ENGINEERS AUSTRALIA

CPD Online

# Nuclear Power – Australia's Secure Energy and Climate Solution 2021

# Acknowledgement of Country

- Engineers Australia acknowledges the traditional custodians of the country throughout Australia and recognises their continuing connection to land, waters and community.

- We pay our respects to them and their cultures; and to elders past and present and emerging.

Speaker

# Robert James Parker

Founder- Nuclear for Climate Australia

# Nuclear Power – Australia's Secure Energy and Climate Solution 2021

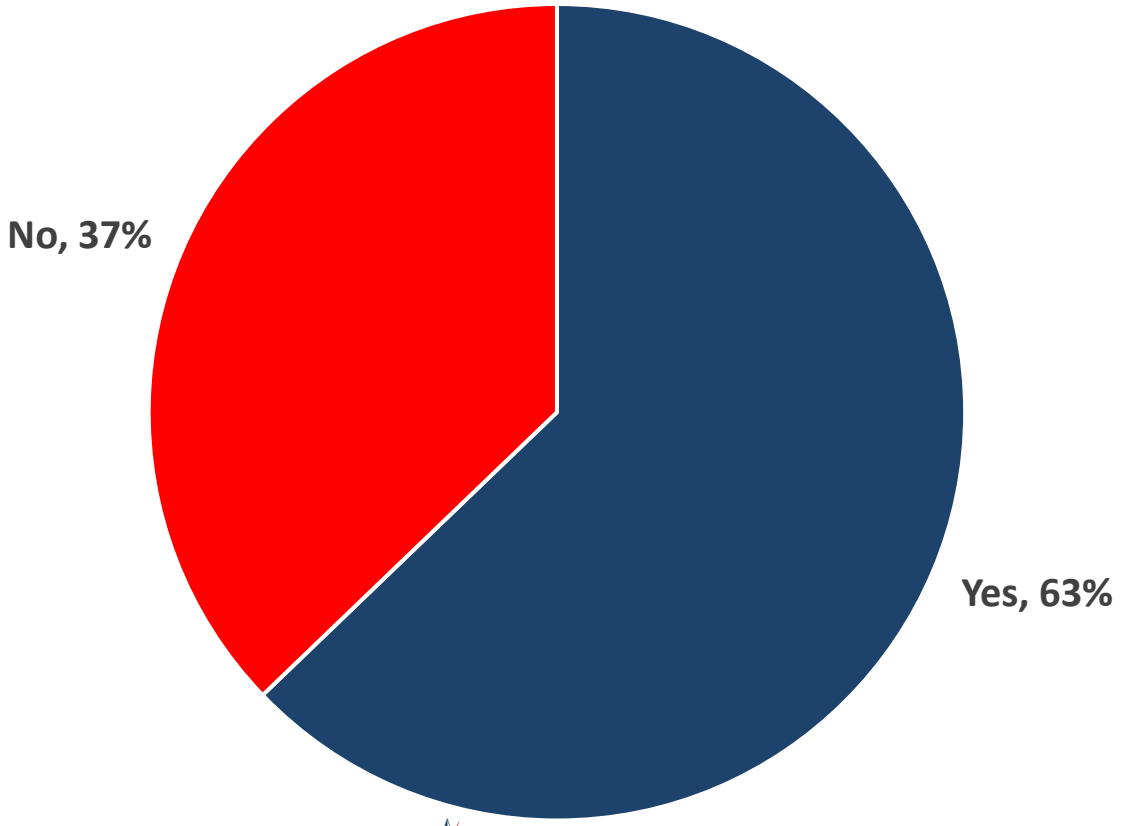
Rob Parker – Nuclear For Climate Australia

1. Who wants low cost, low carbon nuclear energy?
2. Why build nuclear energy – its costs and reliability compared to other low carbon options?
3. What could we build?
4. Where would we build them and how long would it take?

https://nuclearforclimate.com.au/

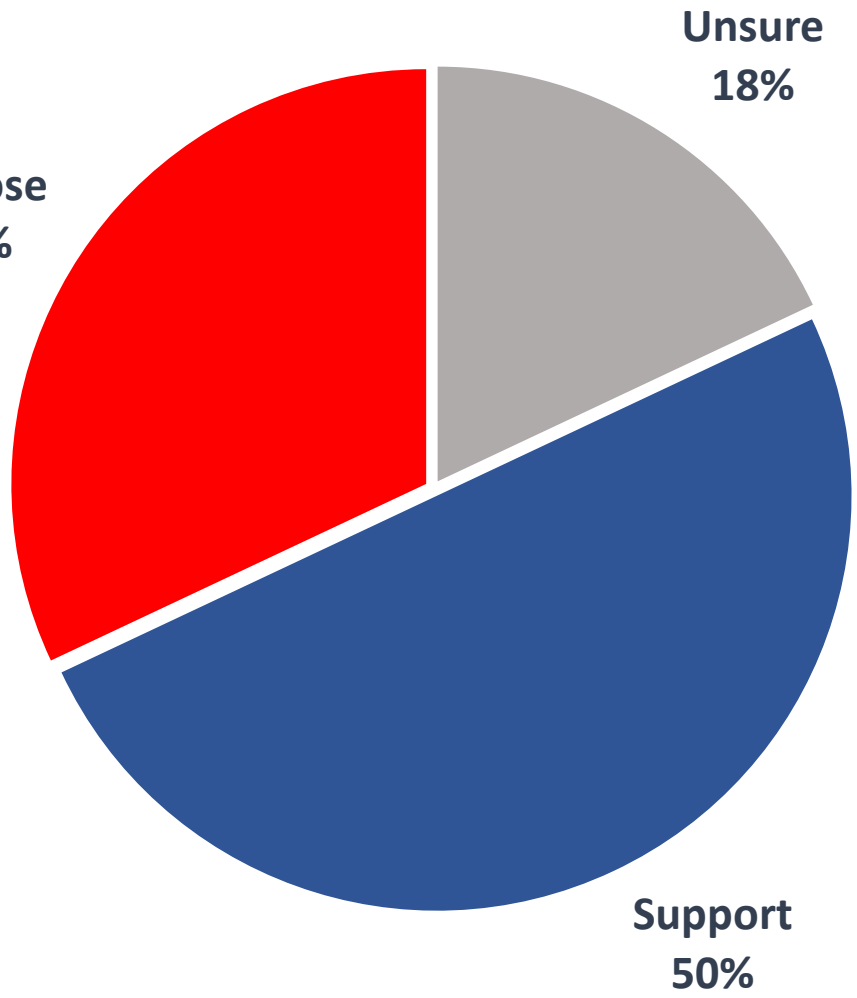
# Who wants low cost low carbon nuclear energy?

Nuclear technology is used to generate much electricity in advanced economies like France, USA, China, Sweden, UK and Canada.
Its safety and reliability have improved considerably in the last 20 years.
Do you think Australia should reconsider nuclear in our plan for cleaner energy and meeting our Paris Agreement targets?



