3,255	5,014	

v. TAS modelling outcomes for Summer Weekdays in 2030

1. TAS Fuel share (Summer Weekdays)

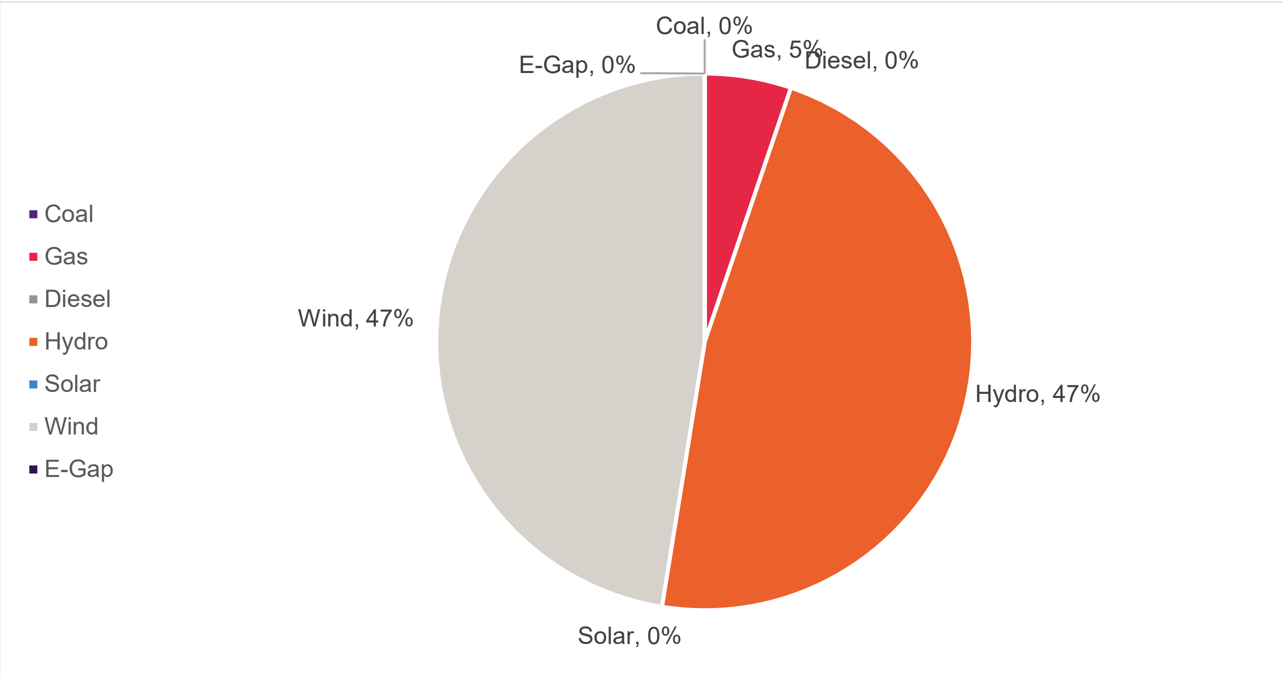

Figure 71: TAS fuel share during SummerWD under sB

Modelling outcomes predict that 47% of electricity generated in TAS in 2030 is sourced from hydro, 47% from wind, and 5% from gas as shown in Figure 71. There is a negligible E-G.

