Fraser Maywood – Chair @ Sustainable Energy Now

Advocating the Energy Transition

Climate Policy Lectures 2023

3rd August 10-11am

Agenda

1. About SEN
2. How did SEN get started?
3. What are SEN's core objectives?
4. What do the SEN models suggest about the energy mix on the South West Interconnected System?
5. How does SEN advocate for change?

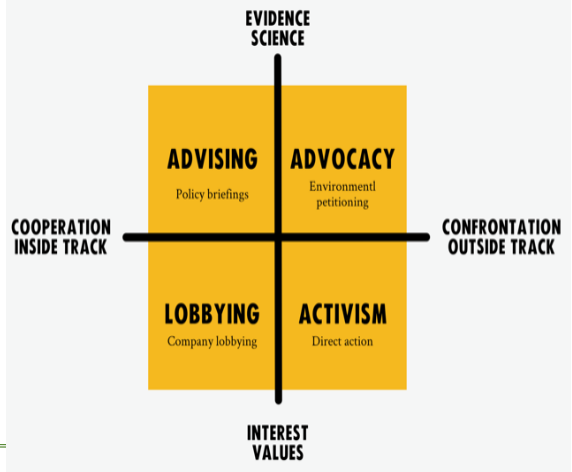
1

About SEN

About SEN

- We are a grassroots not-for-profit member based **advocacy group** promoting Sustainable Energy Now!
- We model the WA electricity grid and advocate on how we can make a swift and orderly transition to clean renewable electricity safely, reliably, and affordably with commercially proven technologies.
- Our 2030 vision is to phase out the majority of fossil fuel-based energy sources in WA and transition towards 100% renewables.
- Our mission is to model and promote practical, affordable strategies for the adoption of renewable energy toward a sustainable global future.
- We provide presentations, submissions and briefings to government agencies, corporations, media, schools, community groups, politicians and hold public events.
- We are 120 strong and looking for members and volunteers – Volunteering WA

QR Code - volunteers don't need have to have technical background... Economic, financial, social media, etc



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How did SEN get started?

3. Core objectives

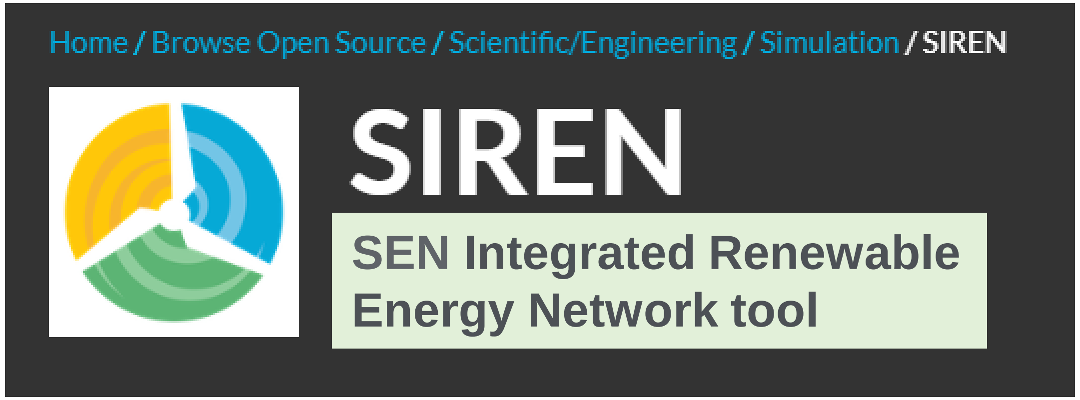
SEN History - Conception

The John Howard-led Coalition government went to the November 2007 federal election with a pro-nuclear power platform.

SEN formed in 2006 following Alarm to Action Community Meeting in Perth

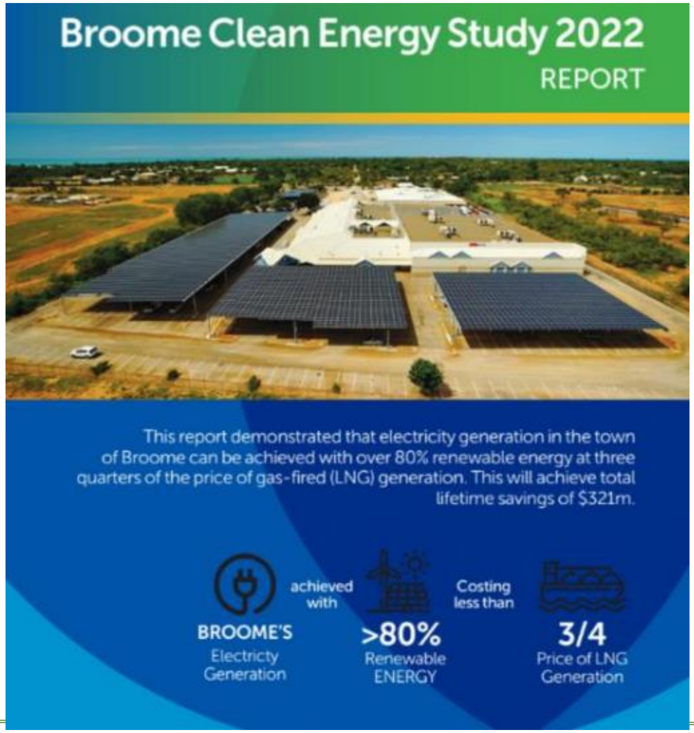
- widespread use of sustainable energy
- efficient energy use
- greater awareness of the economic and environmental benefits of sustainable energy
- sustainable energy research and technology
- a nuclear-free future
- a safe climate future

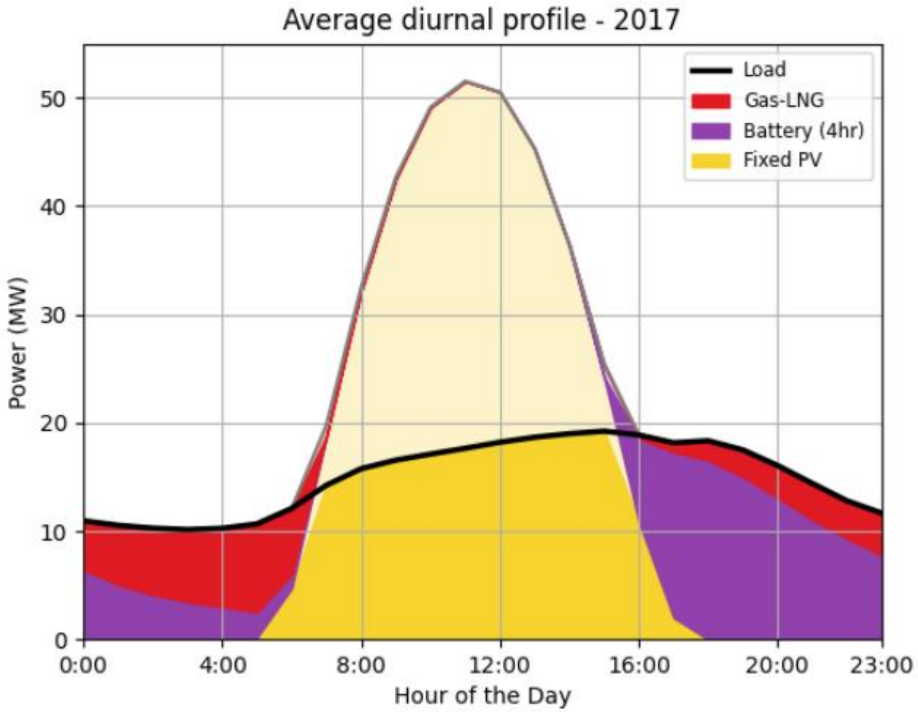
SEN History – Modelling, Reports, Education



Domestic rooftop PV feed in tariff
Strong on coal and gas for power sector
Liked nuclear but not for WA

Technology Agnostic





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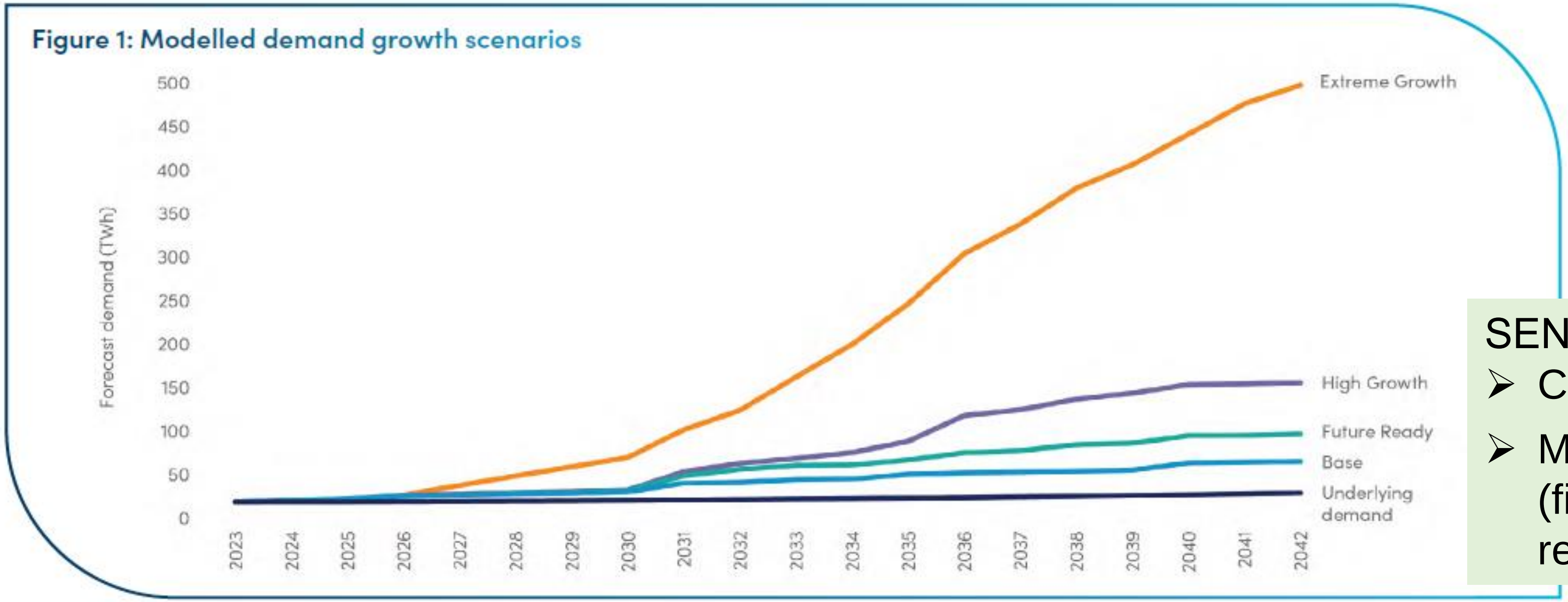
SEN 2023 modelling on the WA South West Interconnected System - SWIS