# To what extent do you support or oppose Australia developing nuclear power plants for the generation of electricity?

Essential Polling 28-9-2021




"In a fascinating development, 50 per cent of Australians support the idea while 32 per cent are opposed"

# Why build nuclear energy?

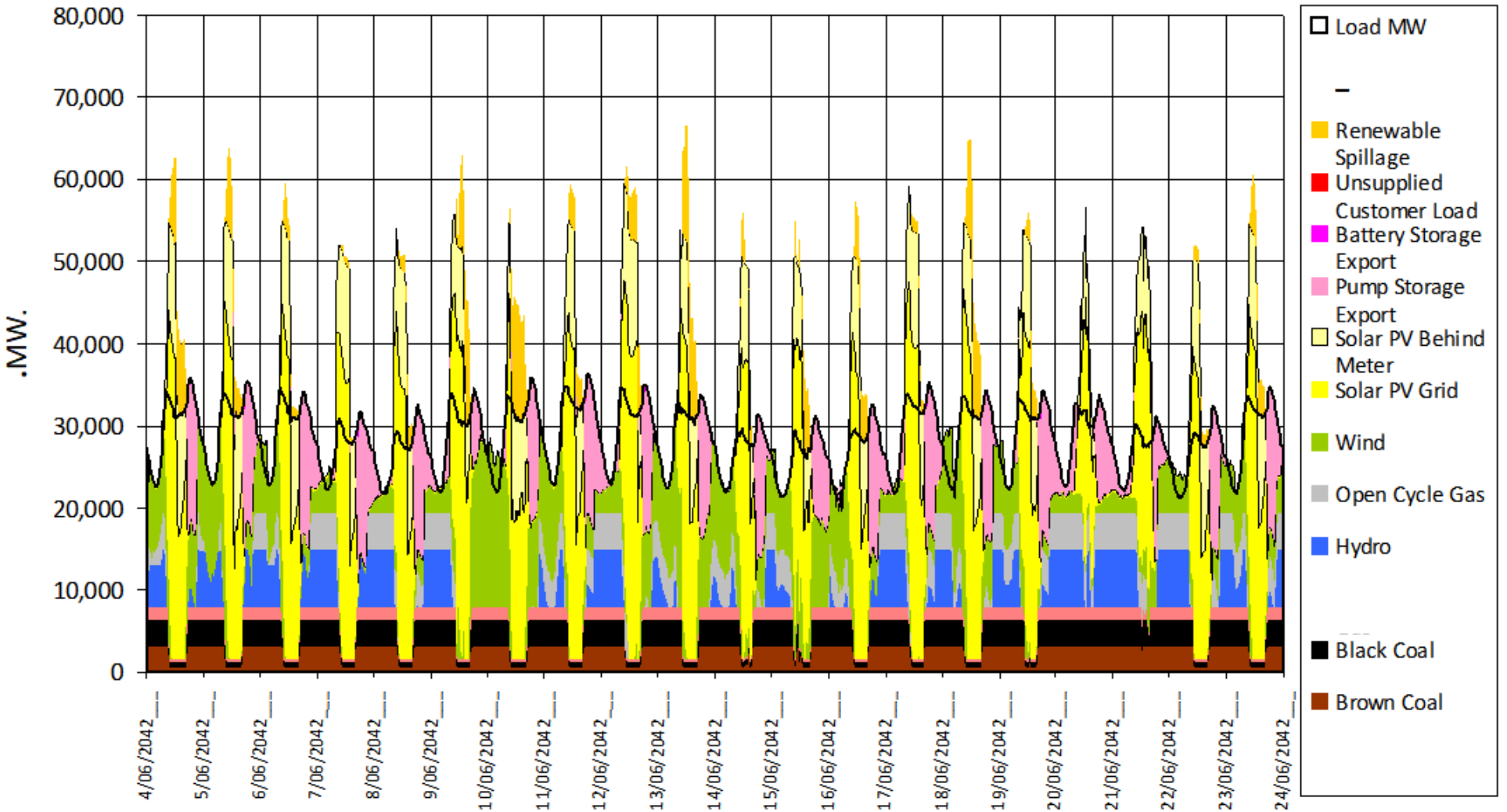
For a dry climate, nuclear fission is the only proven means of achieving economical ultra low carbon energy

- Reliability
- Low Cost Electricity
- Low carbon
- Regional renewal, education and wealth generation
- Most sustainable use of non-renewable materials

Nuclear for CLIMATE AUSTRALIA

Priority access to the NEM by intermittent renewable generators displaces baseload coal.

Becomes more difficult to provide low cost electricity and manage variability.

