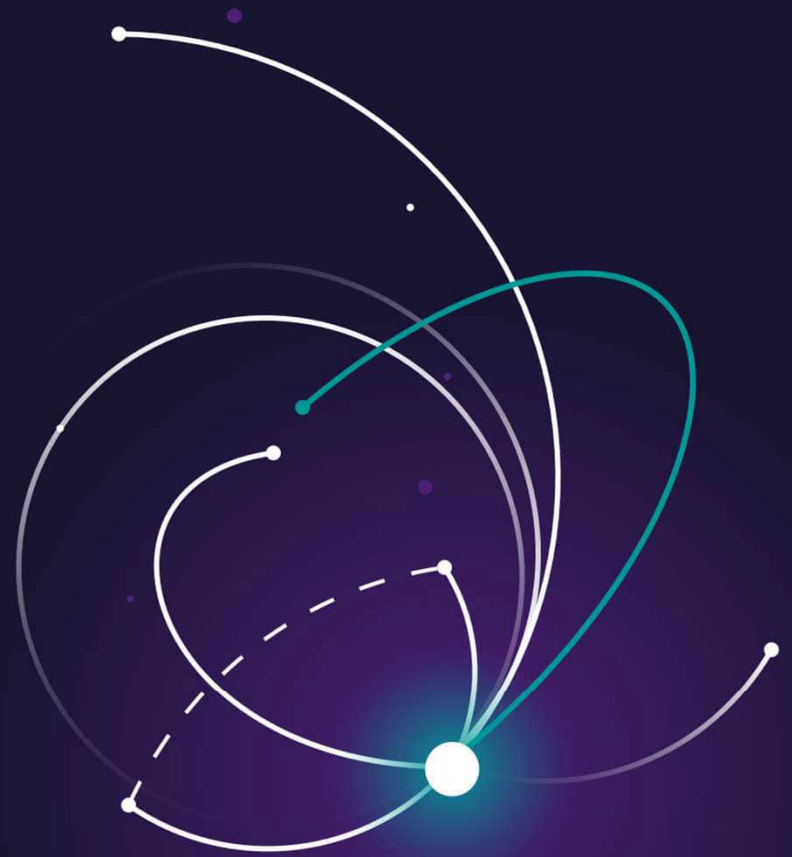
MEI*network*22 Seminar #5:

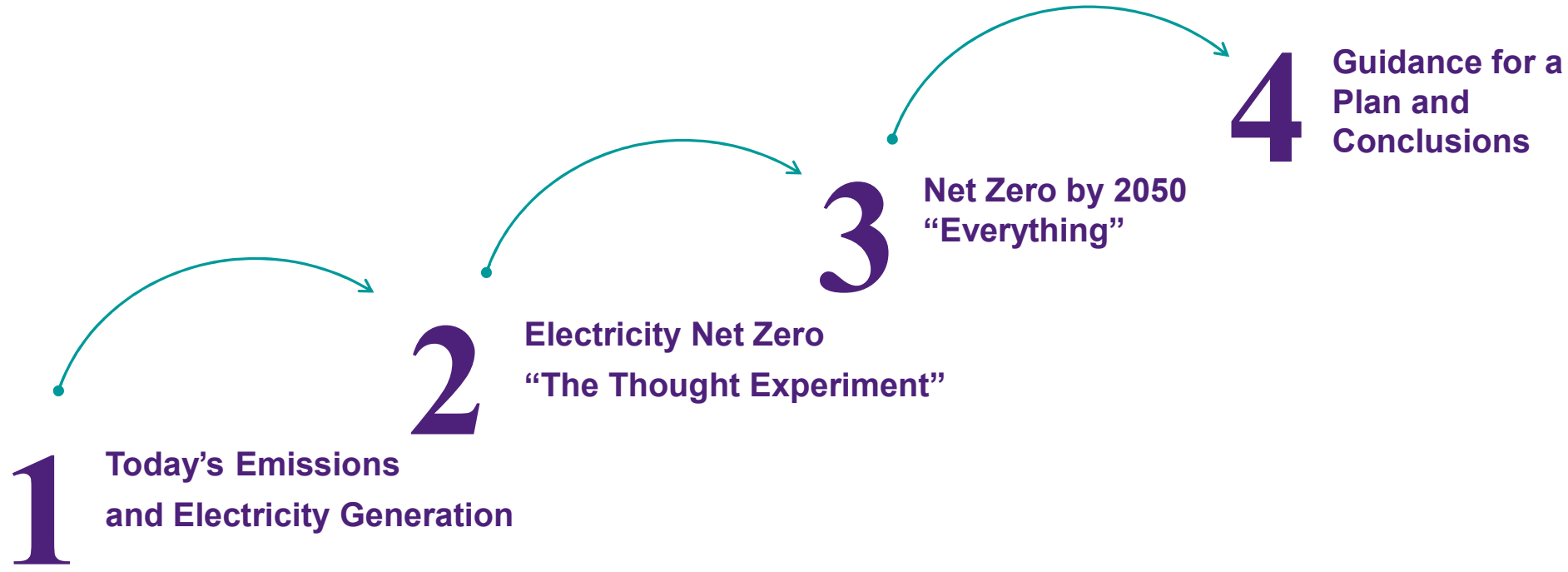
Green hydrogen as an alternative to natural gas