Acknowledgement to all SEN volunteers who contributed to the 2023 modelling including Gus King, Len Bunn, Rob Phillips, Paul Caston and others

SEN SWIS Modelling – Basis

Sustainable Energy Now

State Government Announcement “State-owned coal power stations to be retired by 2030 with move towards renewable energy” Jun 2022 – 810MW Wind + 1,100MW storage



SWIS DEMAND ASSESSMENT MAY 2023 5

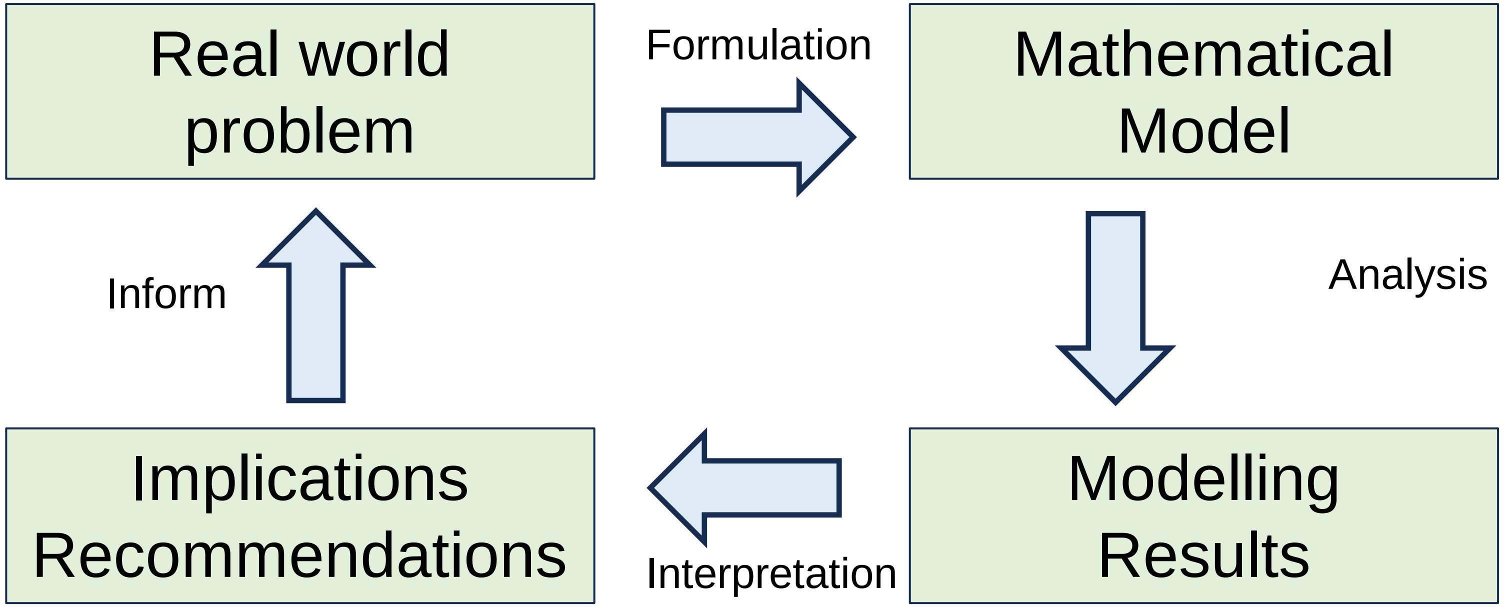
SEN’s modelling is for:

- Coal exit (Synergy + Bluewater)
- Minimum gas power generation (firming of VRE –variable renewable energy)

Energy Policy WA – South West Interconnected System Demand Assessment – SWIS DA released in May 2023

SEN Modelling – Method

Real World



Inputs

1. Methodology
2. Scope (inc area map to be modelled)
3. Data (solar and wind weather data, load forecast, theoretical models of RE technologies, existing grid and generation assets, CAPEX and OPEX costs, cost of capital)
4. Scenarios
5. Assumptions (only as good as), try to be conservative
6. Resources

SEN Modelling – SIREN and Power Match
User Input and Outputs

User Input

1. Location of virtual RE plants of desired technologies in the area – Power Match subsequently optimises that RE capacity
2. Dispatch order

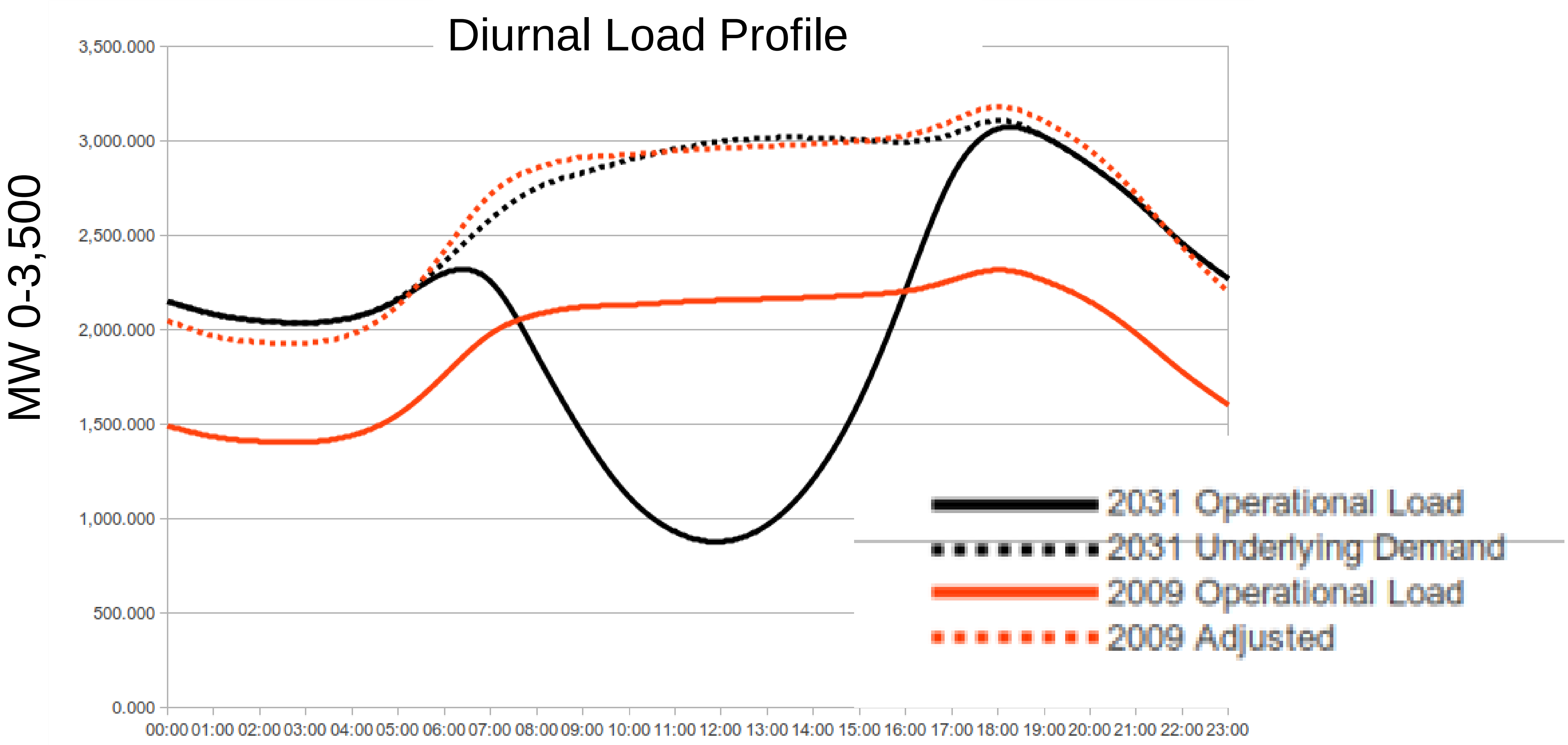
Outputs

1. The potential contribution of each virtual plant to meet the load – annual and hourly
2. Aggregated contribution per RE technology
3. Generation shortfalls and excesses against load (demand)
4. RE technology MW, MWh pa, capacity factor, $/yr, LCOE $/MWh, tCO2-e
5. Capital and lifetime cost
6. Emissions and lifetime emissions

Modelling Key Assumptions and Approach

1. 2022 weather data, 2023 CSIRO/AEMO Gen Costs, 2027 technology costs, 7% weighted average cost of capital
2. 2029 load profile - more onerous than earlier years as the duck curve extremities are more challenging to meet.
3. Actual generation ex AEMO data, extrapolated using AEMO forecasts
4. Carbon price of $75/tonne CO2-e, in place by 2027 – aligned to the Safeguard Mechanism.
5. Centrally-generated operational load modelled hence rooftop PV currently ignored in meeting underlying demand.
6. Two ‘zones’ - Zone 1 – current Wind and PV profile; Zone 2 – new Wind and PV profile.
7. Small geographical variations across WA – RE location / onshore or offshore wind agnostic
8. Model does not include any coal or combined cycle gas turbines (CCGT) – retired by 2029 as driven by the duck curve
9. **Model does not include for Reserve Capacity**
10. Starting point - assumed 3.9GW of new flexible gas generation capacity (total existing gas capacity ~ 3.1GW)
11. Approach was to minimise LCOE (with a carbon price) at an optimised amount of 4 hour battery for each of the various mixes of wind and utility PV.
12. Use storage to soak up surpluses and to meet shortfalls
13. Use fossil fuels to meet the rest of the load – future role for Long Duration Energy Storage
14. Ran batch calculations in groups of 26 increments of battery capacity and increments of Wind or PV capacity

SEN SWIS Modelling - Predicted load curves



Time of Day
0.00 – 23.00

SEN SWIS Modelling – Results

Minimum LCOEs with optimised battery

Solar (MW)