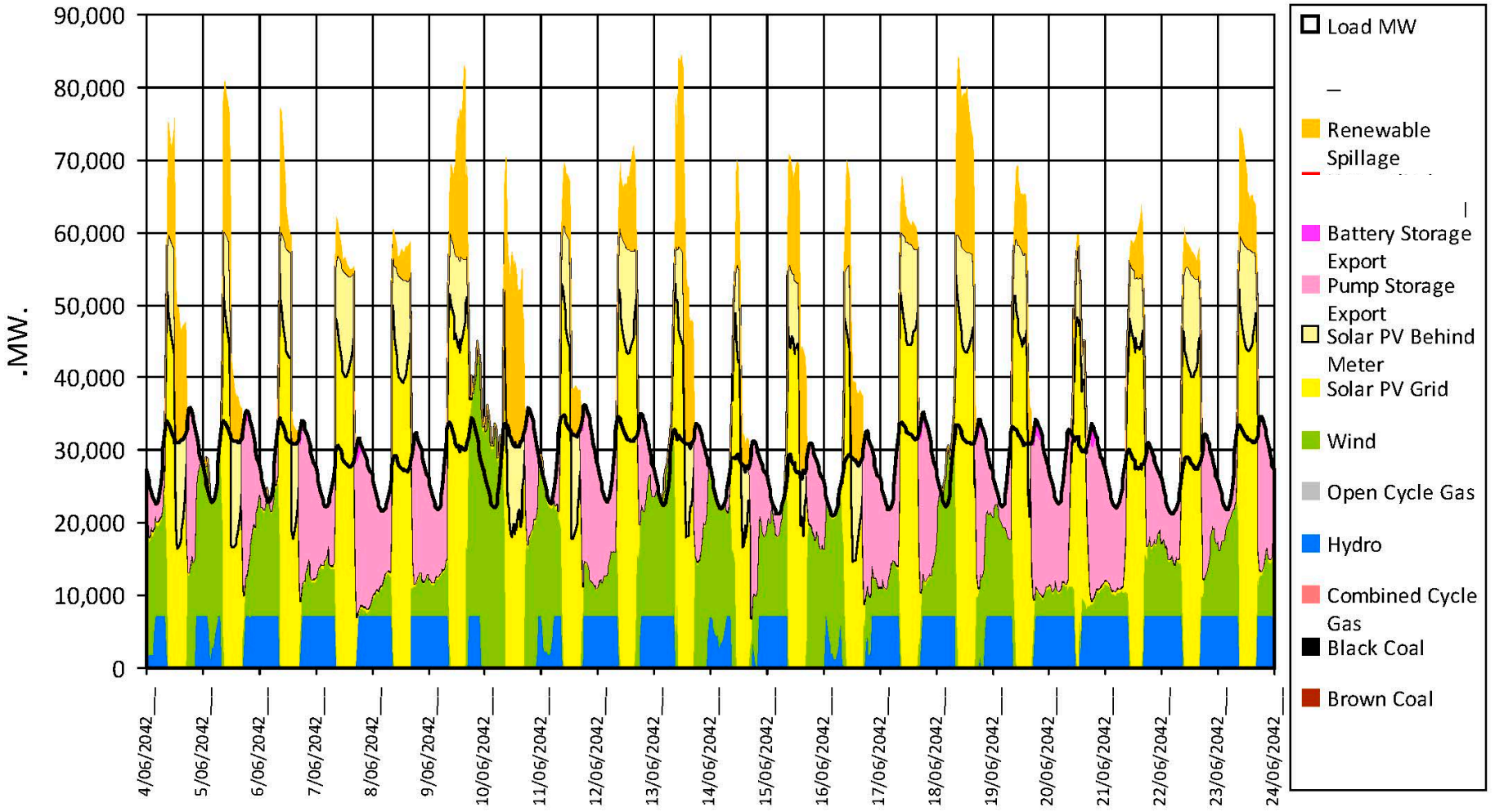



52, 560 data points

Nuclear for CLIMATE AUSTRALIA

**Electric Power Consulting Pty Ltd**
**Power System Generation Mix Model**

ISP Fast 100% RE 21GW PS

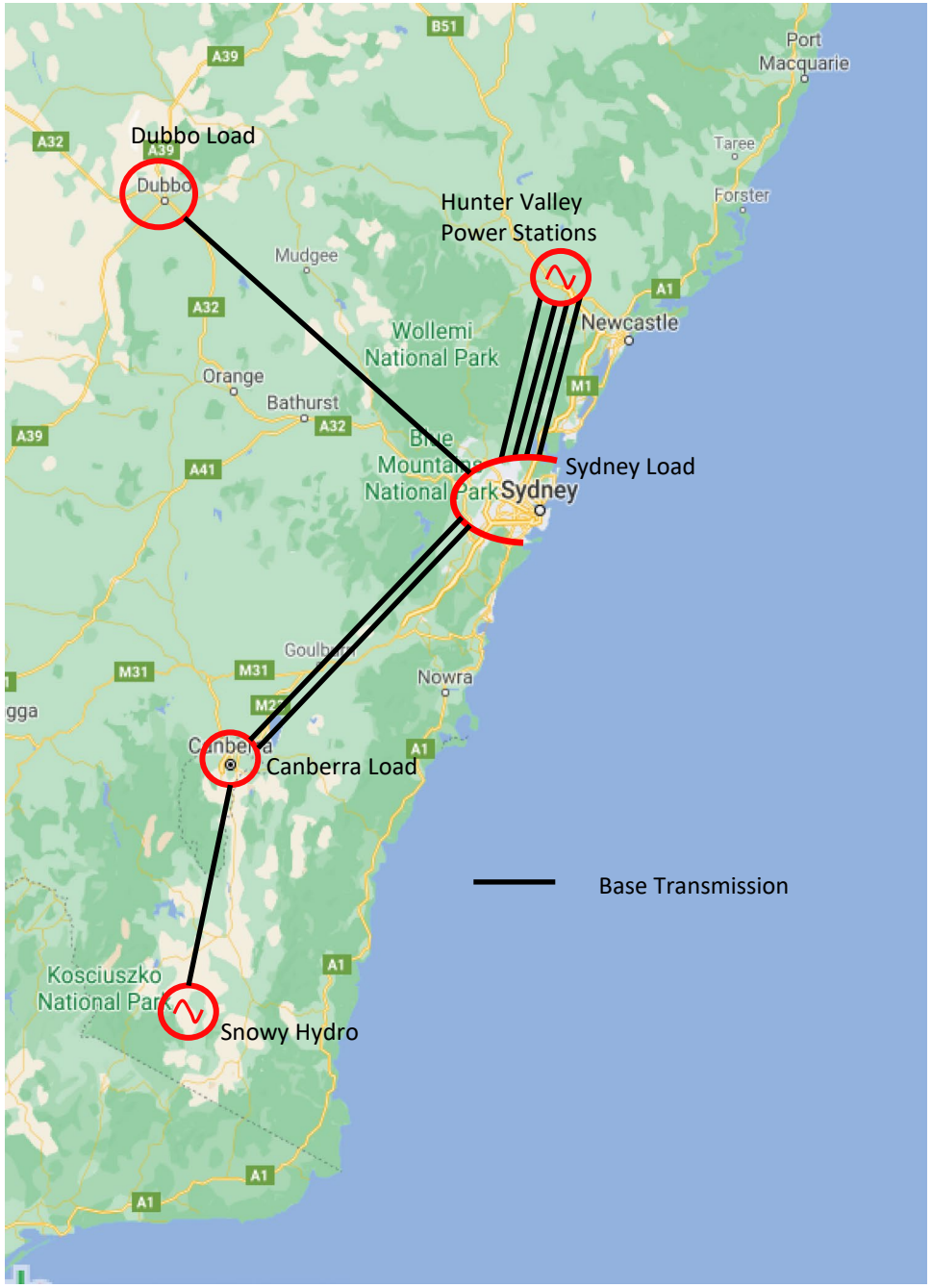



100% renewables even with large scale storage incurs large levels of "spillage".

Its use in hydrogen production is problematic due to varied availability

# Transmission

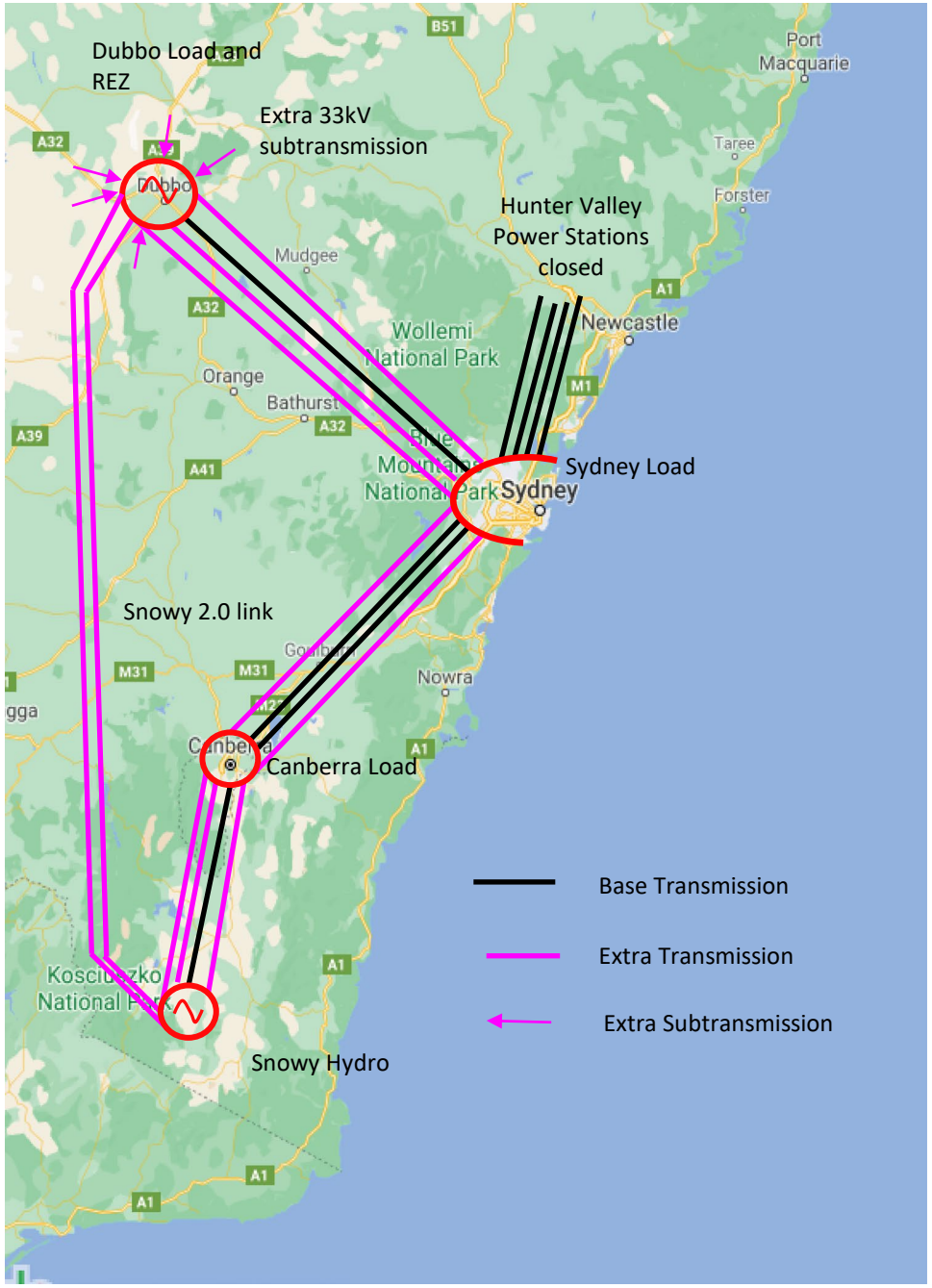
## Existing with no Renewable Energy Zones




Note: This is a simplified conceptual diagram designed to illustration relative strengths and costs of the transmission and subtransmission system.

# Transmission

## 100% renewable with REZ at Dubbo & added Pump Storage at Snowy




Note: This is a simplified conceptual diagram designed to illustration relative strengths and costs of the transmission and subtransmission system.