[30] Source: AEMO Generation Information July 2020

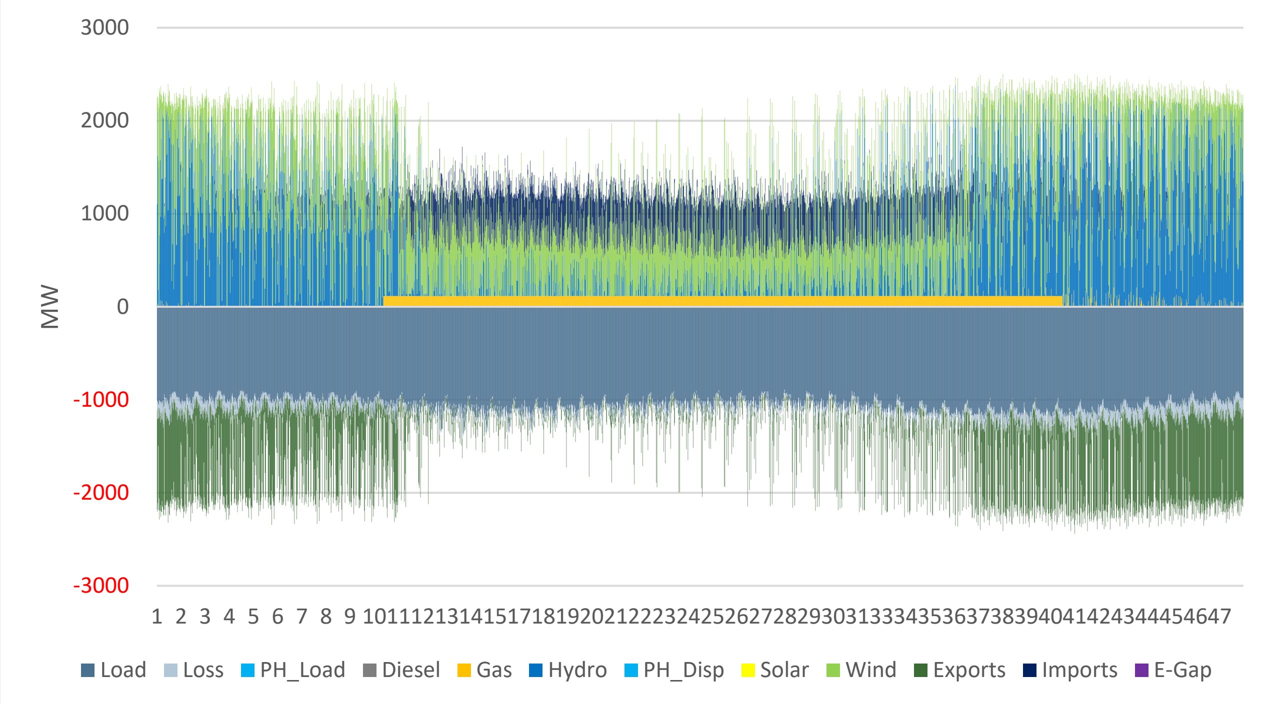

Figure 72: TAS energy flows for SummWD under sB

Figure 72 provides detail on the flow of energy through TAS by time-period according to source. Of note:

- the dark green coloured series indicates exports to VIC which are greatly reduced during sunlight hour, increasing from evening peak through to morning peak
- the navy blue coloured series indicates imports from VIC which are relatively small and predominantly during daylight hours
- the gold coloured series indicates gas generation within TAS from capacity of 372MW which tends to dispatch from morning to evening peak
- the royal blue coloured series indicates hydro generation within TAS from capacity of 2275MW which dispatches predominantly from evening peak through to morning peak with significantly reduced dispatch during sunlight hours
- the light green coloured series indicates wind generation from 2.3GW of capacity, which achieves a capacity factor of 31% with a 5% curtailment. Further detail can be seen in Figure 73
- the grey-blue coloured series indicates TAS load
- the purple coloured series indicates E-G which is negligible throughout all nodes in TAS.

Table 62 provides totals and averages of the summer weekday energy flows. Wind and hydro generate equal shares of total TAS supply with gas contributing a 5% share. Wind resource is fair and only 5% curtailed due to oversupply.

Table 62: TASMANIA salient statistics under sB

TASMANIA SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(1,532)	(1,126)	(1,064)	(1,372)	78%	(1,059)
Gas	109	98	76	237	20%	115
Hydro	992	926	689	2,146	32%	374
Wind	994	702	690	2,230	31%	566
E-G	0	0	0	4	0%	0
Exports	(633)	(564)	(440)	(1,235)	36%	(233)
Imports	285	130	198	577	34%	19
Wind_spill	55	5	38	885	4%	1
Wind spill %	5%	1%	5%			