Wind (MW)	0	300	600	900	1200	1500	1800	2100	2400	2700	3000	3300	3600	3900	4200	4500	4800	5100	5400	5700	6000	6300	6600	6900	7200	7500
0	235.64	227.76	220.54	214.95	210.19	206.27	202.91	200.04	197.45	195.07	192.80	190.72	188.71	186.80	185.02	183.57	182.80	182.42	182.48	182.75	183.31	184.06	184.92	185.95	187.11	188.34
300	224.01	216.47	209.88	204.67	200.30	196.54	193.39	190.63	188.13	185.81	183.61	181.57	179.69	178.07	176.82	175.99	175.55	175.47	175.70	176.17	176.91	177.75	178.77	179.95	181.22	182.58
600	212.75	205.68	199.73	194.85	190.66	187.13	184.10	181.45	179.04	176.77	174.74	173.01	171.62	170.67	170.15	169.91	169.95	170.21	170.71	171.48	172.41	173.47	174.66	175.98	177.39	178.87
900	201.92	195.35	189.96	185.29	181.39	178.03	175.09	172.51	170.27	168.38	166.89	165.81	165.13	164.85	164.88	165.21	165.78	166.53	167.45	168.49	169.62	170.89	172.30	173.79	175.33	176.92
1200	191.62	185.60	180.51	176.17	172.49	169.35	166.71	164.51	162.81	161.60	160.71	160.29	160.27	160.54	161.11	161.89	162.86	163.92	165.09	166.42	167.84	169.36	170.94	172.59	174.34	176.15
1500	182.23	176.70	171.87	167.79	164.47	161.76	159.68	158.14	157.08	156.43	156.21	156.44	156.95	157.73	158.71	159.84	161.10	162.45	163.92	165.50	167.13	168.82	170.56	172.36	174.24	176.14
1800	174.09	168.79	164.39	160.81	157.91	155.75	154.23	153.37	153.00	153.03	153.45	154.14	155.10	156.23	157.49	158.85	160.27	161.81	163.45	165.13	166.87	168.68	170.57	172.50	174.47	176.46
2100	167.16	162.32	158.35	155.17	152.88	151.41	150.62	150.37	150.47	150.97	151.77	152.85	154.08	155.38	156.79	158.30	159.94	161.63	163.40	165.23	167.12	169.05	171.01	173.00	175.02	177.04
2400	161.54	157.16	153.66	151.12	**149.49**	**148.62**	**148.32**	**148.43**	**148.97**	**149.83**	150.93	152.20	153.58	155.08	156.69	158.37	160.13	161.97	163.86	165.77	167.72	169.70	171.71	173.73	175.76	177.80
2700	157.22	153.30	150.39	**148.44**	**147.32**	**146.87**	**146.94**	**147.37**	**148.23**	**149.39**	150.69	152.10	153.65	155.33	157.06	158.87	160.75	162.66	164.60	166.57	168.57	170.58	172.61	174.65	176.69	178.74
3000	154.01	150.61	**148.16**	**146.62**	**145.90**	**145.81**	**146.18**	**147.00**	**148.16**	**149.47**	150.93	152.52	154.20	155.98	157.82	159.72	161.63	163.58	165.57	167.58	169.60	171.63	173.66	175.71	177.76	179.81
3300	151.71	**148.72**	**146.65**	**145.54**	**145.21**	**145.50**	**146.23**	**147.30**	**148.62**	**150.08**	151.65	153.36	155.13	156.97	158.87	160.80	162.77	164.77	166.77	168.79	170.81	172.85	174.89	176.94	178.99	181.05
3600	**150.21**	**147.58**	**145.92**	***145.20***	**145.24**	**145.78**	**146.76**	**148.02**	**149.44**	150.99	152.68	154.46	156.32	158.22	160.15	162.12	164.11	166.11	168.13	170.15	172.19	174.23	176.28	178.33	180.39	182.46
3900	**149.45**	**147.19**	**145.90**	**145.52**	**145.78**	**146.54**	**147.66**	**149.04**	150.56	152.22	153.97	155.82	157.72	159.66	161.62	163.61	165.60	167.61	169.63	171.66	173.71	175.75	177.81	179.87	181.93	184.01
4200	**149.25**	**147.34**	**146.39**	**146.22**	**146.67**	**147.62**	**148.91**	**150.35**	151.96	153.68	155.50	157.39	159.32	161.28	163.26	165.25	167.26	169.27	171.30	173.34	175.39	177.45	179.51	181.57	183.64	185.72
4500	**149.56**	**148.00**	**147.29**	**147.34**	**148.00**	**149.07**	150.41	151.96	153.63	155.41	157.27	159.19	161.13	163.11	165.09	167.09	169.11	171.13	173.17	175.22	177.28	179.34	181.41	183.48	185.55	187.63
4800	**150.36**	**149.09**	**148.56**	**148.79**	**149.60**	150.79	152.24	153.86	155.58	157.40	159.29	161.22	163.18	165.15	167.15	169.15	171.17	173.21	175.25	177.30	179.36	181.43	183.50	185.57	187.65	189.74
5100	151.50	150.45	**150.18**	150.56	151.49	152.76	154.26	155.91	157.68	159.53	161.43	163.37	165.34	167.33	169.34	171.35	173.38	175.42	177.48	179.54	181.61	183.68	185.75	187.83	189.91	192.00
5400	152.97	152.15	152.05	152.56	153.58	154.91	156.46	158.16	159.95	161.81	163.72	165.67	167.64	169.63	171.63	173.65	175.68	177.73	179.78	181.84	183.91	185.99	188.07	190.15	192.23	194.32
5700	154.72	154.05	154.06	154.69	155.78	157.16	158.74	160.47	162.29	164.16	166.09	168.05	170.03	172.02	174.03	176.06	178.10	180.15	182.21	184.28	186.36	188.44	190.52	192.60	194.69	196.78
6000	156.66	156.13	156.25	156.99	158.13	159.56	161.18	162.94	164.77	166.66	168.59	170.54	172.53	174.52	176.53	178.56	180.60	182.65	184.71	186.78	188.86	190.94	193.02	195.11	197.20	199.29
6300	158.76	158.39	158.61	159.42	160.61	162.06	163.71	165.48	167.31	169.21	171.14	173.11	175.10	177.10	179.12	181.15	183.20	185.26	187.33	189.40	191.49	193.57	195.66	197.75	199.84	201.93
6600	161.03	160.77	161.05	161.90	163.15	164.63	166.31	168.09	169.94	171.85	173.79	175.77	177.77	179.78	181.80	183.85	185.90	187.97	190.05	192.12	194.21	196.29	198.38	200.47	202.57	204.66
6900	163.42	163.22	163.58	164.50	165.78	167.30	169.01	170.80	172.66	174.58	176.54	178.52	180.53	182.54	184.58	186.63	188.70	190.77	192.84	194.92	197.01	199.10	201.19	203.28	205.37	207.47
7200	165.90	165.76	166.20	167.18	168.50	170.06	171.77	173.58	175.46	177.39	179.35	181.35	183.36	185.39	187.43	189.49	191.56	193.63	195.71	197.79	199.88	201.97	204.06	206.16	208.26	210.35
7500	168.44	168.39	168.90	169.94	171.30	172.88	174.61	176.43	178.32	180.26	182.24	184.24	186.26	188.30	190.35	192.41	194.48	196.56	198.64	200.72	202.81	204.91	207.00	209.10	211.20	213.30

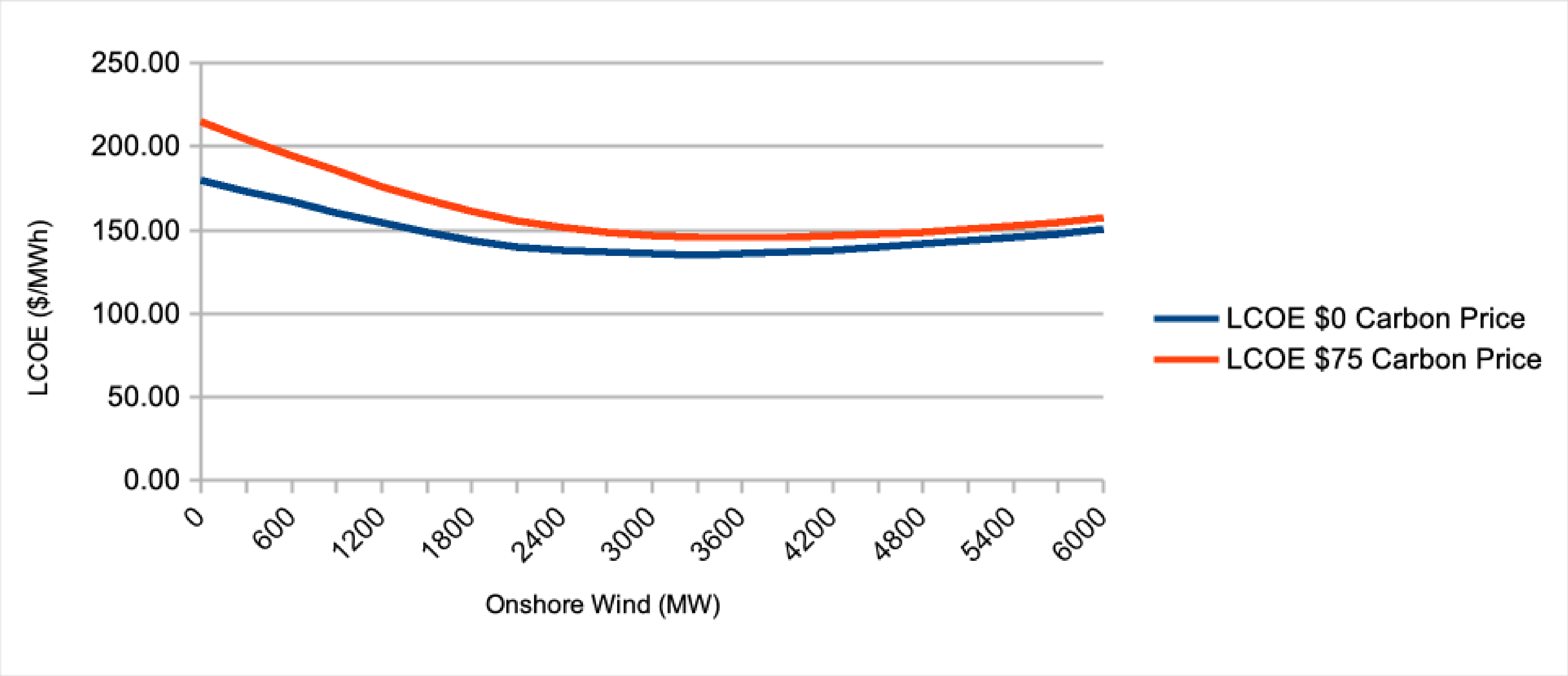
Understanding sensitivities around model derived optimal solution is important