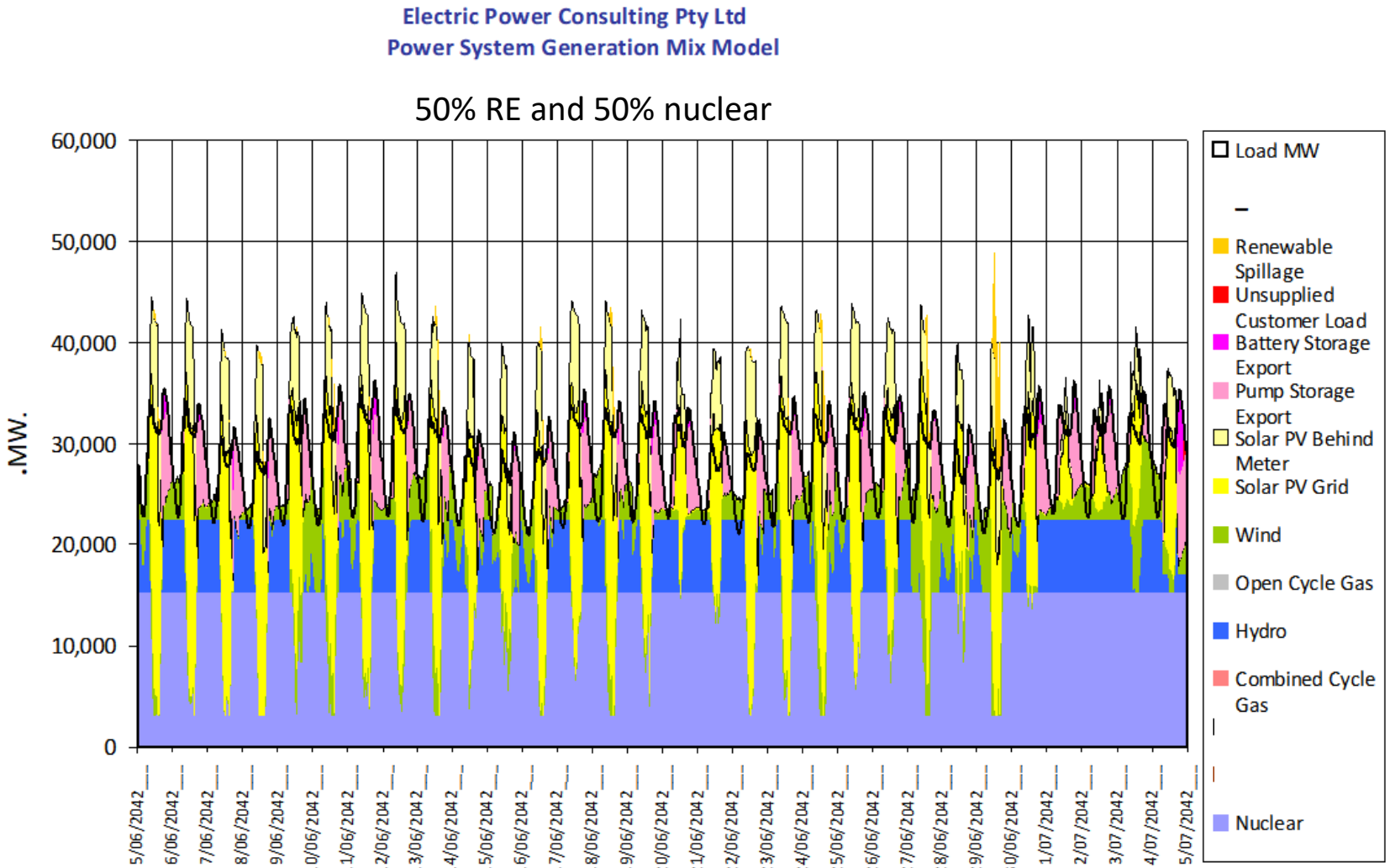
# Options?

1. Nuclear requires a PPA which drives up the costs for dispatchable RE or,

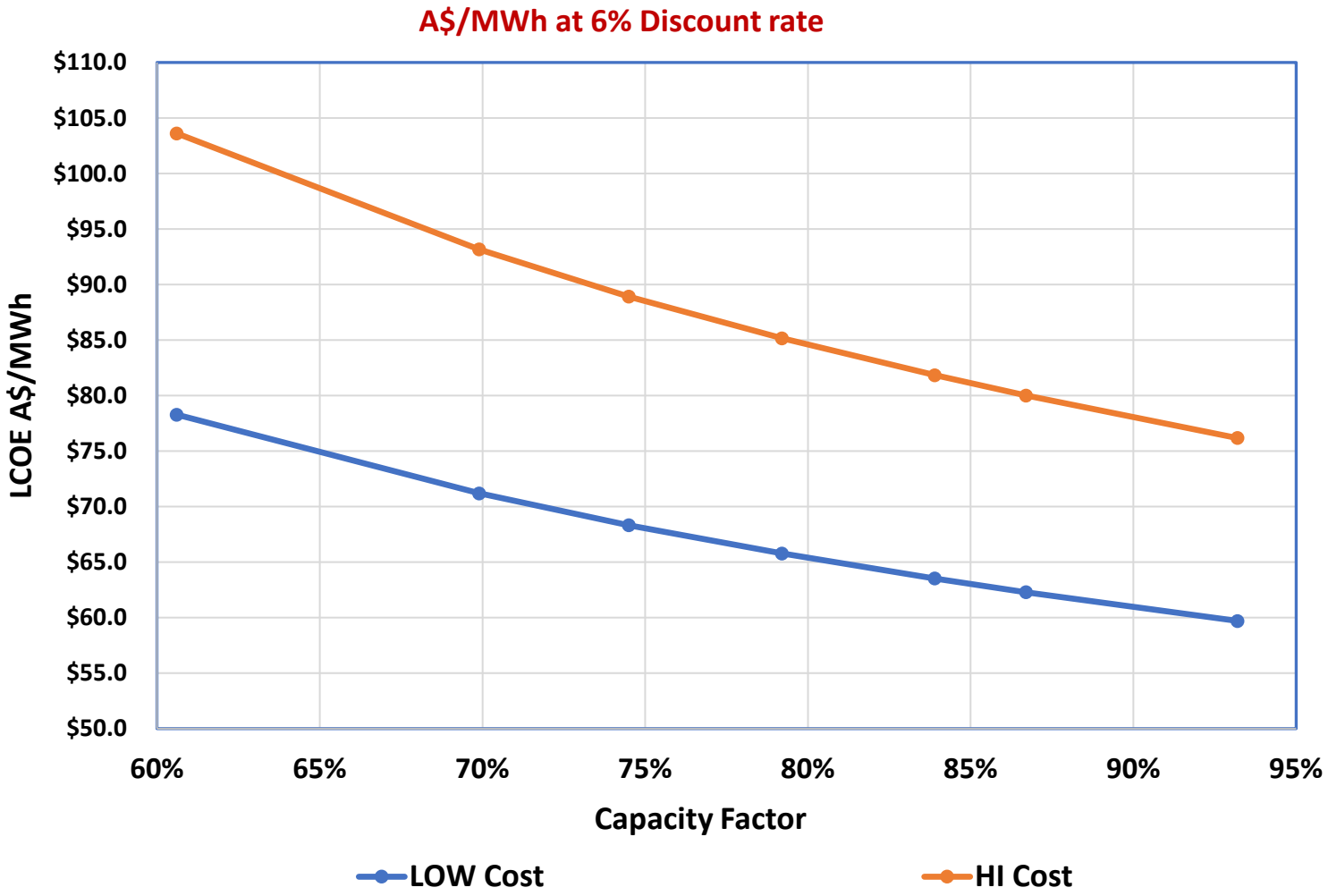
2. Nuclear competes with intermittent RE which drives up nuclear costs due to reduced capacity factors