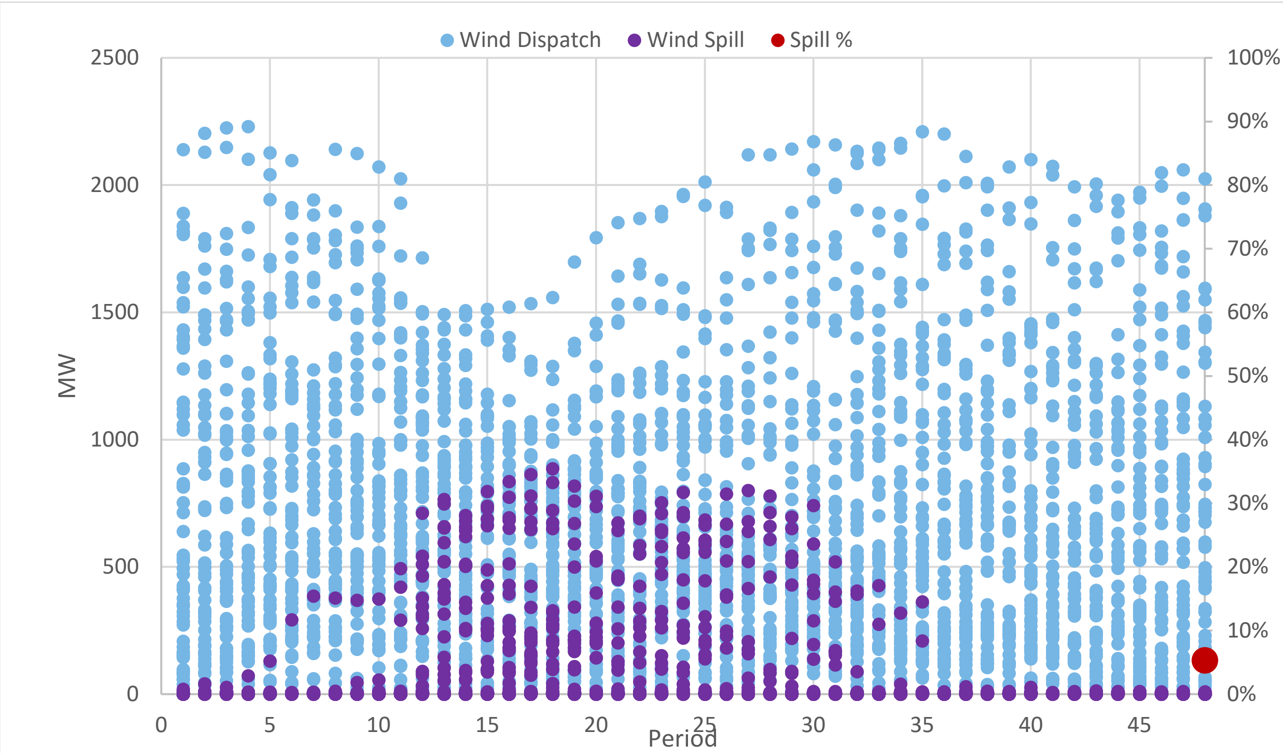

Figure 73: TAS coincident wind dispatch and curtailment under sB

2. GEORGETOWN details for summer weekdays

Table 63 provides a summary of generating capacity assumptions for GeorgeTown (GT) node

Table 63: GEORGETOWN capacity assumptions under sB

GT Capacity assumptions	Current [31] (MW)	2030 (MW)	Notes
Gas	386	372	Capacity factor: 20%
Wind		30	Capacity factor: 27%
Storage/Other		-	
TOTAL	386	402	

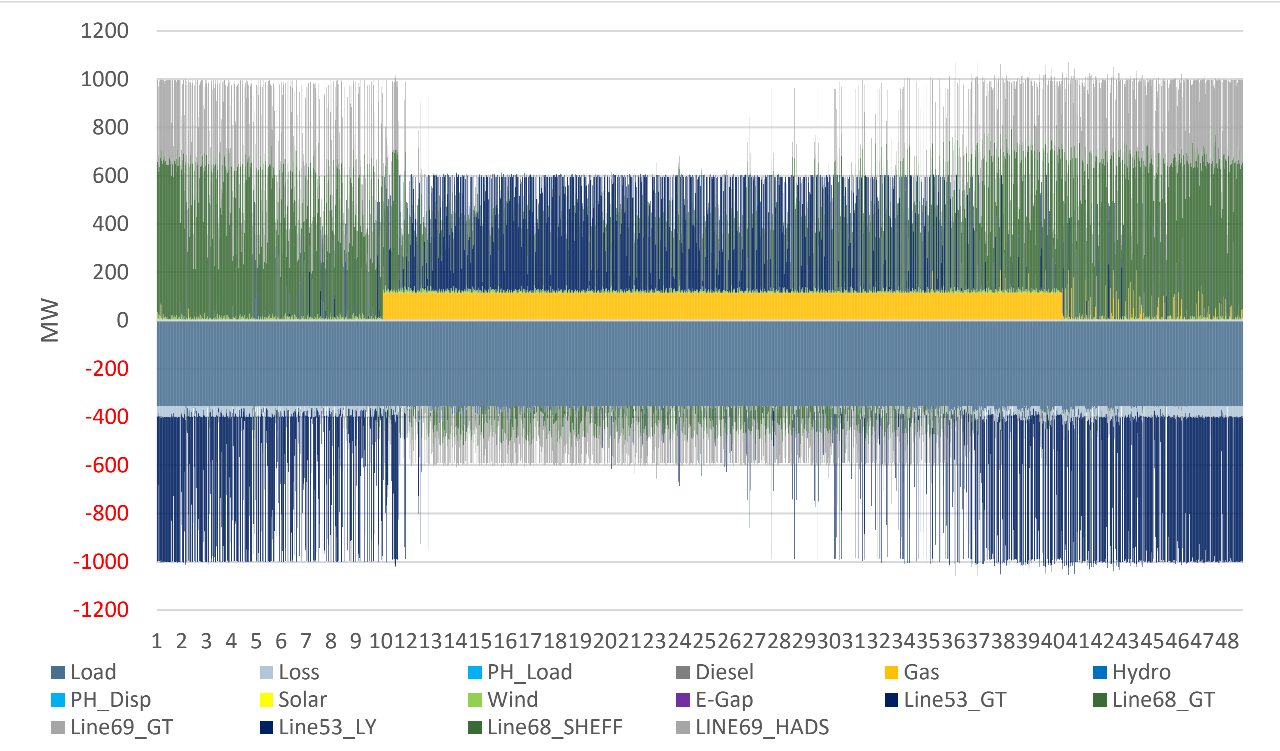

Figure 74: GEORGETOWN energy flows for SummWD under sB

Figure 74 provides detail on the flow of energy through GT by time-period according to source. Of note:

- the dark green coloured series indicates imports from Sheffield to the west which has wind (456MW) and hydro (308MW) capacity
- the navy blue coloured series indicates imports-exports from VIC. Imports tend to occur during the day whilst exports are predominantly overnight