13 September 2022

Michael Bielinski

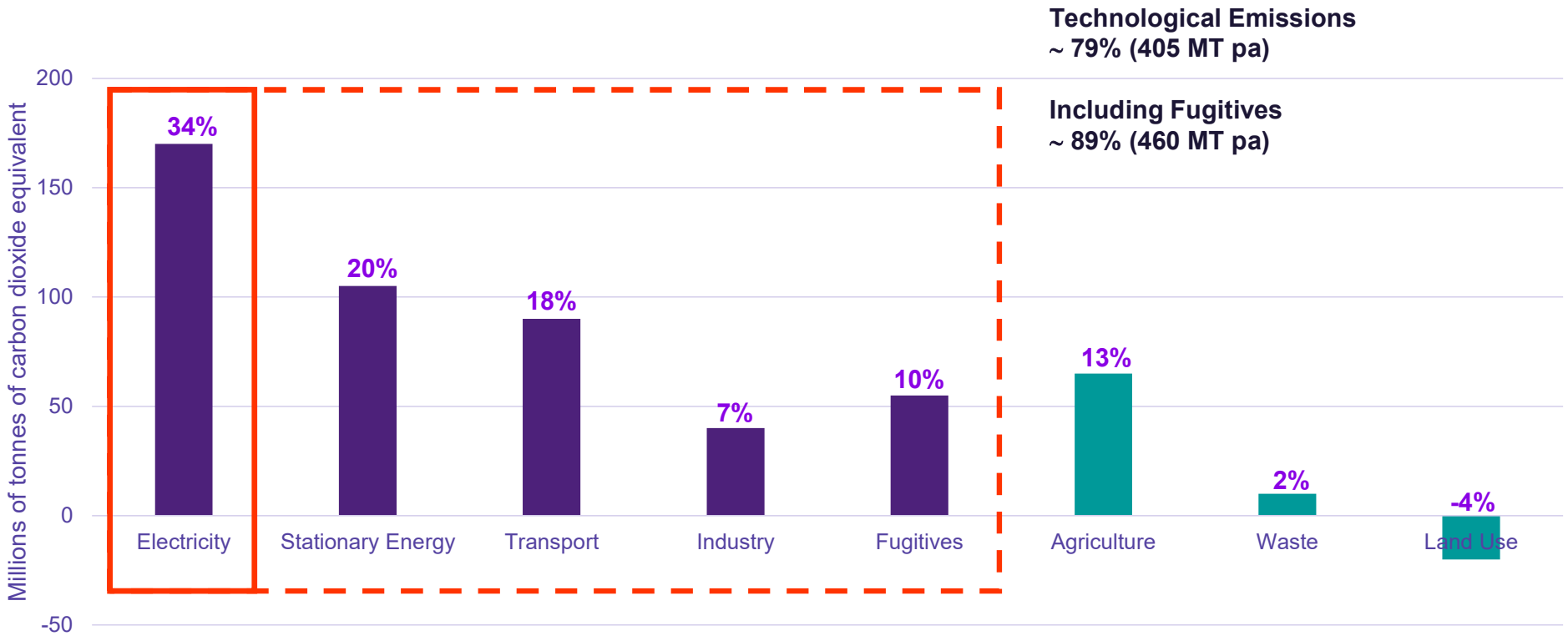


Our Goal: Guidance for a plan to achieve net zero by 2050 and how Green Hydrogen must be a part of this plan



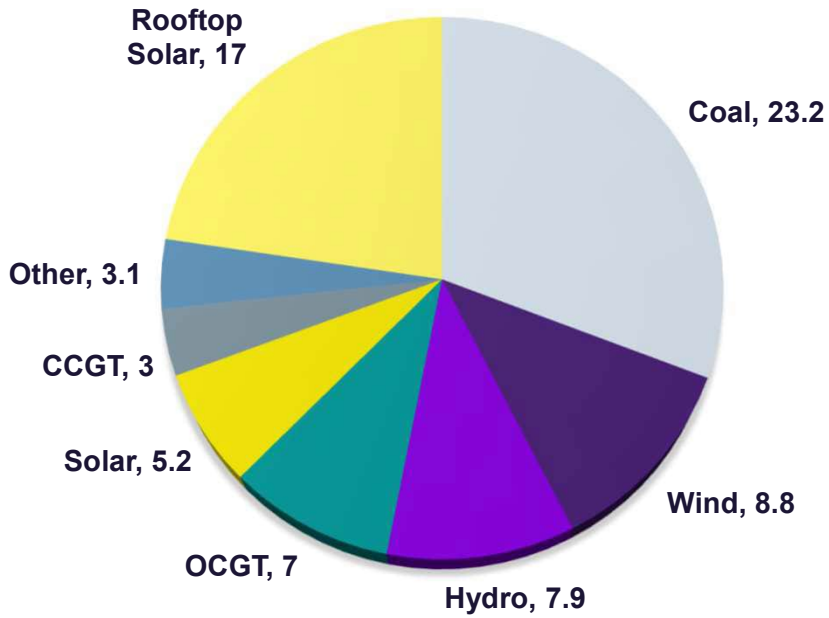
Today's Emissions and Electricity Generation

Today's CO_2 Emissions – Total 515 MT pa CO_2 e

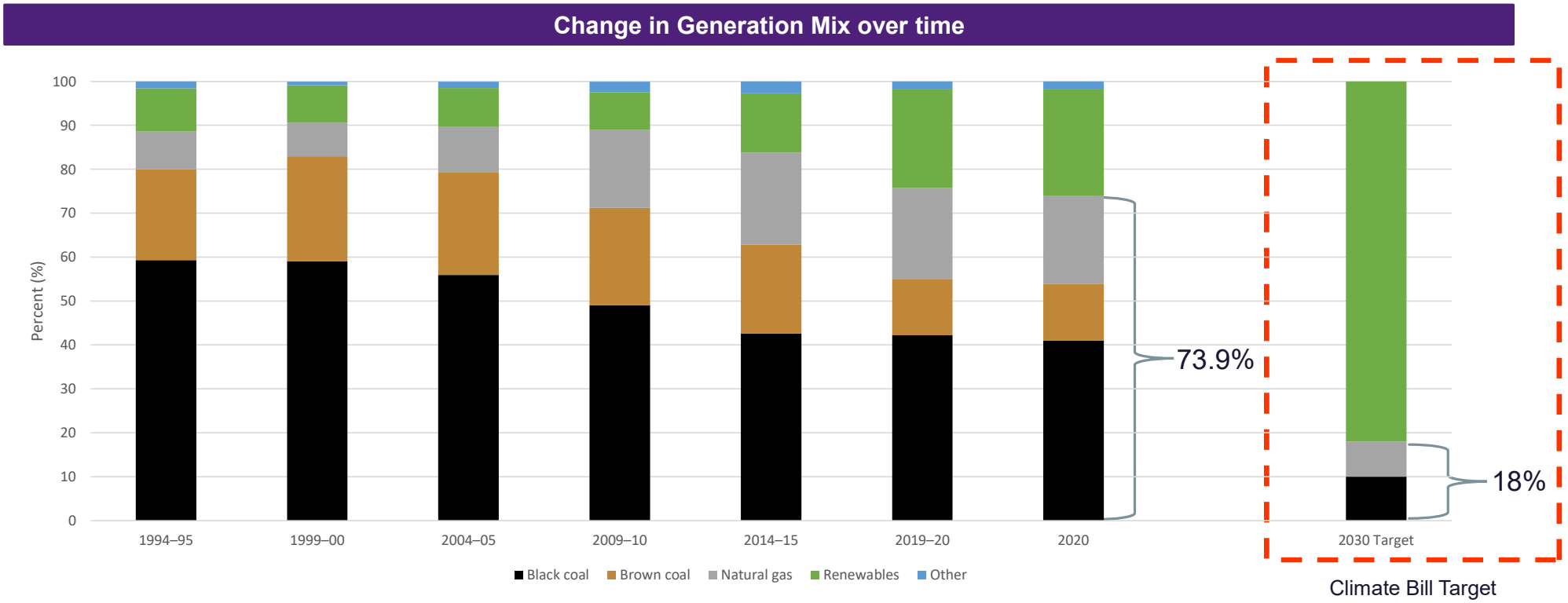


Data from Quarterly Essay – Getting to Zero Australia's Energy Transition, Alan Finkel)

Installed Generation Capacity – Total 75 GW (incl rooftop solar)