Optimum Table

Capacity (MW/MWh)	Units	W4200 B4-1600	W3600 B4-2400	W3000 B4-4800	W2700 B4-8000	W2400 B4-9600
Existing.Onshore Wind	MW	1,025	1,025	1,025	1,025	1,025
Existing.Fixed PV	MW	10	10	10	10	10
Existing.Single Axis PV	MW	141	141	141	141	141
Proposed.Single Axis PV	MW	**0**	**900**	**1,800**	**2,700**	**3,600**
Proposed.Onshore Wind	MW	**4,200**	**3,600**	**3,000**	**2,700**	**2,400**
Optimised.Battery (4hr)	MWh	1,600	2,400	4,800	8,000	9,600
Gas Recip	MW	3,900	3,900	3,900	3,900	3,900
Total RE	MW	5,376	5,676	5,976	6,576	7,176
Total	MW	9,276	9,576	9,876	10,476	11,076
To Meet Load (MWh)						
RE Contribution To Load	MWh	14,389,201	14,540,853	14,193,509	13,968,716	13,630,968
Optimised.Battery (4hr)	MWh	315,343	514,056	1,084,922	1,772,168	2,248,567
Gas Recip	MWh	3,018,246	2,667,881	2,444,358	1,981,906	1,843,255
Surplus	MWh	5,801,709	5,383,922	5,023,747	5,585,626	6,511,345
LCOE						
LCOE $0 Carbon Price	$/MWh	$139.21	$135.87	$137.12	$141.22	$145.39
Carbon Price ($/tCO2e)		$75	$75	$75	$75	$75
LCOE $75 Carbon Price	$/MWh	$149.25	$145.20	$146.18	$149.39	$153.58
RE %age	%	81.2%	82.0%	80.1%	78.8%	76.9%
Storage %age	%	1.8%	2.9%	6.1%	10.0%	12.7%
RE %age of Total Load	%	83.0%	84.9%	86.2%	88.8%	89.6%
Max MW used						
Gas Recip	MW	3,271	3,275	3,279	3,281	3,303
Max Load	MW	4,319	4,319	4,319	4,319	4,319