3. Nuclear load following while possible may not be cost effective

# Nuclear and high levels of variable renewables are not compatible

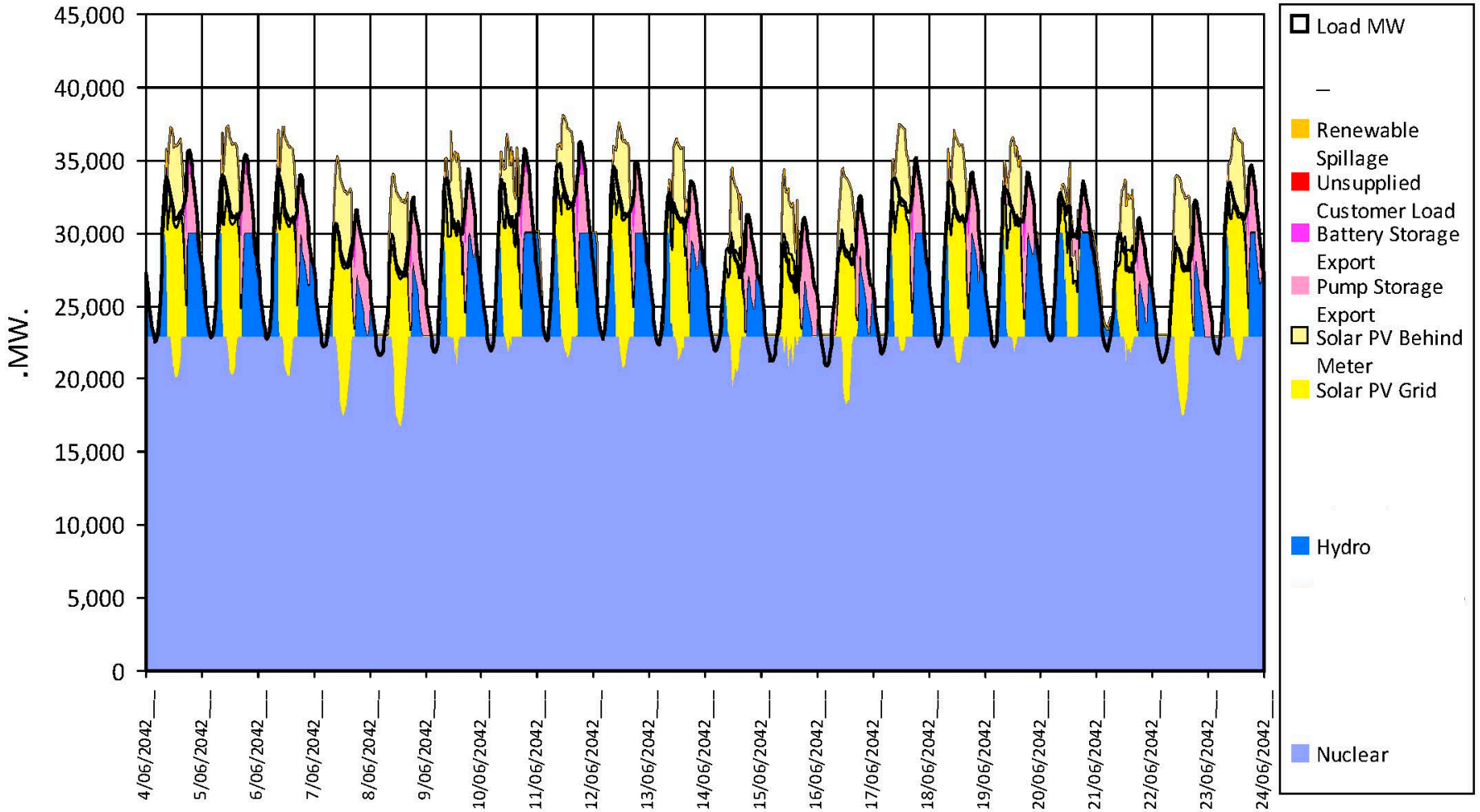


# Capacity factor vs LCOE for BWRX 300 Nuclear Power Plant at High and Low cost base



Nuclear for CLIMATE AUSTRALIA

Electric Power Consulting Pty Ltd
Power System Generation Mix Model




## Nuclear Integrated System Plan.

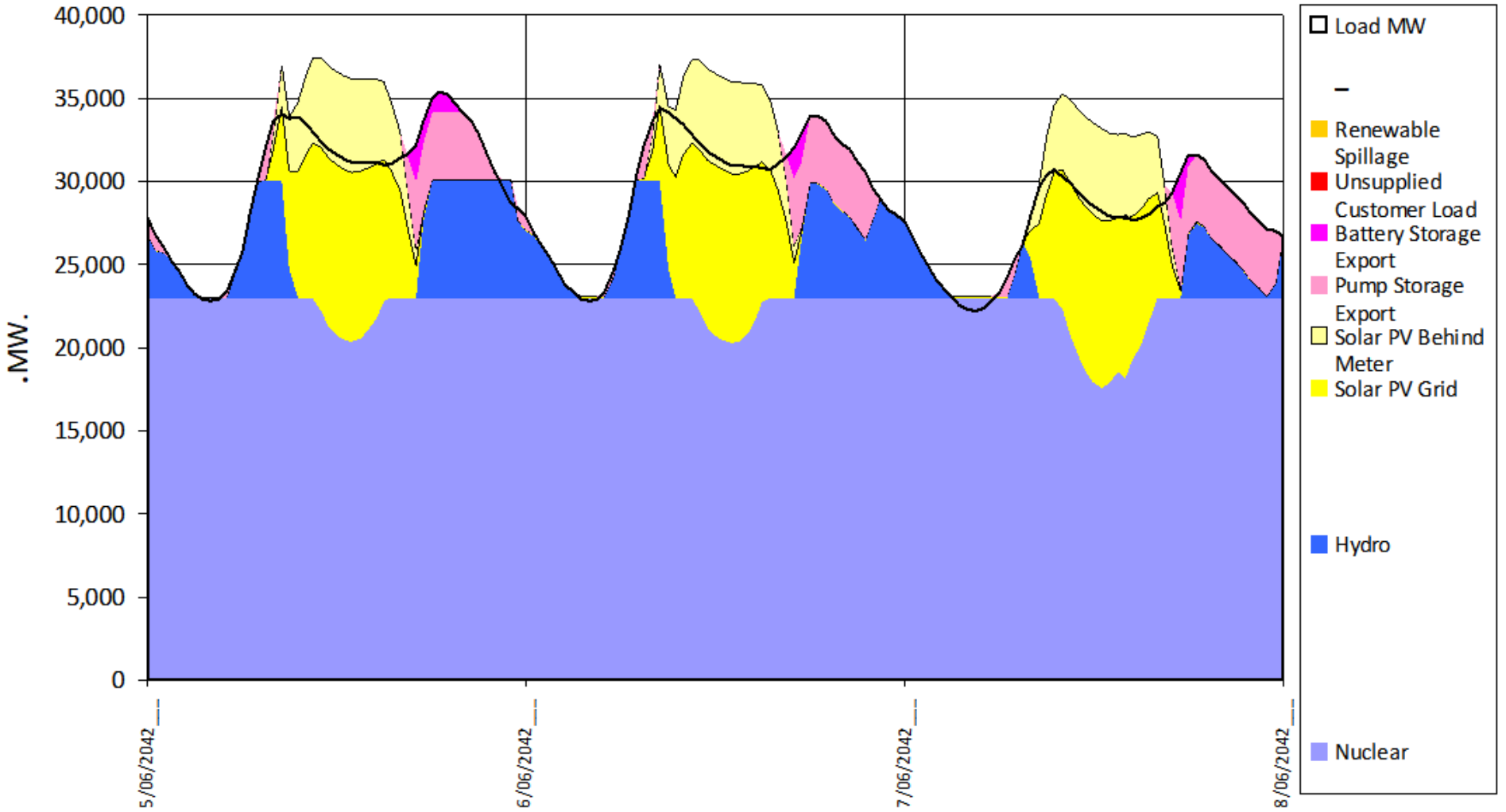
Generation MWh mix:
Solar Utility – 11%
Roof top solar – 6%
Existing Hydro – 7%
Nuclear - 76%