[31] Source: AEMO Generation Information July 2020

- the light grey coloured series indicates imports-exports from Hadspen to the south-east of GT. Imports tend to occur overnight and exports during the day
- the light green coloured series indicates wind generation in GT. Generation capacity is only 30MW, so it is obscured in the details of Figure 74. Details of dispatch and curtailment can be found in Figure 75
- the gold coloured series indicates gas generation from Bell Bay and Tamar Valley GT within GT from capacity of 372MW which tends to dispatch from morning to the end of evening peak
- the steel-blue coloured series indicates GT load, at an average of 360MW
- there is no E-G

Table 64 details statistics for GT energy flows

Table 64: GEORGETOWN salient statistics under sB

GT SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(518)	(365)	(360)	(435)	83%	(355)
Gas	109	98	76	237	20%	115
Wind	12	7	8	30	27%	7
E-G	0	0	0	0	6%	0
Exports	(453)	(364)	(315)	(600)	52%	(237)
Imports	871	641	605	1,037	58%	480
Wind_spill	1	1	1	5	20%	0
Wind spill %	11%	13%	11%			

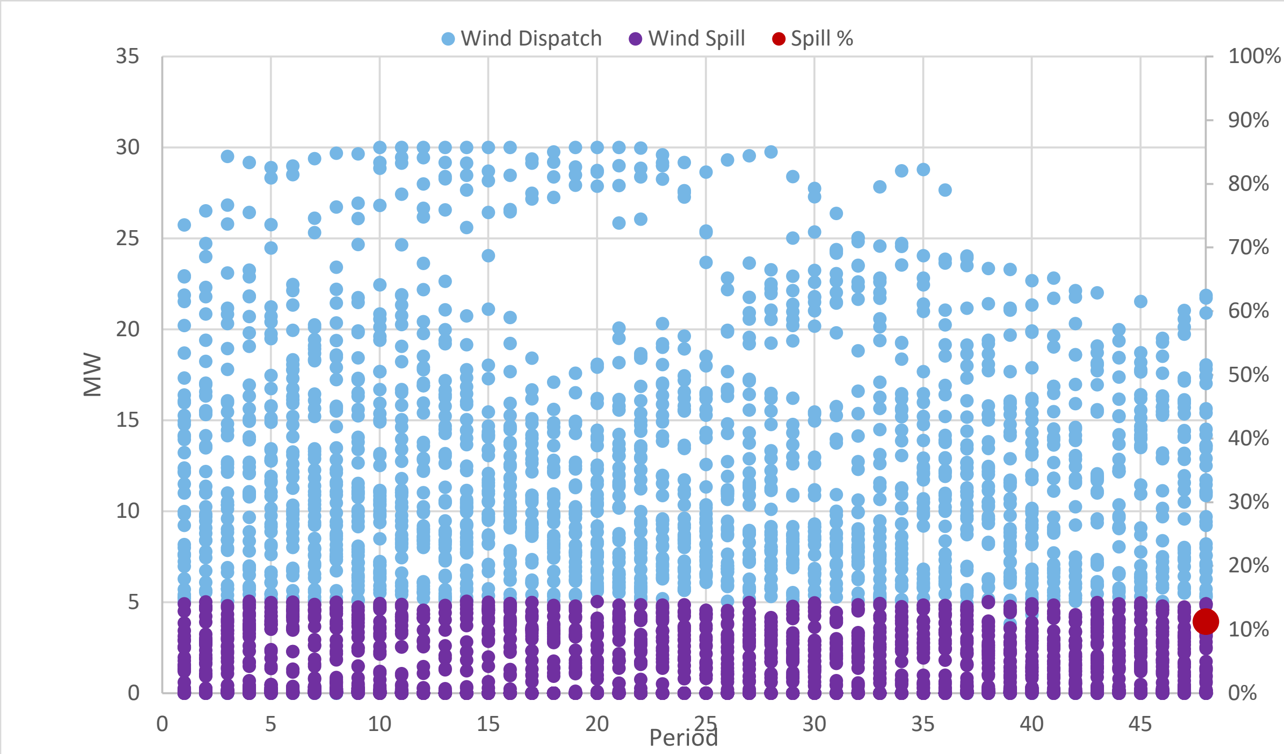

Figure 75: GEORGETOWN wind dispatch and curtailment under sB

3. CHAPEL STREET details for summer weekdays

Table 65 provides a summary of generating capacity assumptions for Chapel Street (CHAP) node

Table 65: CHAPEL STREET capacity assumptions under sB

CHAP Capacity assumptions	Current [32] (MW)	2030 (MW)	Notes
Gas		-	
Wind		-	
Storage/Other		-	
TOTAL	-	-	Load only node