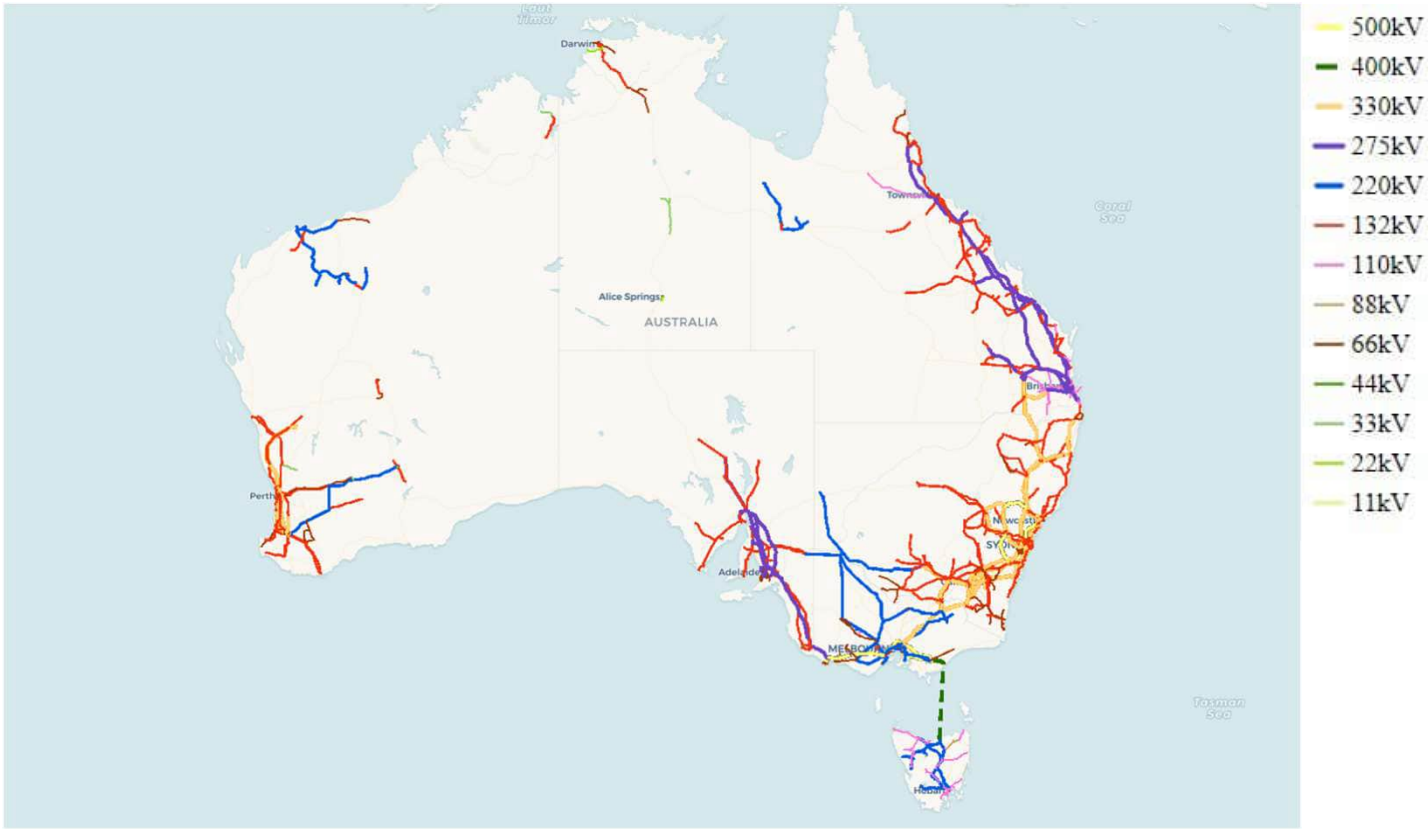


Today's Electricity Generation Mix

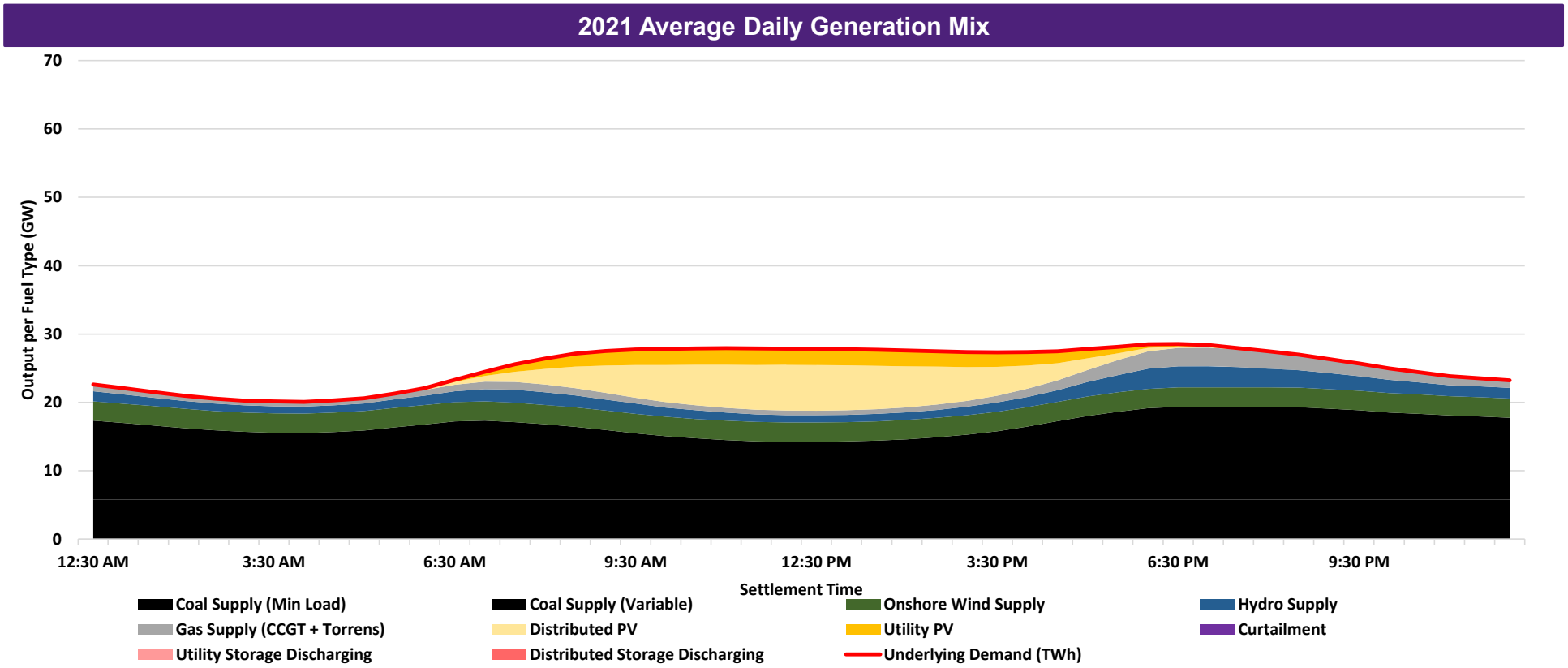


Source: https://www.energy.gov.au/data/electricity-generation

High Voltage Transmission Network(s)