Grid emissions – 22 gr CO2eq/kWh

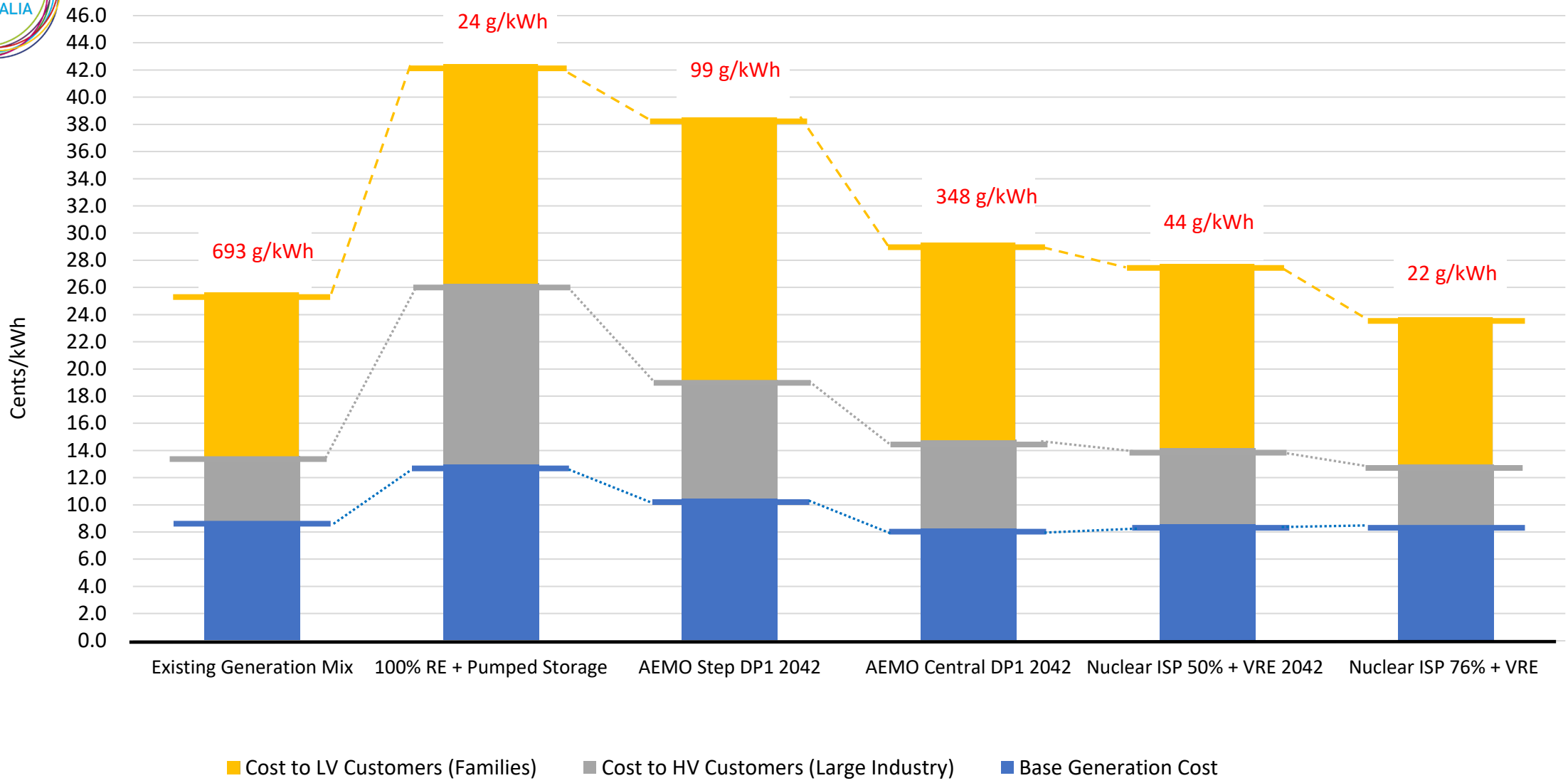
Small Grid
A compact minimalist system.

## Three Day Plot of Nuclear Integrated System Plan

- Note the demand curve
- Nuclear Provides 76% base load
- Solar in excess of demand goes to battery and pumped storage
- Hydro up to 7% of demand provides remainder
- Wind is not used due to high variability which requires expensive gas backup or storage