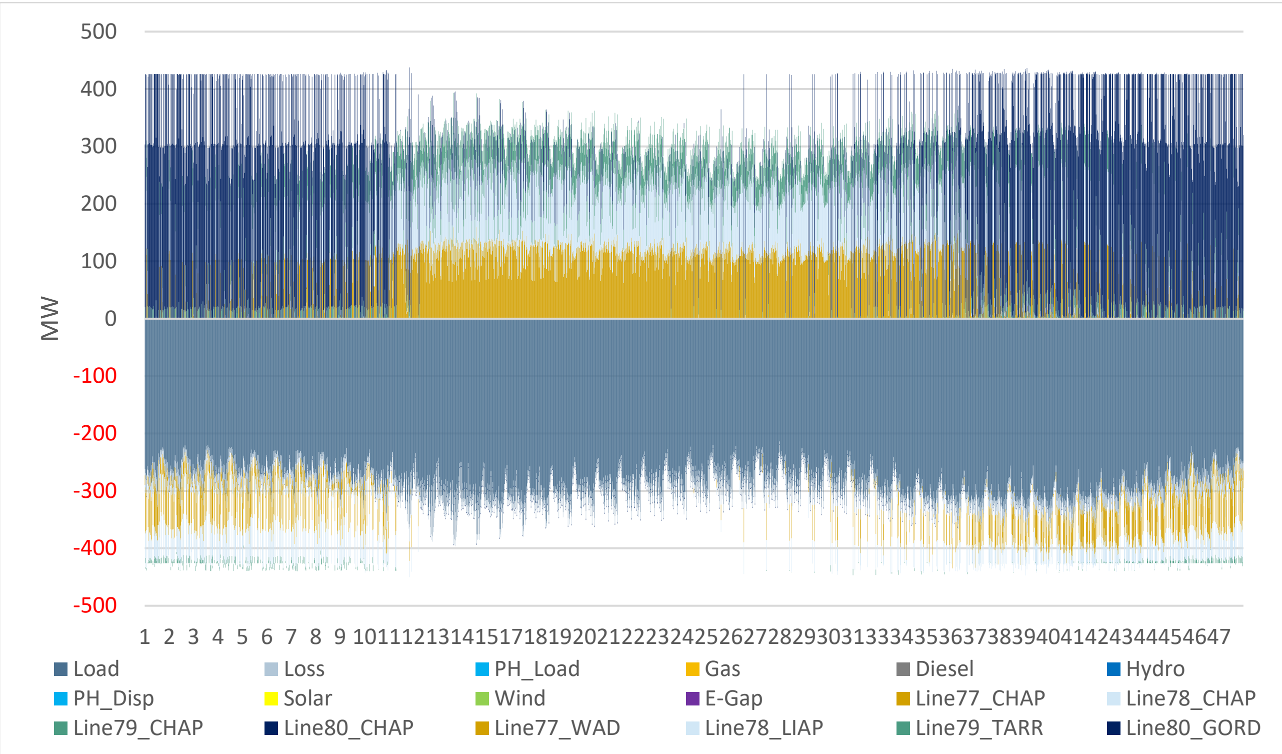

Figure 76: CHAPEL STREET energy flows for SummWD under sB

CHAP is the demand centre for Hobart. Figure 76 provides detail on the flow of energy through CHAP by time-period according to source. Of note:

- the navy blue coloured series indicates imports from GORDON to the west which has 432MW of hydro capacity

[32] Source: AEMO Generation Information July 2020

- the dark gold coloured series indicates imports-exports from Wadamanna to the north and ultimately GT. Imports tend to occur during the day whilst exports are predominantly overnight
- the blue-green coloured series indicates imports-exports from Tarralea to the north
- the light blue coloured series indicates imports-exports from Liapootah which has 215MW of hydro capacity
- the steel-blue coloured series indicates CHAP load, at an average of 286MW
- there is no E-G

Table 66 details statistics for CHAP energy flows

Table 66: CHAPEL STREET salient statistics under sB

CHAP SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(412)	(309)	(286)	(386)	74%	(286)
Hydro	0	0	0	0	0%	0
Wind	0	0	0	0	0%	0
E-G	0	0	0	0	0%	0
Exports	(48)	(34)	(33)	(188)	18%	(2)
Imports	477	356	331	438	76%	313

4. BURNIE details for summer weekdays

Table 67 provides a summary of generating capacity assumptions for Burnie (BURN) node

Table 67: BURNIE capacity assumptions under sB

BURN Capacity assumptions	Current [33] (MW)	2030 (MW)	Notes
Wind	65	1,387	Capacity factor: 30%
Storage/Other		-	
TOTAL	65	1,387	