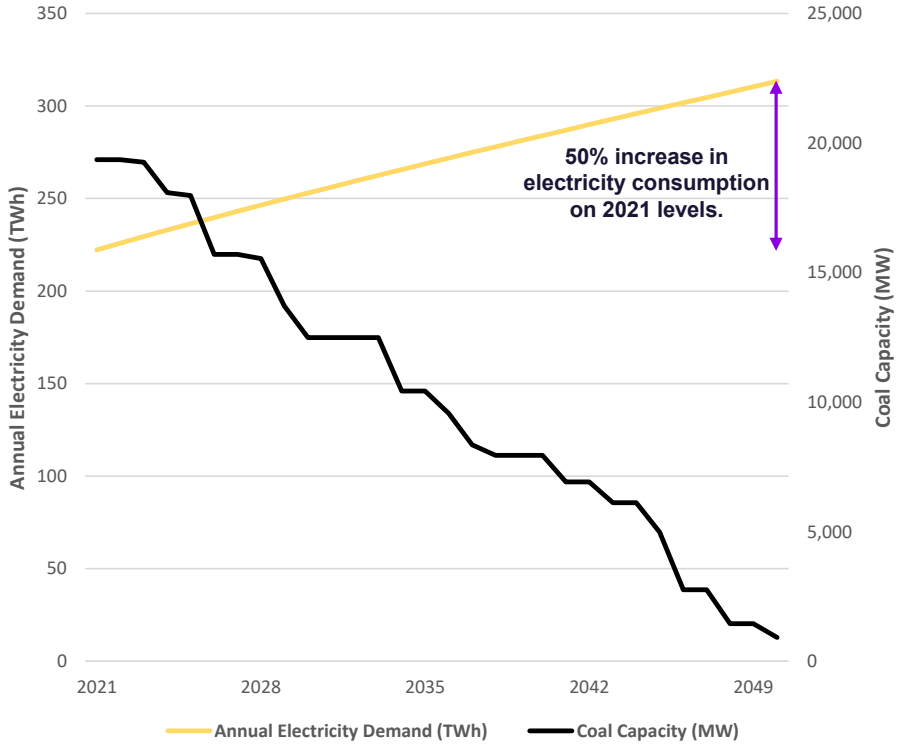
Typical 24 Hour Generation Profile - Today



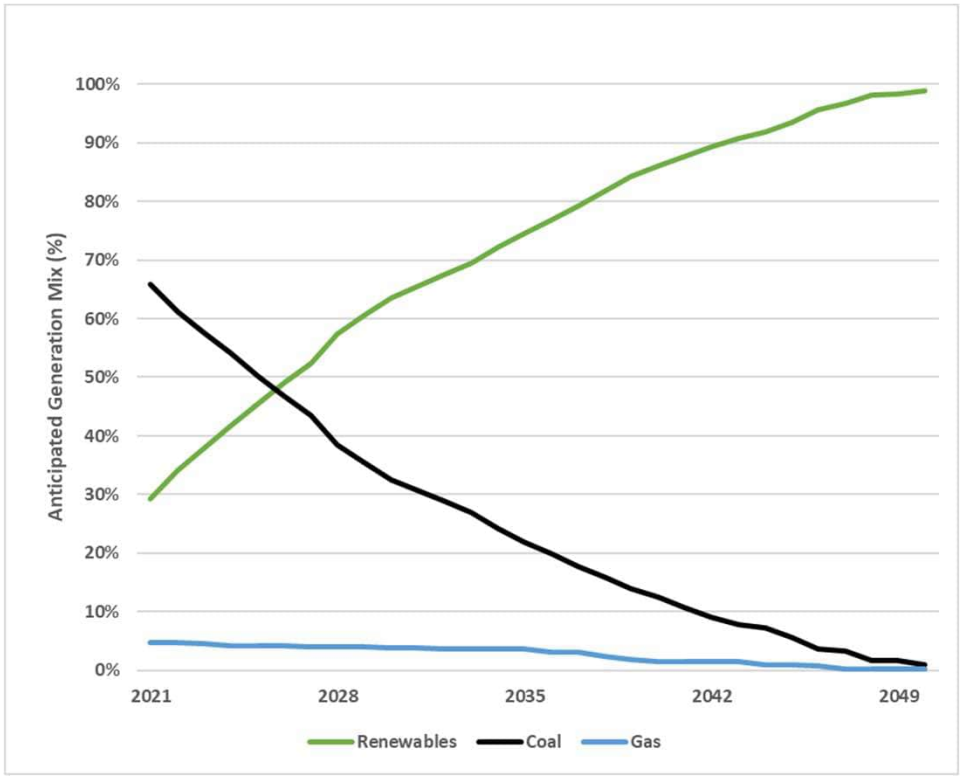
Electricity Net Zero
“The Thought Experiment”