# Electricity Sector Integrated System Plan Scenarios using 2042 costs



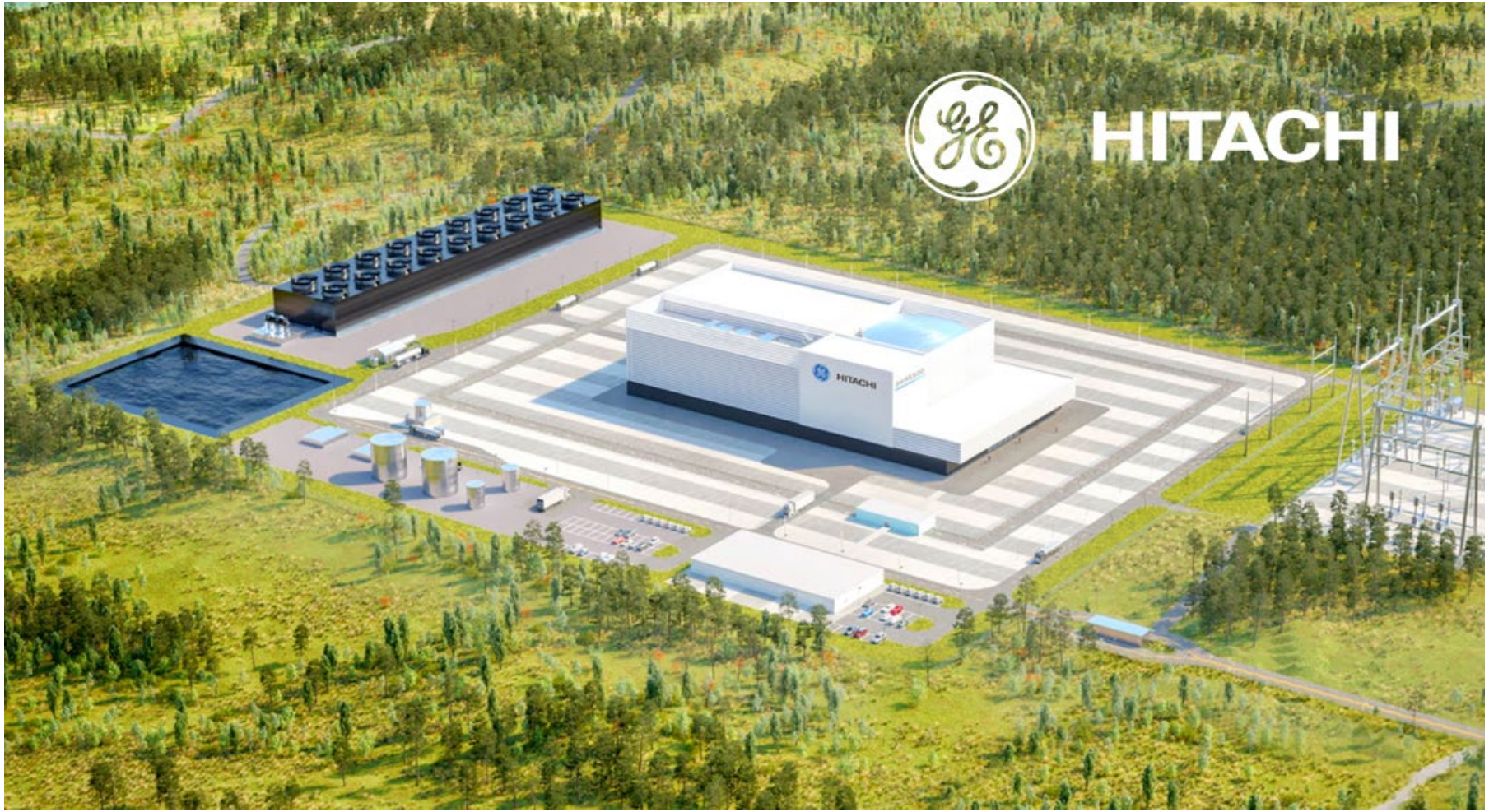

VRE = Variable Renewable Energy

# What would we build and why?

**The future of nuclear energy is in Australia's hands – we can drive decisions made by vendors**

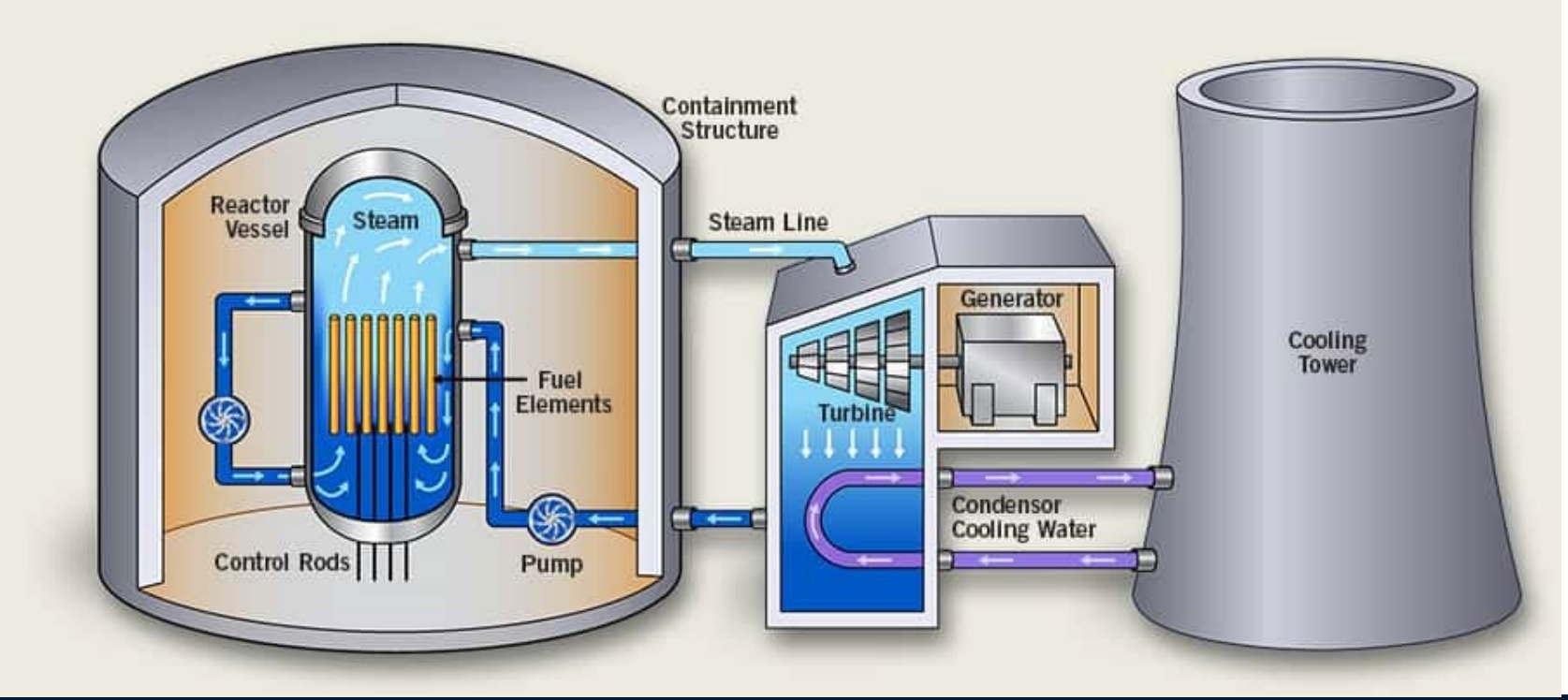
- Lowest cost option requires 24 GW of installed nuclear power capacity
- Equivalent to 80 number 300MW small nuclear power generators combined into groups.
- Availability of small nuclear power plants expected after 2028 however planning and options evaluation could take place immediately
- Options could include 10 Large 1,100MW nuclear power plants in the near term and 13GW of small nuclear plants as they become available.
- Large plants are an option especially suited to Victoria and New South Wales

# Better low cost solution for Australia
# BWRX 300 – 300MWe Small Nuclear Power Plant



# Low impact structure of BWRX 300

# Boiling Water Reactors (BWR) … the simplest way to make steam




INHERENTLY SIMPLE REACTOR DESIGNS

- Direct cycle design with no secondary steam generator and pressurizer
- Traditional balance of plant for electricity generation
- Low enriched (3-5% U-235) oxide fuel in metal cladding
- Water coolant that also serves as “moderator” to slow down fast neutrons
- Coolant circulated through core with natural circulation (forced circulation in legacy designs)

# BWRX 300

300MWe boiling water nuclear power plant from GE-Hitachi

**US$2,500/kW, Say A$4,580/kW > A$1.37 Billion per unit,**

This Study

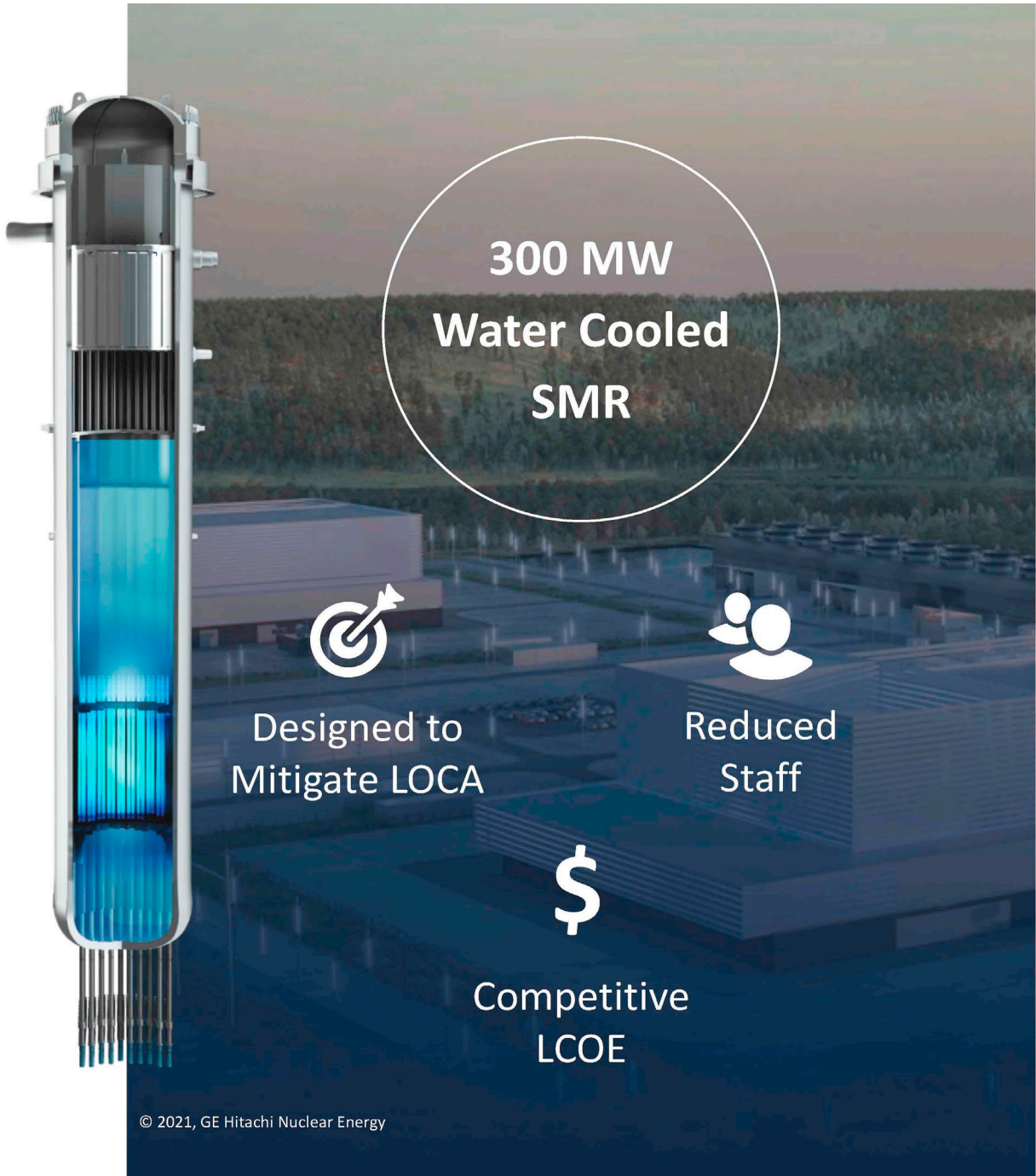
**A$6,767/kW > A$2.03 Billion per unit**