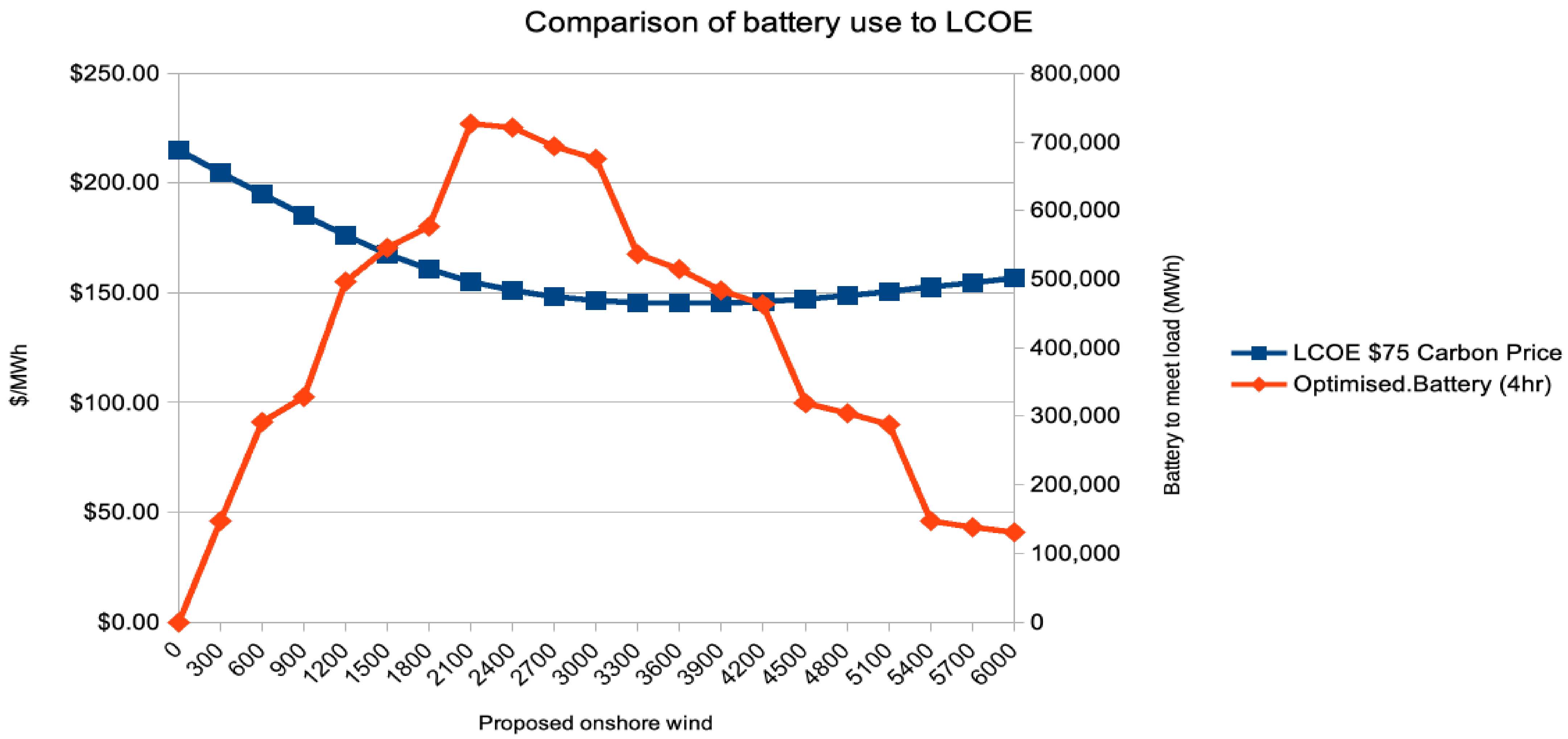
Best Scenario - LCOE vs Capacity

New Wind 3600 MW, New PV 900MW



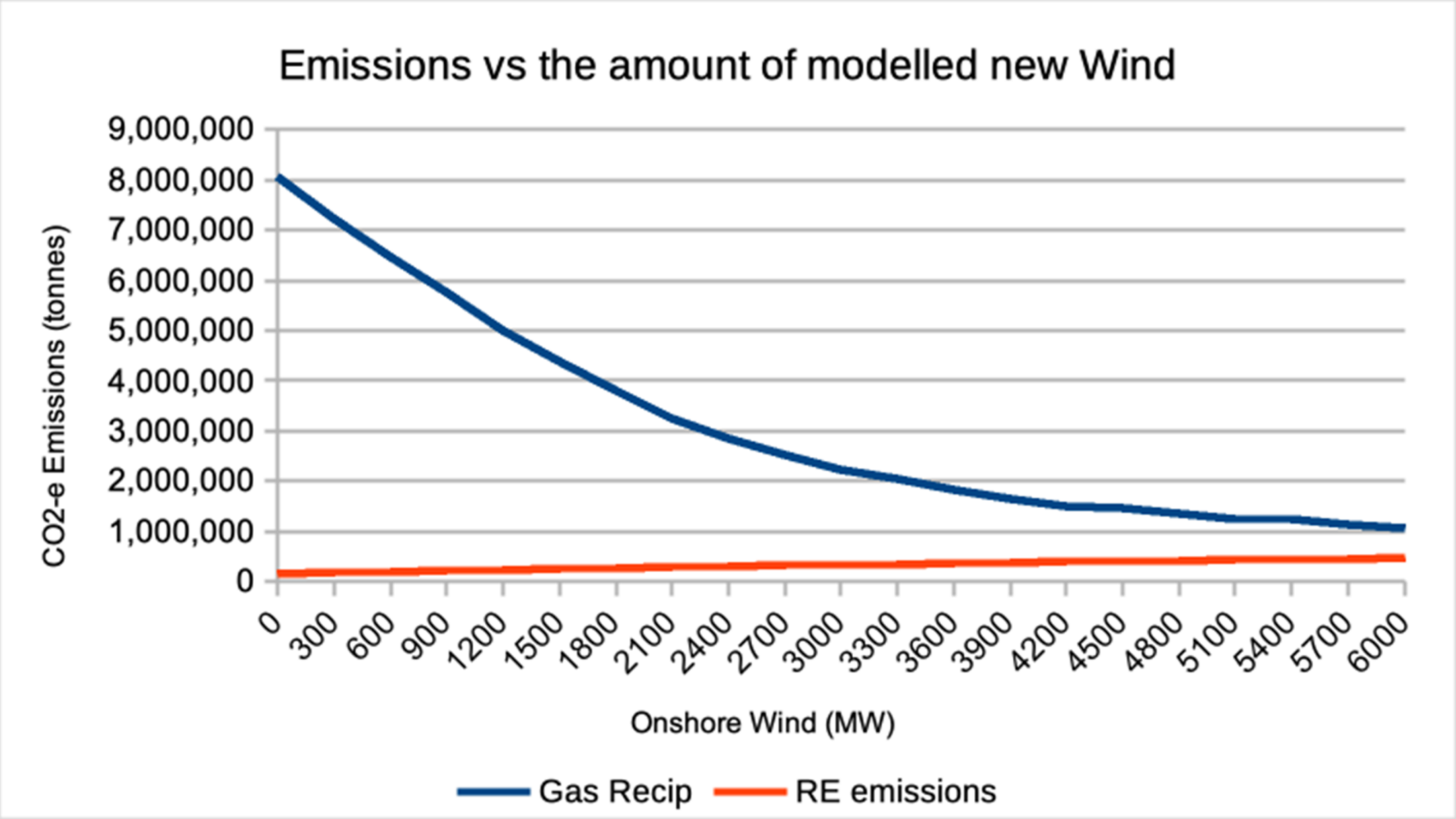
Best Scenario - Battery Use

New Wind 3600 MW, New PV 900MW



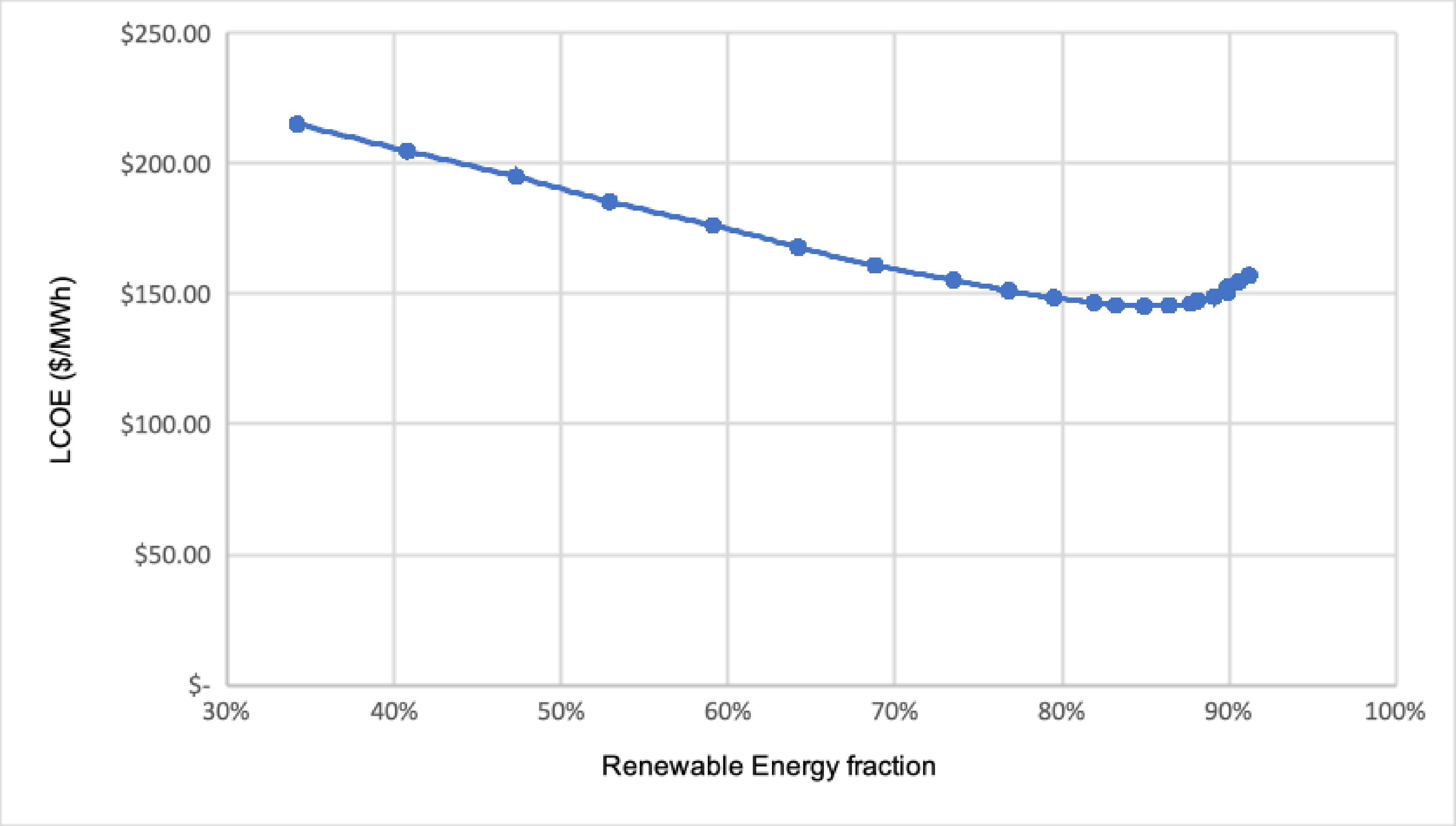
Best Scenario - Emissions Gas vs RE

New Wind 3600 MW, New PV 900MW



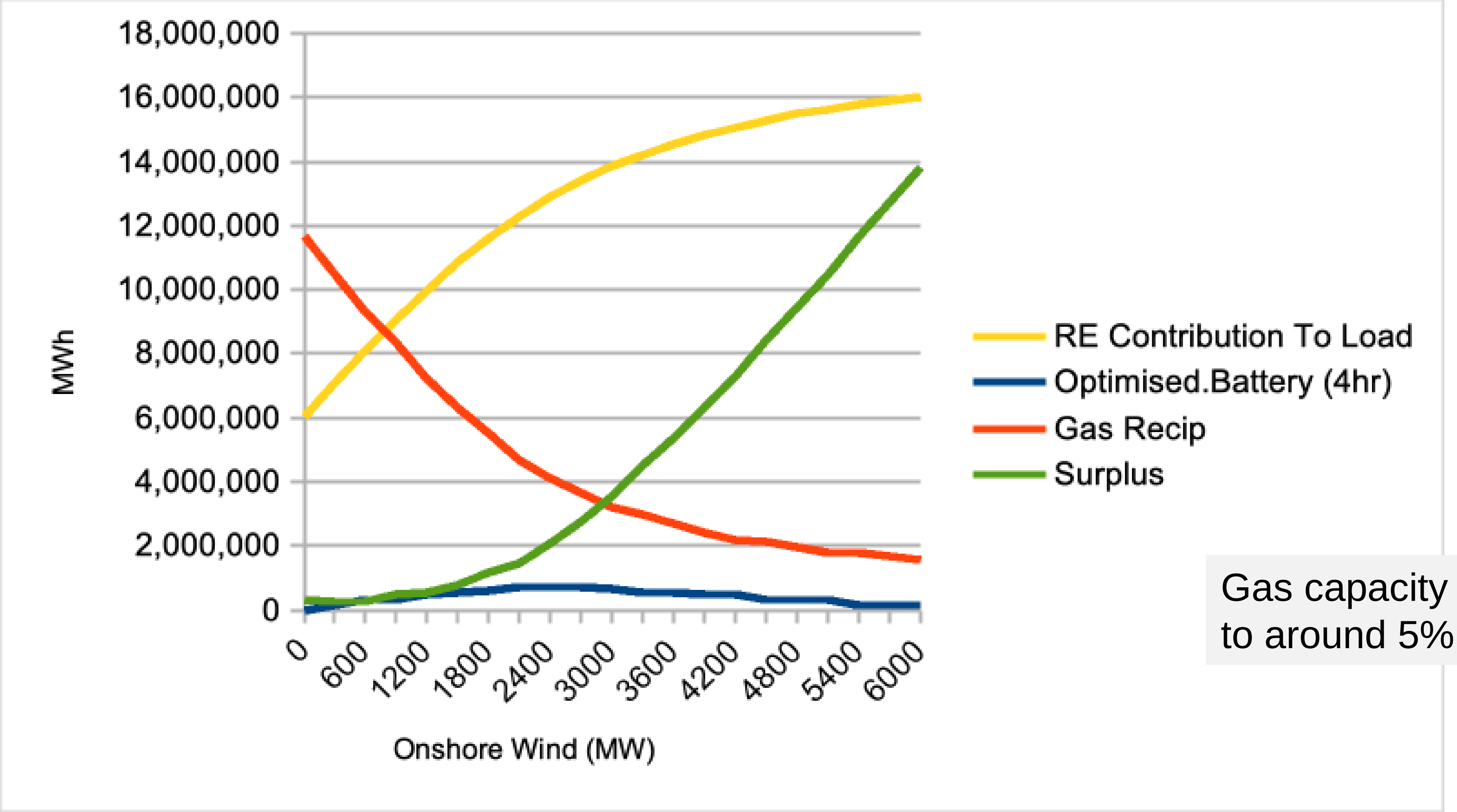
Best Scenario - LCOE vs RE%

New Wind 3600 MW, New PV 900MW



Best Scenario - Contribution to Load

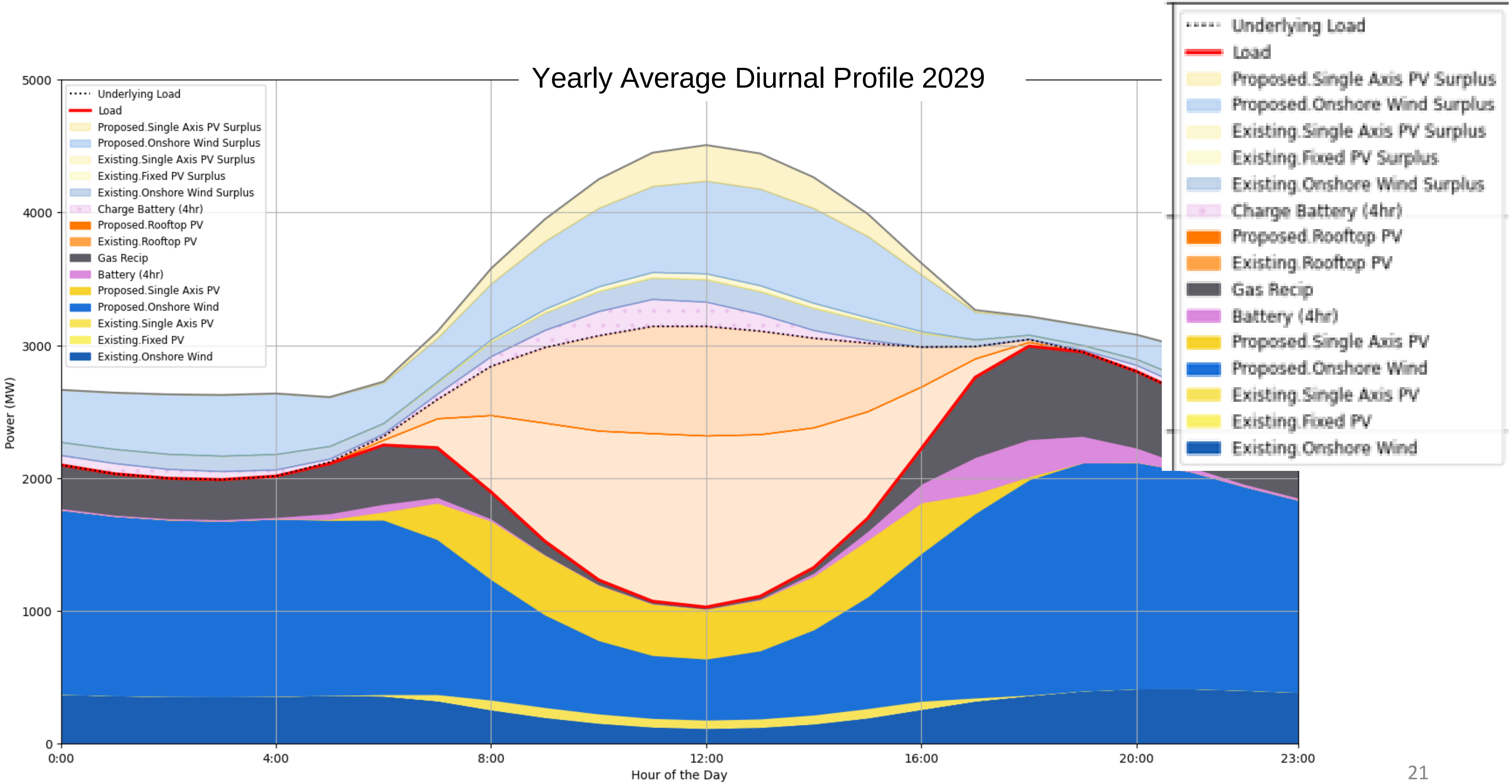
New Wind 3600 MW, New PV 900MW



Gas capacity factor falls to around 5%

Seasonal Factors

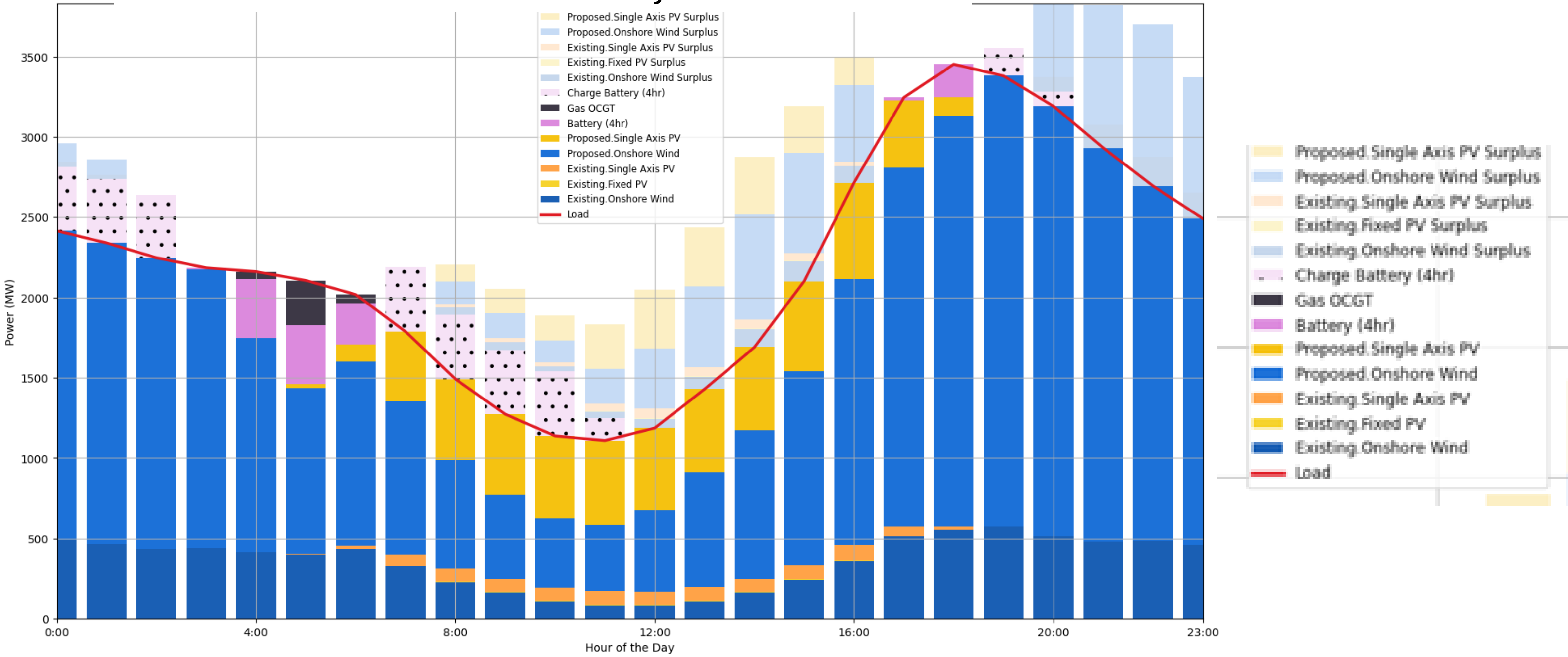
Power (MW) 0 – 5000 MW



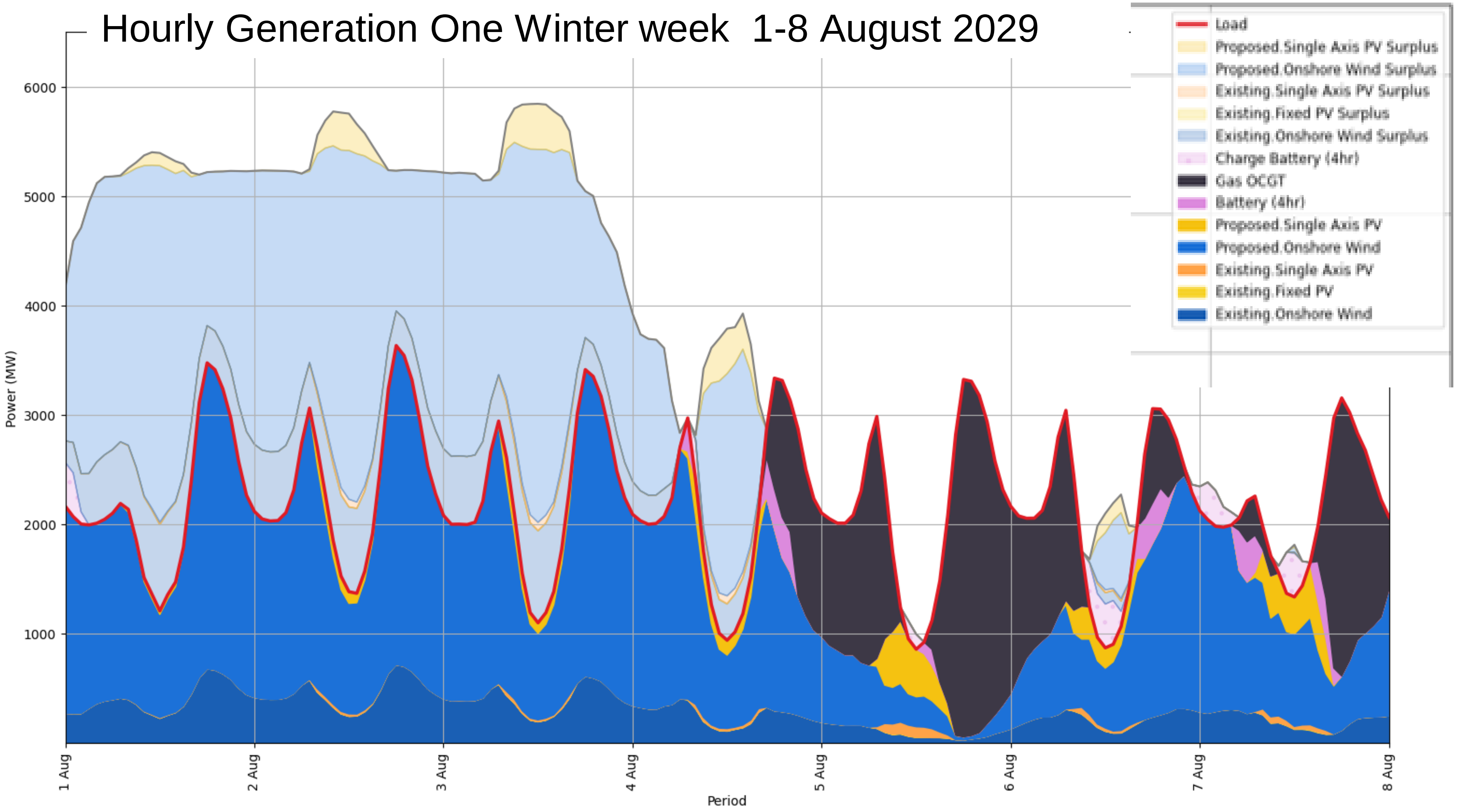
Time of Day 0.00 – 23.00

Seasonal Factors

Diurnal Profile – One Summer Day 1st Jan 2029



Seasonal Factors – 'Dunkeflaute'



What does this all mean???

It needs new eyes and insights

- Broad alignment with SWIS DA outcomes
- State coal closure modelling to be released to allow critic
- Insensitive to PV and Wind mix
- Surplus from RE overbuild is not a waste – opportunity
- Gas required in decreasing amount in the transition – low capacity factors, technical and commercial challenges
- Long-duration energy storage (LDES) remains key – WA no inter-connectors, Pumped Hydro Energy Storage (PHES) limited
- Model different weather years to fully understand RE mix, including LDES
- Demand Side Management – Supply following / smart grids / DSM is key in managing investment /RE overbuild

5

How does SEN advocate for change?

Energy Transition – a Political Process

- Energy tightly bound to economics, jobs and growth, rise and fall of empires, core to our modern lifestyle, controlled by government(?)
- Government objectives: energy security; energy costs; emissions reduction / environmental impacts
- Over focus on socio-technical aspects of the transition without considering power and politics