Massive change in generation type

50% increase in electricity consumption on 2021 levels

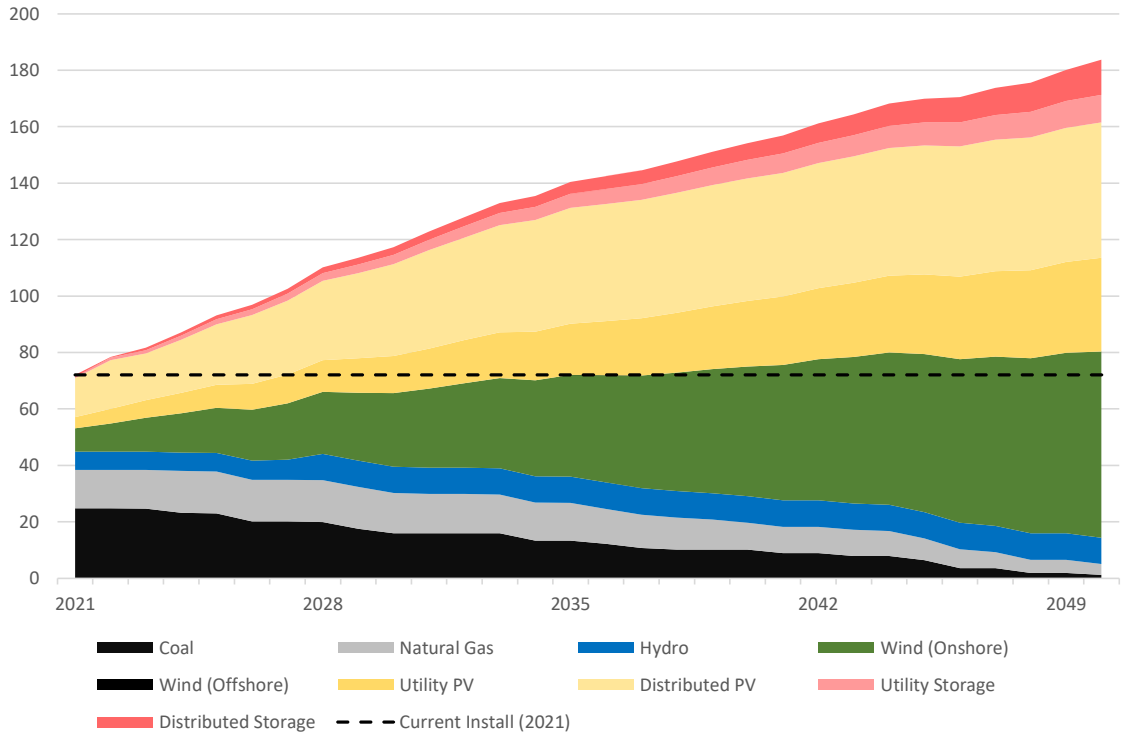


Anticipated Generation Mix Change to 2050



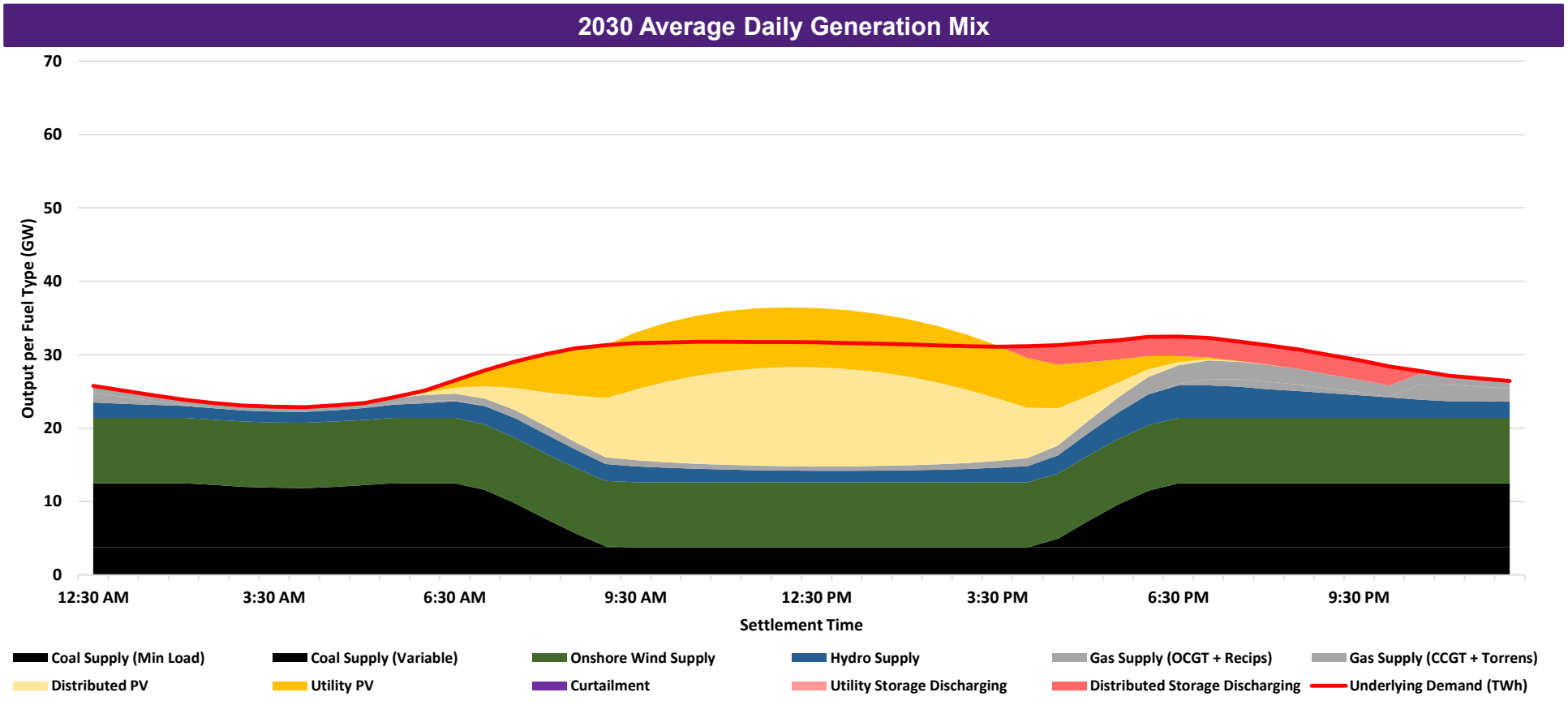
Electricity Net Zero 2050– Installed Capacity / Growth Rate

Total Generation Capacity by Type (GW)



Growth Rate	Av 2019-21	2050 (Scenario)
Distributed Solar PV	2,500 MW pa	2,000 MW pa (until 2035)
Utility Solar PV	1,000 MW pa	1,000 MW pa
Wind	850 MW pa	2,000 MW pa
Distributed Storage	170 MW pa 340 MWh pa	400 MW pa 1600 MWh pa
Utility Storage	133 MW pa 205 MWh pa	320 MW pa 2,000 MWh pa

Electricity Net Zero - Typical 24 Hour Generation Profile (2030)