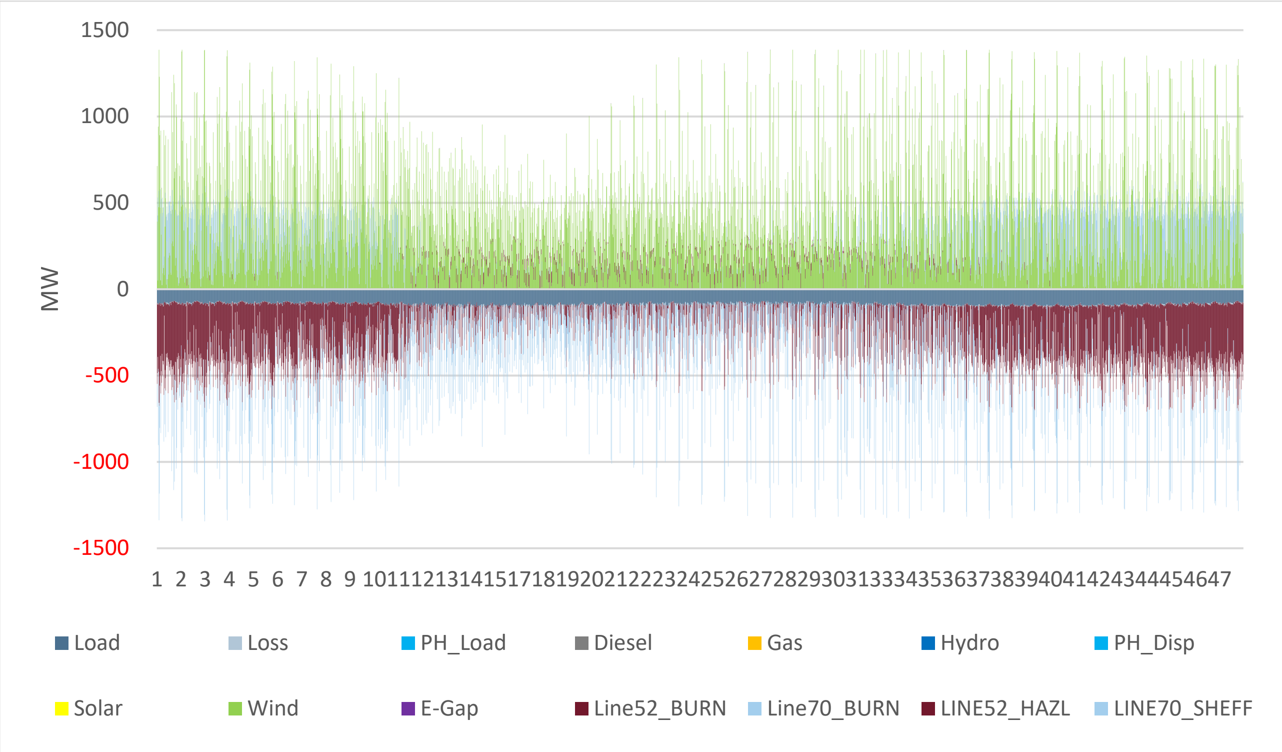

Figure 77: BURNIE energy flows for SummWD under sB

Figure 77 provides detail on the flow of energy through BURN by time-period according to source. Of note:

- the light blue coloured series indicates imports-exports from Sheffield to the south east which has 456MW of wind and 308MW of hydro capacity
- the maroon coloured series indicates imports-exports from VIC – primarily exports to VIC (252GWh) compared to 12GWh imported from VIC
- the light green coloured series indicates wind generated in the BURN node. Figure 78 provides detail on dispatch and curtailment

[33] Source: AEMO Generation Information July 2020

- the steel-blue coloured series indicates BURN load, at an average of 86MW
- E-G is negligible

Table 68 details statistics for BURN energy flows

Table 68: BURNIE salient statistics under sB

BURN SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(124)	(93)	(86)	(117)	74%	(87)
Wind	592	437	411	1,387	30%	332
E-G	0	0	0	0	8%	0
Exports	(506)	(394)	(352)	(1,267)	28%	(313)
Imports	114	107	79	423	19%	1
Wind_spill	53	3	36	885	4%	0
Wind spill %	8%	1%	8%			