- Energy policy controlled by incumbents - interests are not aligned to a viable future
- WA state net zero 2050 policy (Nov'21), Sectoral Emission Reduction Strategies – low hanging fruit is electricity sector
- Investment needed for once in a lifetime transition
- Technology is here right now! – solar, wind, batteries, LDES, communications, software - Lowest Cost of Energy
- Technology integration, policy, system planning and market regulation are key - not new technology (CCS, hydrogen etc are planned distractions)

Advocating for Change

Organisational Capability

Policy Engagement

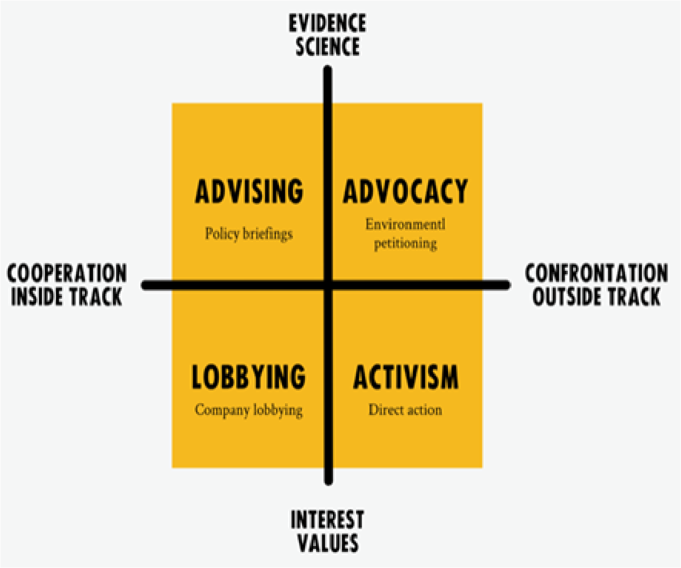
Communications

Public and Industry Education

Allies

Technical Modelling and Research

Civil Society Advocacy

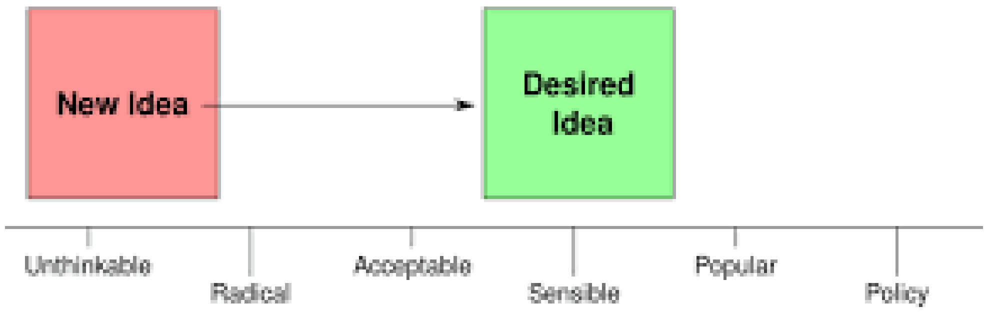


Facts and information

- Robust alternative solution – modelling and reports
- Recognised / professional / credible
- Well developed theory of change
- Stakeholder relationships (mutual respect, listening, understanding, trust, ability to compromise)
- Ability to influence public opinion – political power

Civil Society Advocacy Works

- Promotion of RE from “8% maximum” to 95-100% “Unthinkable”
- Whole of System Plan
- Transition Authority to manage the transition and act as ‘system planner’
- Renewal energy zones / renewable generation hubs
- Behavioural change – time of use charges
- Transmission upgrades – state investment required
- Energy efficiency
- Smart grids – supporting demand side management
- Decarbonisation via electrification
- Sector coupling – EVs are an asset
- Community involvement - bring them along
- Public education on energy



Summary

- Civil society works
- 90%+ renewable energy future for WA
- Industry decarbonisation via electrification
- Work to be done to overcome roadblocks
- Energy sector moving rapidly – keep informed of the news and implications
- We need your help!