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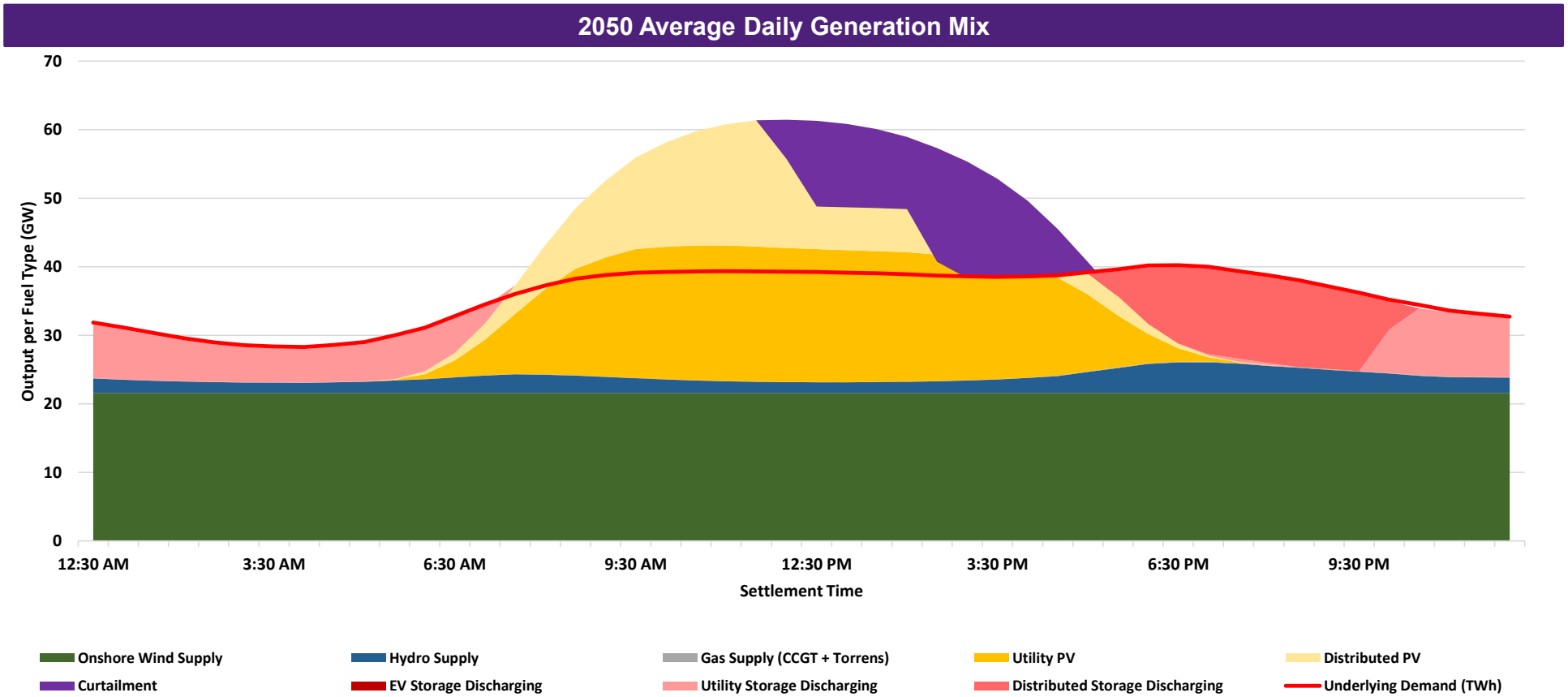


Net Zero by 2050 “Everything”

Displace Coal, Gas, Petrol, Diesel & Aviation Fuel ("Everything") The Design Questions

Electrify wherever possible

Stop importing petrol – 100% passenger EV's by 2050

Electric Vehicle Arbitrage (EVA) will provide significant storage – reducing the required utility scale storage by around 1/3.

Use hydrogen everywhere else

Stop importing diesel, aviation fuel and other petrochemicals – replace with hydrogen or derivatives

Hydrogen production will become like the current oil & gas industry – 24/7/365

Key Design Questions

How much additional electricity do we need for direct electricity and green hydrogen??

How much more wind / solar / storage do we need to produce this additional electricity?

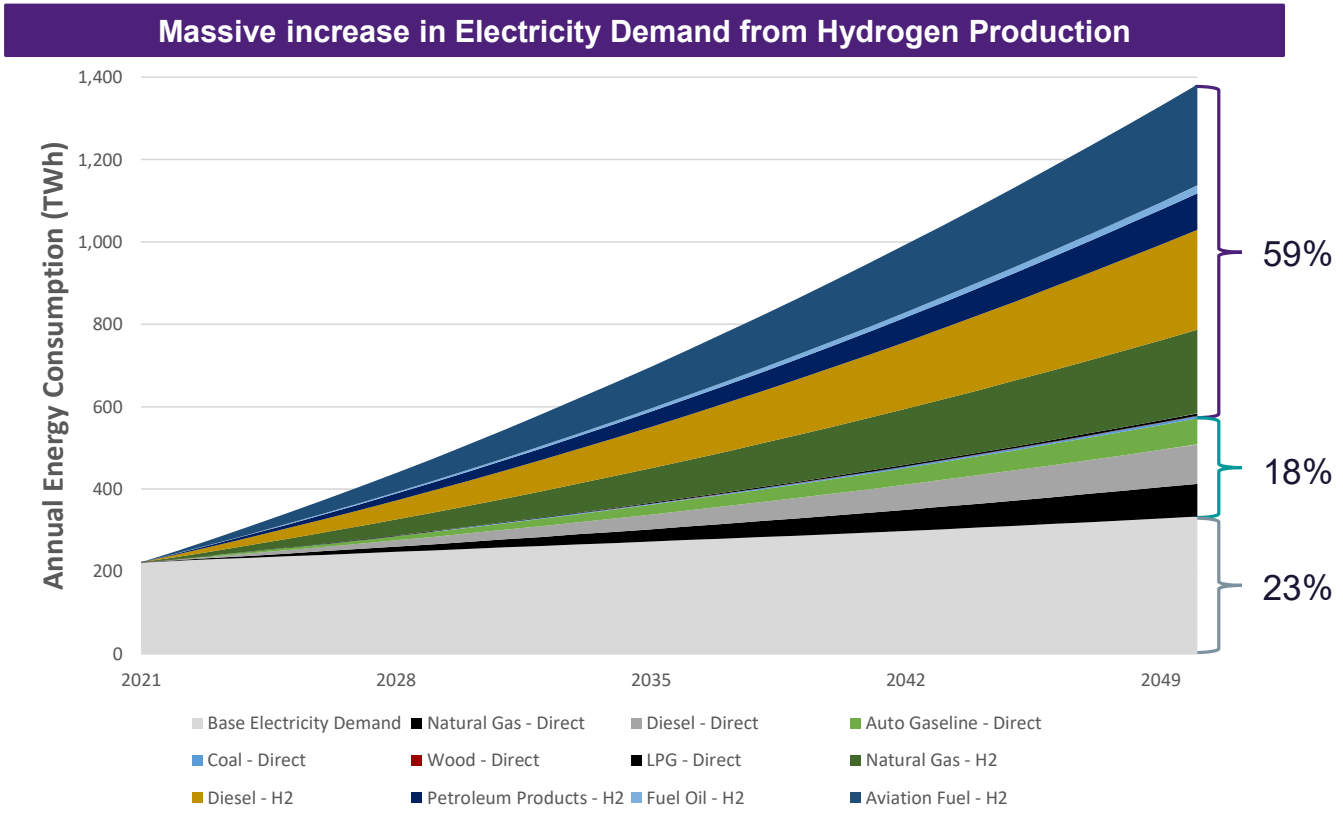
How do we address the long-term storage issue (3-5 days of bad weather)

Displace Coal, Gas, Petrol, Diesel & Aviation Fuel ("Everything") Required Electrical Generation (1400 = 4 x 330 TWh)

Fossil fuels replaced by Hydrogen
800 TWh (59%)
- Natural Gas, Diesel, Petroleum Products, Avgas, Fuel Oil