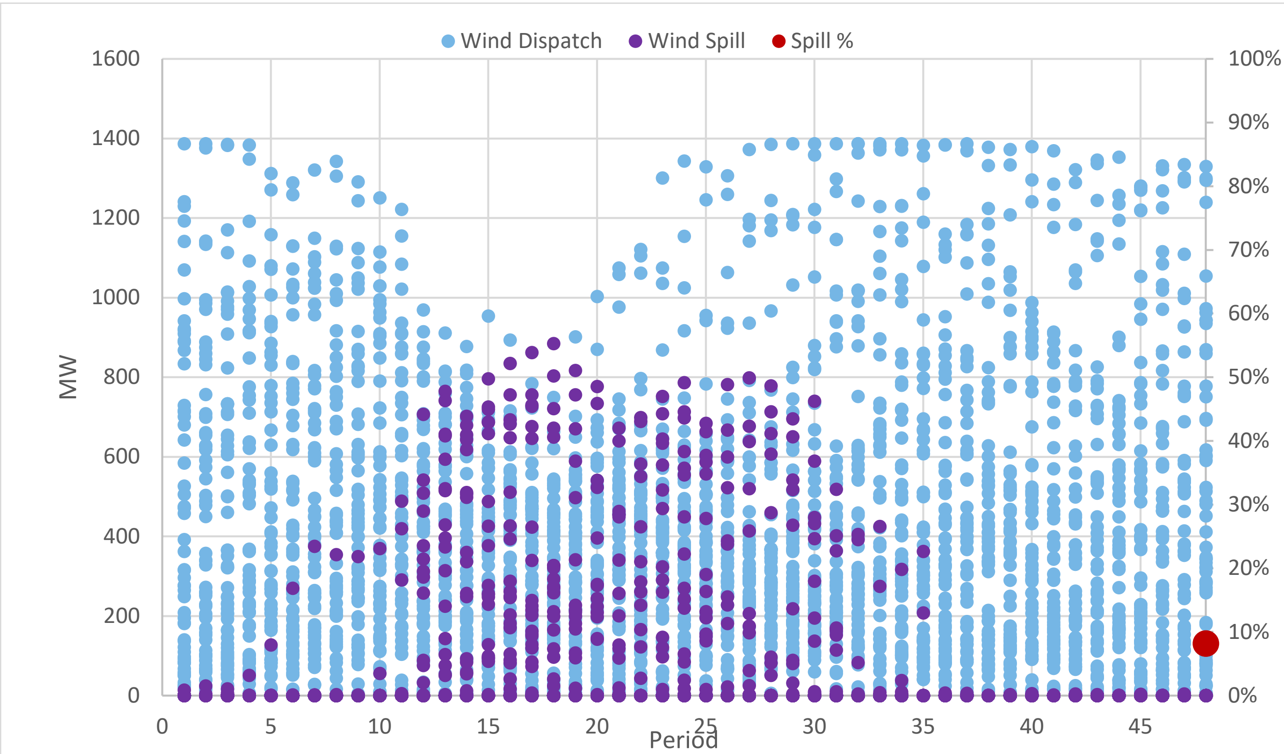

Figure 78: BURNIE wind dispatch and curtailment under sB

5. SHEFFIELD details for summer weekdays

Table 69 provides a summary of generating capacity assumptions for Sheffield (SHEFF) node

Table 69: SHEFFIELD capacity assumptions under sB

SHEFF Capacity assumptions	Current [34] (MW)	2030 (MW)	Notes
Hydro	298	308	Capacity factor: 30%
Wind		456	Capacity factor: 31%, curtailment: 0%
Storage/Other		4	Capacity factor: 0%
TOTAL	298	768	

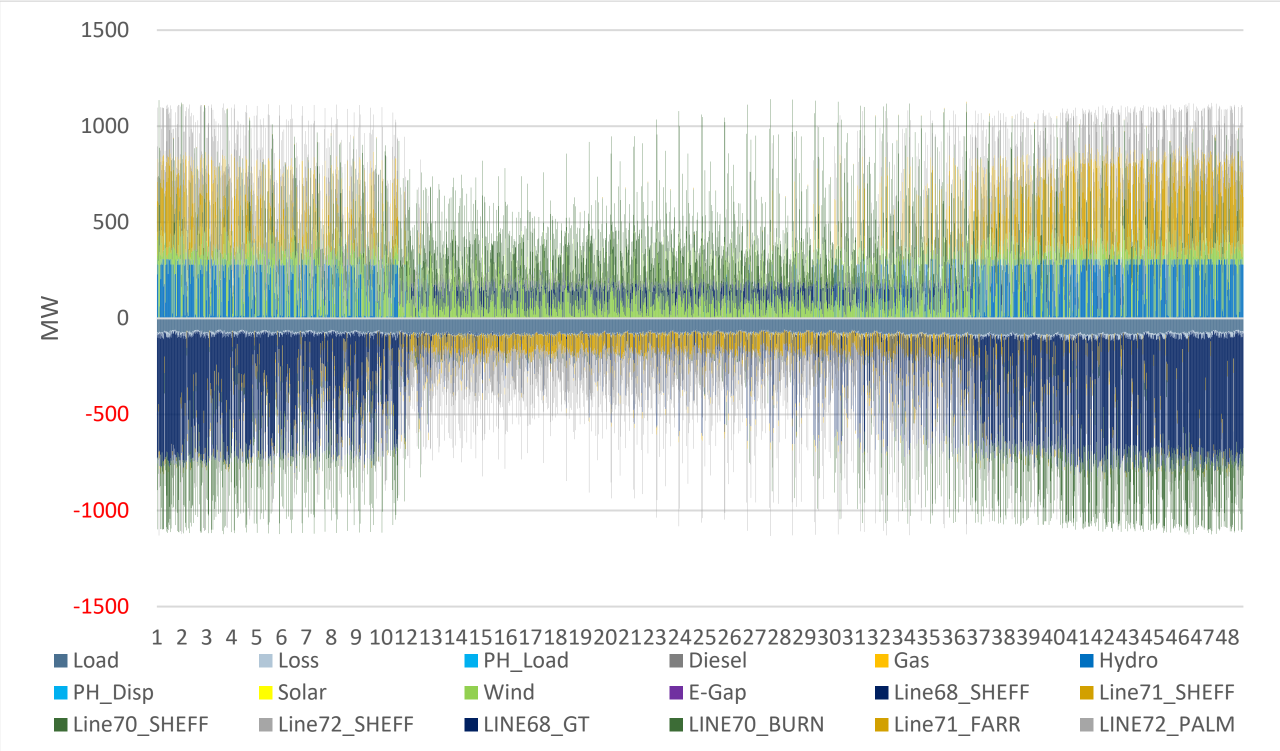

Figure 79: SHEFFIELD energy flows for SummWD under sB

Figure 79 provides detail on the flow of energy through SHEFF by time-period according to source. Of note:

- the light grey blue coloured series indicates imports-exports from-to Palmerston to the south east which has 300MW of hydro capacity
- the dark green coloured series indicates imports-exports from-to BURN node with 1.4GW of wind capacity. Energy flows primarily BURN-SHEFF (1867GWh) versus SHEFF-BURN (1013GWh).