Neoen wins WA's Collie big battery tender, moves into long-duration storage market

French renewables developer Neoen has won a 197 MW / 4-hour duration storage contract with AEMO. The contract pertains to the Collie big battery in WA's south west, with Stage 1 to be operating commercially by October 2024.

JUNE 20, 2023 **BELLA PEACOCK**

SEN
Sustainable Energy Now

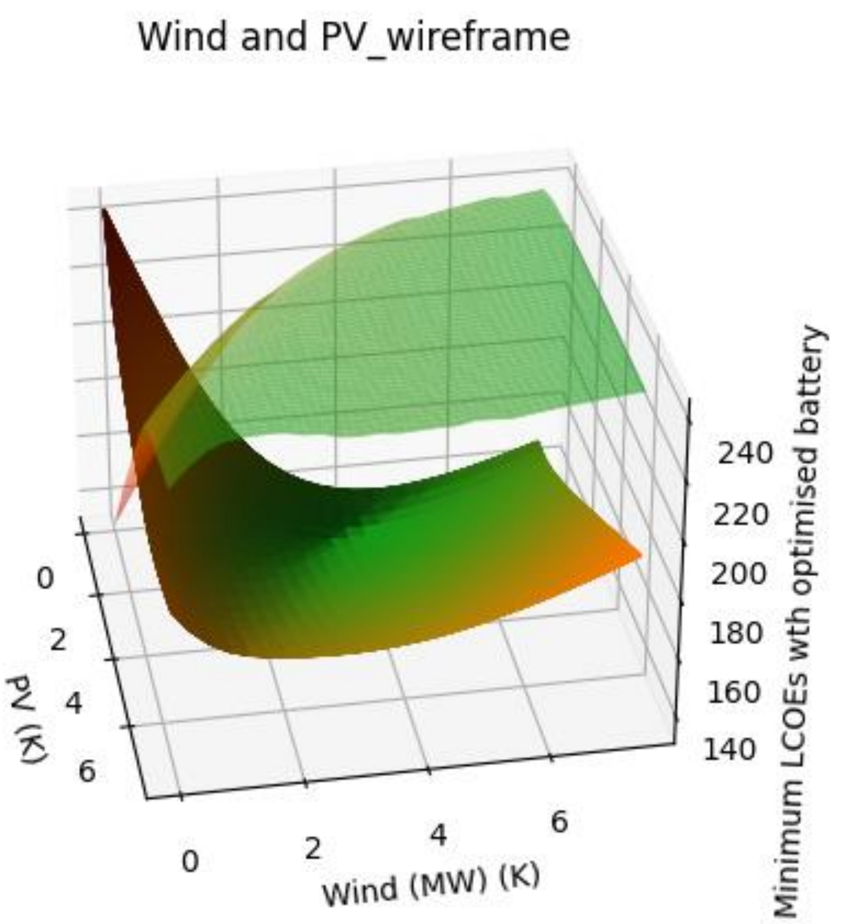
Thank You

Q & A

QR Code - volunteers don't need have to have technical background... economic, financial, social media, etc

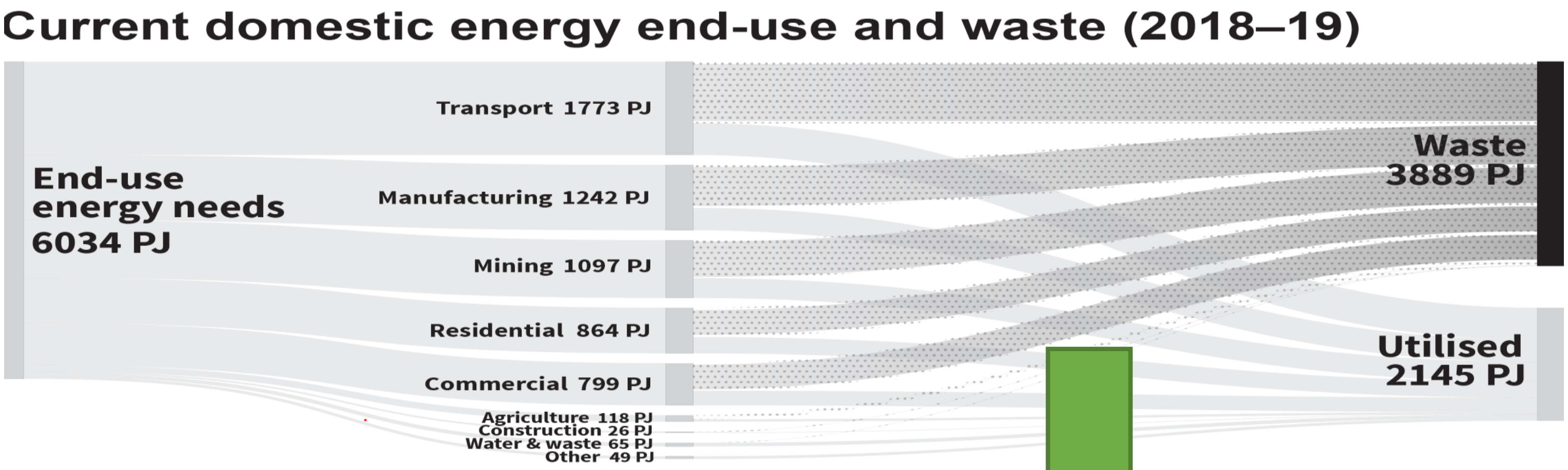
RE% Graph

Percentage RE of load

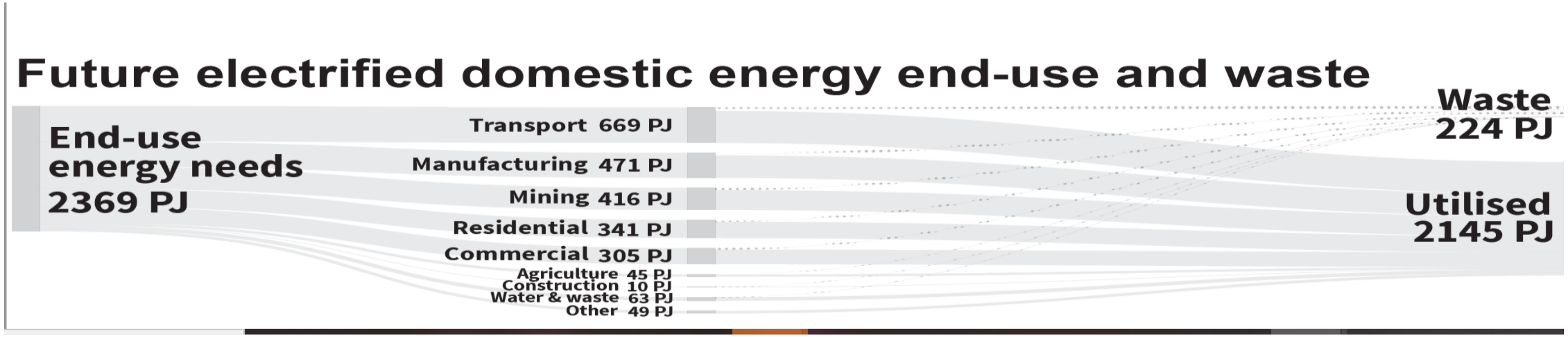


Sample data
for illustrative purposes only

Domestic Energy Use - Sankey Diagram



64% of primary energy wasted
Fossil Fuel Home

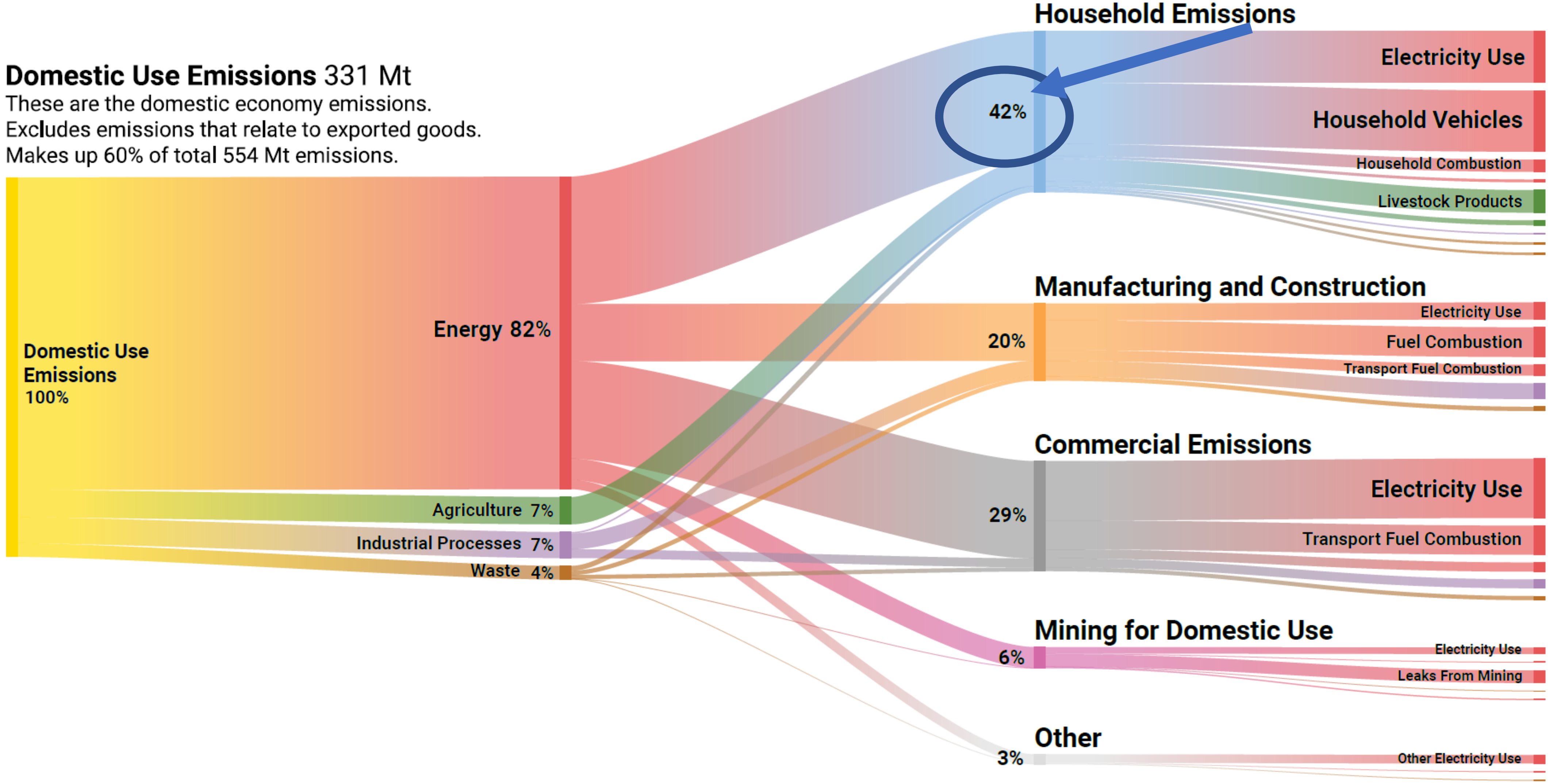


92% of primary energy used
Fully Electric Home

“Domestic Energy” is national ‘running the country’ energy use.