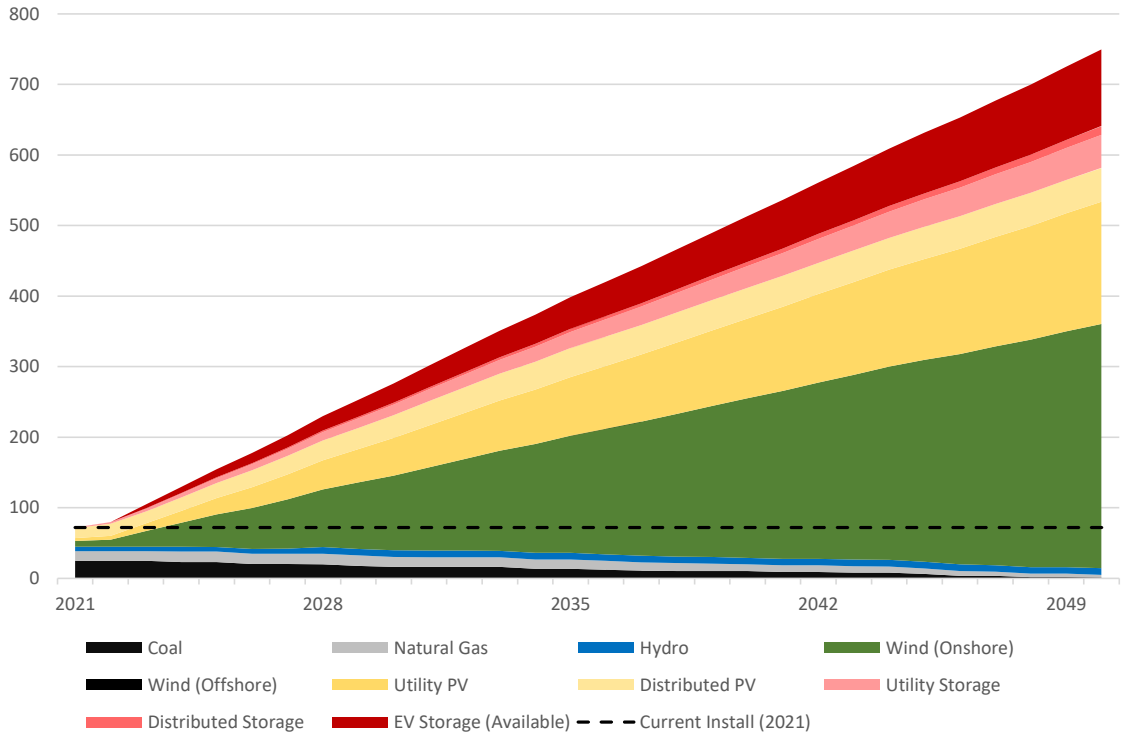
Fossil fuels replaced by Electricity
250 TWh (18%)
- Natural Gas, Diesel, Petrol

Base Electricity Demand
310 TWh (23%)
- Grows with population growth



Everything Net Zero 2050– Installed Capacity / Growth Rate

Total Generation Capacity by Type (GW)



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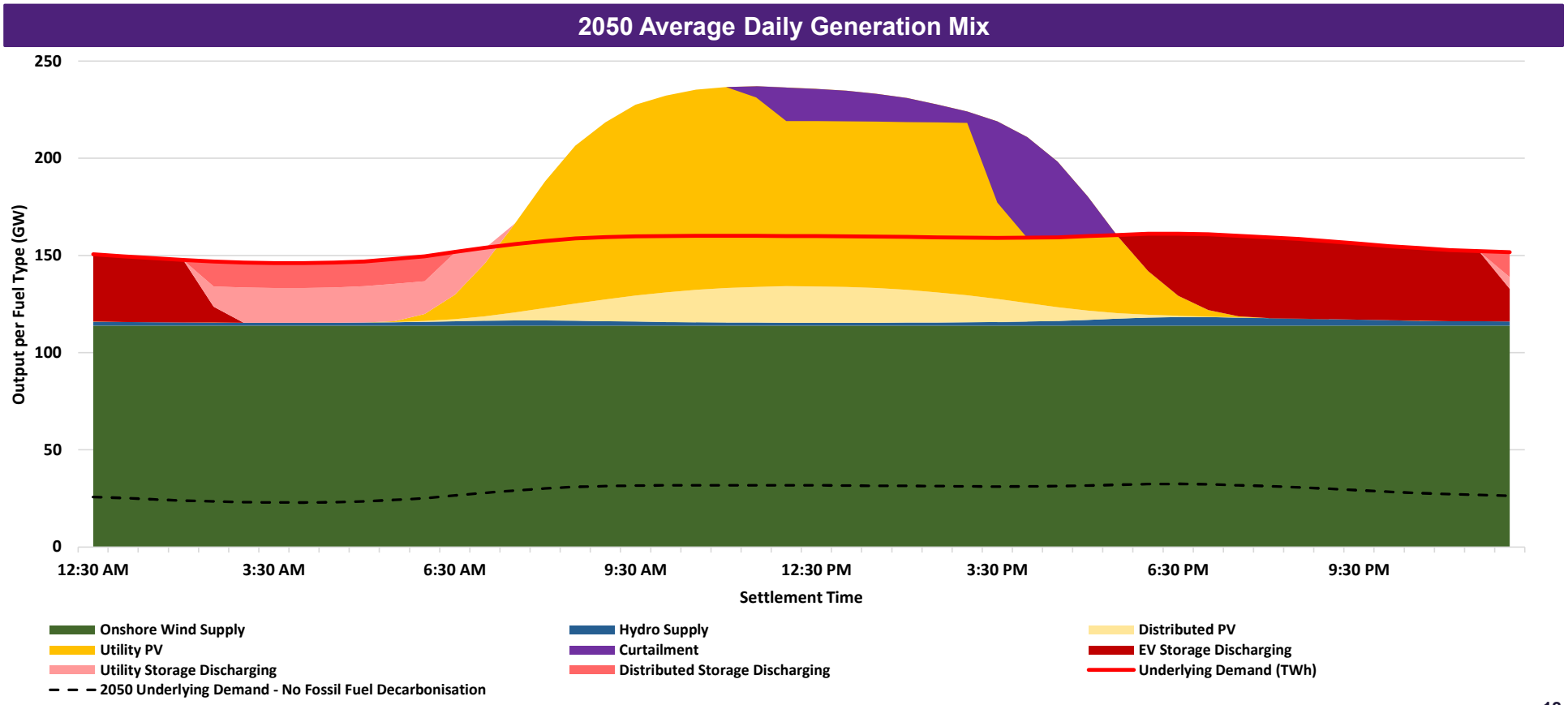
Displace Coal, Gas, Petrol, Diesel & Aviation Fuel (“Everything”) Typical 24 Hour Generation Profile (2050)



Summary of Findings

How big is big?