[34] Source: AEMO Generation Information July 2020

- the dark gold coloured series indicates imports-exports from-to FARRELL to the south west with 618MW of hydro and 112MW of wind capacity
- the light green coloured series indicates wind generated from 456MW capacity in the SHEFF node. Figure 80 provides detail on dispatch and curtailment
- the royal blue coloured series indicates hydro generated from 308MW of capacity. It is less evident in the graph but dispatch occurs primarily overnight
- the steel-blue coloured series indicates SHEFF load, at an average of 86MW
- E-G is negligible
- Table 70 details statistics for SHEFF energy flows

Table 70: SHEFFIELD salient statistics under sB

SHEFF SALIENT STATISTICS	Energy (GWh)	EvenPeak (MW)	AveAll (MW)	Max (MW)	CF (%)	Median (MW)
Load	(110)	(83)	(77)	(104)	74%	(77)
Hydro	135	134	94	308	30%	0
Wind	204	139	142	456	31%	110
E-G	0	0	0	4	0%	0
Exports	(732)	(591)	(508)	(1,029)	49%	(457)
Imports	519	413	360	802	45%	290
Wind_spill	0	0	0	26	1%	0
Wind spill %	0%	0%	0%			

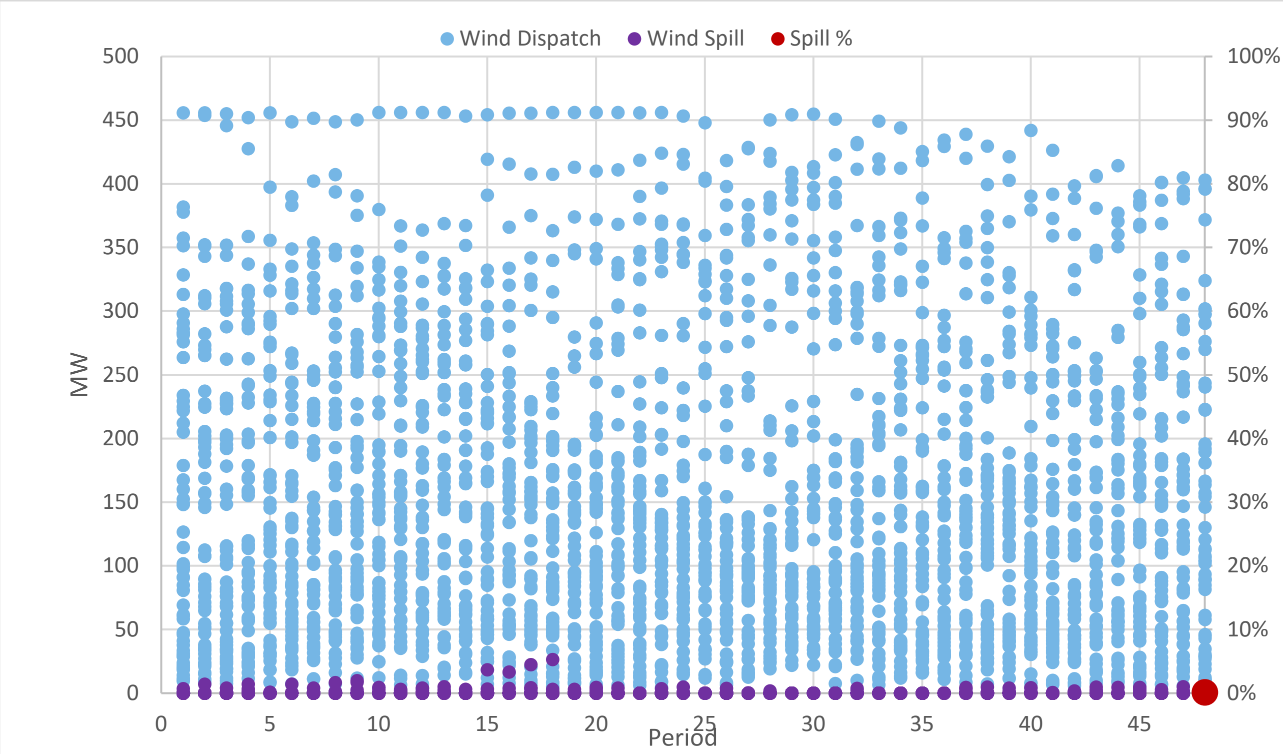

Figure 80: SHEFFIELD wind dispatch and curtailment under sB

6. CONCLUDING OBSERVATIONS for TAS nodal supply-demand balance

TasHydro Battery of the Nation (BoN) proposal posited significant wind at both BURN and SHEFF to be the main power source for exports of energy to HAZL on the new BoN interconnection. This contrasts with the ISP findings, which assumed large wind installations in the central highlands, well away from the BoN interconnector. ANEM model predicts that energy will flow predominantly from SHEFF to BURN and on to HAZL. These findings tend to support the assumptions underpinning the BoN proposal.

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