Domestic Emissions - Sankey Diagram

"Domestic emissions" 331Mt CO2-e are national 'running the country' emissions. Trade emissions are another 224 Mt – this includes agriculture exports, iron ore coal, LNG etc … but not the burning of those fossil fuels



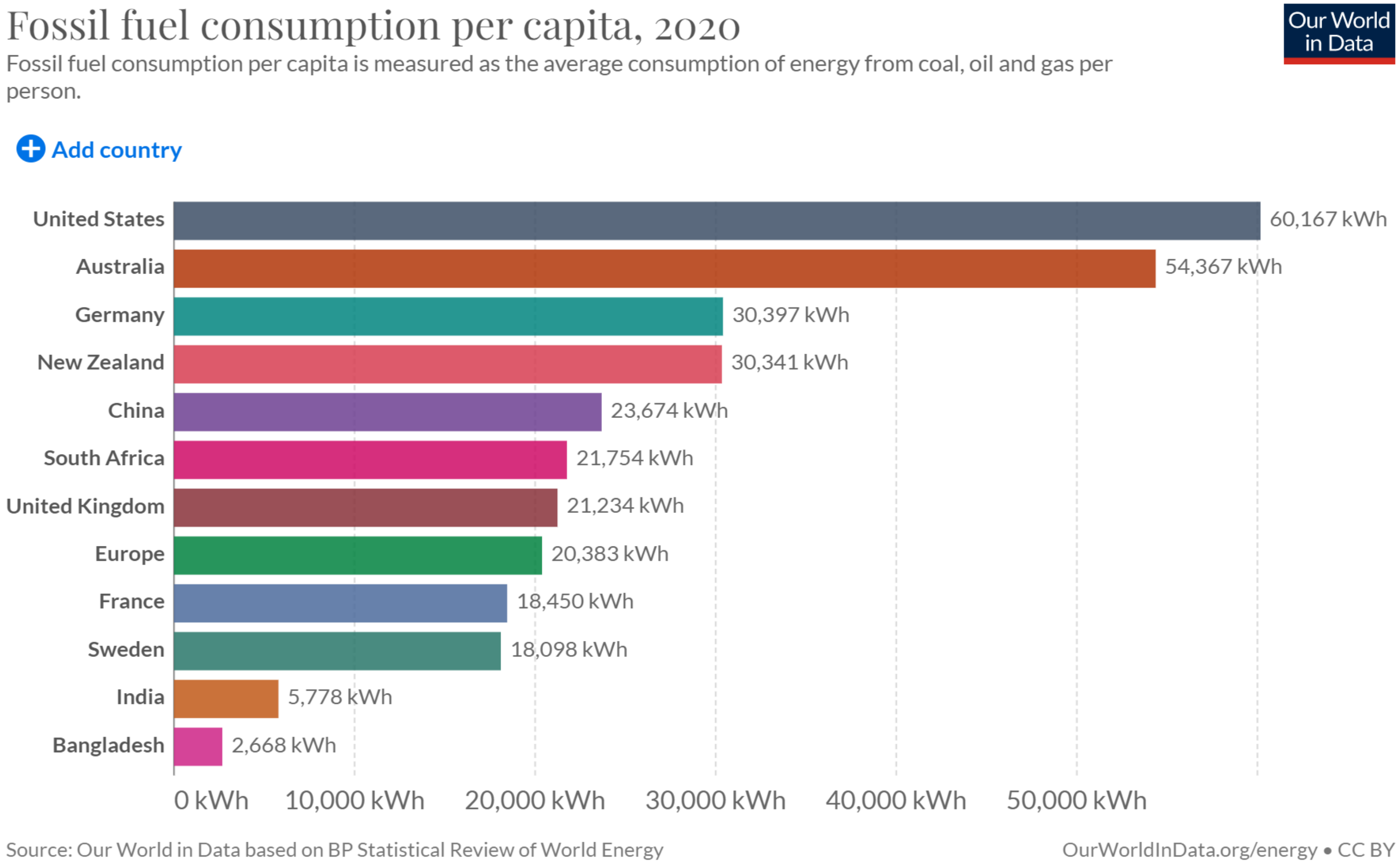
International and National Home Electrification

1. Just 9% of Australian household consumers seriously considering electrification. 77% either had not thought about it or had decided not to.
2. Small business consumers : 27% said they were seriously considering electrification. 30% report they are considering it but not seriously

https://energyconsumersaustralia.com.au/

28th April 2022 - Esperance is in the process of quitting gas, as part of a state government-backed transition to full electrification prompted by the closure of the area's privately-owned gas network.[6]

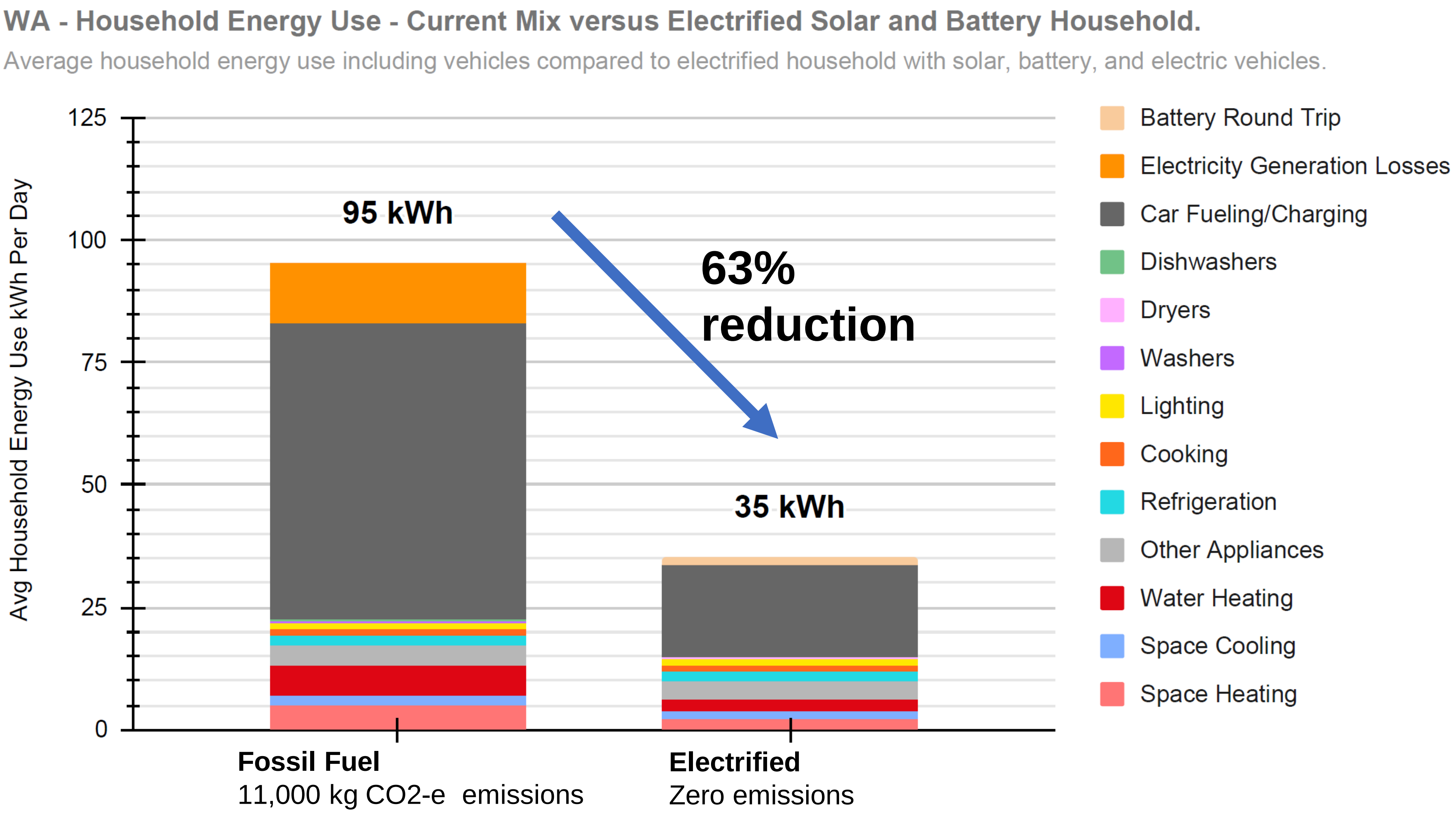
December 15th 2021, New York City Council passed a motion 40 to 7 vote banning new fossil fuel hook-ups in buildings for heat, hot water, and kitchen stoves starting as early as 2024.



Per capita energy by source: calculated as primary energy consumption by source, divided by population.

Ref 6 https://onestepoffthegrid.com.au/why-this-state-government-is-kicking-gas-out-of-big-coastal-community/

Household Energy Usage



Energy Transition – Domestic

- Ten million Australian homes – focus on them now – via energy efficiency and electrification The Big Switch, treat as essential infrastructure, help everyone benefit from the transition
- Individual householders – carbon footprint / emissions reduction (average household 11,000 kg CO2-e)
- Individual householders – economic
- Individual householders – health reasons - cooking with gas responsible for up to 12% of childhood asthma in Australia = living with household cigarette smoke
- Individual householders – socio-political – getting off gas undermines the gas companies social licence