Requirements
180 GW Utility Solar: 60 x 60km = 3600 km2 0.05% of Australia 135 MW per week 2021 World production = 3.2 GW /wk
360 GW Wind: 72,000 Turbines 48 Turbines per week 2021 World production = 350 Turbs/wk
340 GWh Batteries: 7.5 x 7.5 km = 60 km2 220 MWh per week 2021 World production = 570 MWh/wk

Summary of Findings – Society and Economics

The Net Zero Challenge

- Net Zero electricity is clearly achievable
- Net Zero for all of energy is much more challenging!!

Regulation

- Likely need a carbon price to make all of this work Energy costs will increase (social/political issues)
- Must have a regulatory target for green hydrogen in order to kick start the industry (Natural gas dilution or transport diesel replacement)

Supply Chain Issues

- The magnitude of investment, equipment and raw materials is very large
- It seems likely there will be competition for resources, factory capacities, etc.
- Some technologies are likely to be chosen for the raw materials that they use (or do not use)

National Economics

- The costs are likely to be in the range of 5% of GDP pa for 30 years.
- At the end of this period of investment, there will then be the ongoing capital replacement process at a lower level of investment
- In Australia, these costs will be reduced by the petroleum that is no longer imported

Summary of Findings - Technology

Renewable Generation

- Very significant growth of wind and solar generation required
- Some form of “base load” renewable generation (eg geothermal) would be very beneficial

Hydrogen Production

- More electricity is used for hydrogen than for “electricity”. Hydrogen production becomes a huge 24/7 industry.
- Hydrogen and liquid chemical derivatives are a key part of achieving net zero

Energy Storage will be critical

- Geographic distribution of renewable generation reduces need for storage
- Hydrogen industry acts as “free” long term energy storage
- Electric Vehicle Arbitrage (EVA) - Reduces required utility storage

Impact on Transmission

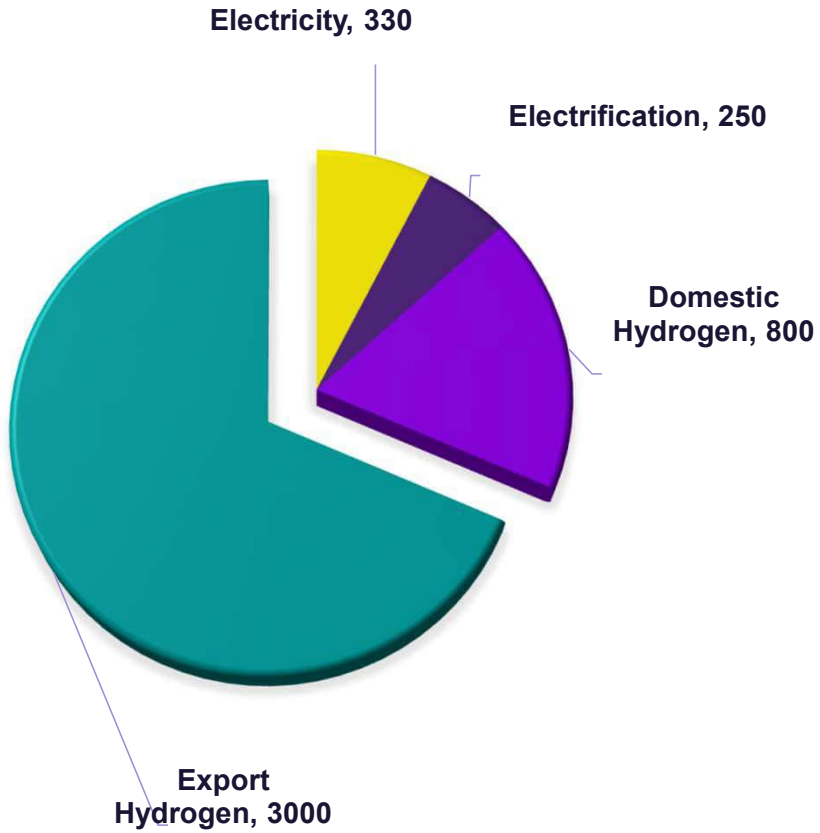
- Significant increase in transmission due to geographical distribution of renewable generation
- East-West Link (Nullabor)
  Multiple Bass Straight links
- Residential batteries to manage Solar + EVA
  House Virtual Power Plants (VPP’s)

What about energy export?

Domestic Electricity Consumption	
Generation Required	1400 TWh pa
Renewable capacity:	590,000 MW
(approx. 10 x current NEM)	

Export Energy (2020)	
Natural Gas	4,000 PJ pa
Coal	11,000 PJ pa
Total	**15,000 PJ pa**

Electricity to produce H_2 equivalent:	3,000 TWh pa
Additional renewable capacity:	1,270,000 MW



Guidance for a Plan and Conclusions

Guidance for a Plan – The Near Future Investment (2030)

We have a goal, now need a plan!

Need a plan to achieve net zero that is flexible and can be adapted as things change over the next 30 years.

Transmission

Existing REZ (renewable energy zone) plans are a good start

Need a plan for a stable grid that can transmit 1400 TWh pa

“Nullabor Link” (East–West HVDC transmission line), Tasmania links at HVDC

Renewable Generation

Utility solar: Must grow quickly combined with large scale storage

Rooftop Solar: Must be linked with house battery and house VPP

Wind: Onshore must grow quickly, viability of offshore to be tested

Electric Vehicles

A key part of reducing emissions

Need integration into house VPP

Requires government policy to phase-out pure internal combustion engine vehicles.

Guidance for a Plan – The Near Future Investment (2030)

Green Hydrogen

- Economics is the key! Current small-scale projects only work with large subsidies
- Focus on diesel replacement, natural gas dilution and chemicals. Export – will this work at $6-8kg?
- To start the growth of the industry must have a regulatory target for green hydrogen

Blue Hydrogen and Natural Gas

- Blue Hydrogen needs CCS – can this really be made to work economically at scale in multiple locations?
- If coal shuts more quickly than renewables are built, then natural gas may have a significant role as a transition fuel

Geothermal (renewable base load)

- Can this technology be made to work economically without the requirement for special geology?
- The higher capacity factor of geothermal is the key issue in driving the economics

Technology and Manufacturing

- At the volumes required does in-country manufacturing start to make sense?
- Solar: Find the next step change in cost/technology
- Batteries:
  - EV's likely to dominate Lithium / drive up the price
  - Grid batteries need to be cheap, not light – what is the right technology?

Conclusions – Is all of this actually possible?

Difficult to answer!

We have a clear goal, we now need to develop a plan and execute.

We must start – now, if we are to have any chance of achieving net zero by 2050

Green hydrogen will play a key part in the transition to net zero, and will replace much more than just natural gas, however, like any technological solution, it must be applied intelligently in the context of the overall energy landscape.

All of this will require strong national and international alignment….

Thanks for your attention!

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