# BWRX-300 small modular reactor

- 10th generation Boiling Water Reactor
- Scaled from U.S. NRC licensed ESBWR
- Design-to-cost approach
- Significant capital cost reduction per MW
- World class safety
- Capable of load following
- Ideal for electricity generation and industrial applications, including hydrogen production
- Constructability integrated into design
- Initiated licensing in the U.S. and Canada
- Operational by 2028

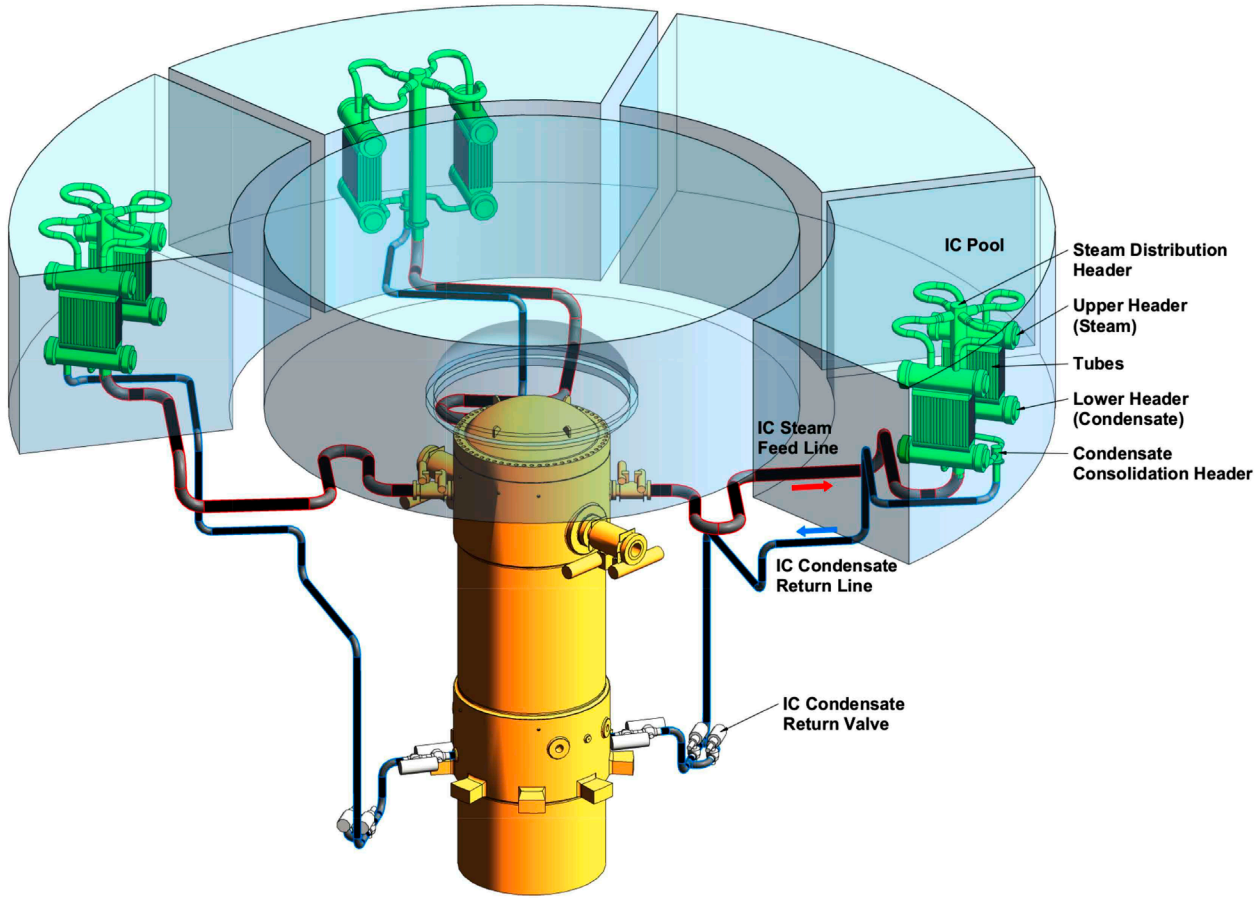
**MOST**
COMPETITIVE SMR

BWRX-300 Small Modular Reactor



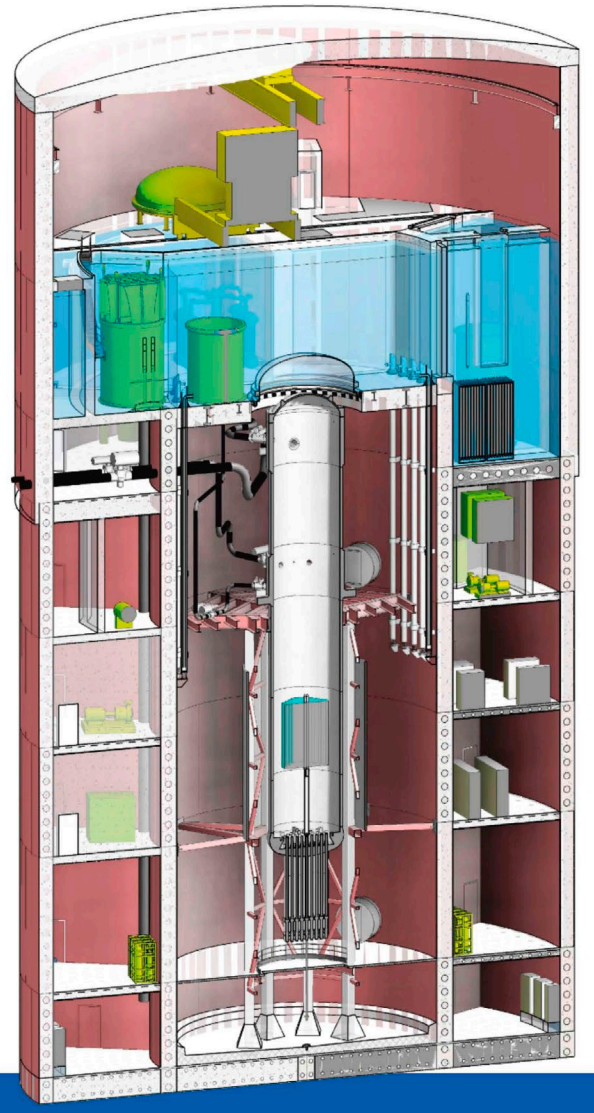
# Safety case results

- Mild transient response due to large RPV
- No need for safety relief valves
- Isolation Condenser System provides heat removal/pressure control
- Only 1 Isolation Condenser required
- Seven-day coping time for design basis accidents (station blackout, LOCA, etc.)
- Simple actions after seven days to increase time indefinitely




SEVEN DAYS COPING TIME IN ALL DESIGN BASIS ACCIDENTS

# Utilizing proven technology



## Nuclear Island components

- RPV
- Reactor internals
- Fuel
- Fuel handling
- Spent fuel racks
- Control Rod Drives/Hydraulic Control Units
- Nuclear Instrumentation
- Airlocks/special tooling
- Main steam isolation valves
- Reactor water cleanup

**Turbine Island based on existing steam turbine and generator in operation globally.**

>90% of Nuclear Island components based on designs already in operation

# Regional renewal, education and wealth generation

PwC has estimated the economic footprint for separate GE SMR capital expenditure scenarios in Ontario

| Scenario | Total economic footprint* |
| --- | --- |
| **First-of-a-kind**: the first SMR that GE will develop in Ontario in partnership with OPG Capital Cost C$2 Billion | During manufacturing and construction: $1.3 billion in GDP, $1.1 billion in labour income, $460 million in tax revenue, and sustain 1,712 jobs per year over seven years<br><br>During operations: $1 billion in GDP, $768 million in labour income, $303 million in tax revenue, and sustain 197 jobs per year over 60 years (discounted) |
| **Future Ontario reactors**: per-reactor benefits of subsequent SMRs that GE will install alongside partners in Ontario | $1.1 billion in GDP, $728 million in labour income, $312 million in tax revenue, and sustain 1,951 jobs per year over four years |

*All values undiscounted unless otherwise noted. Does not include operations except where indicated.

# Where would we build them and how long would it take?

# Site Selection

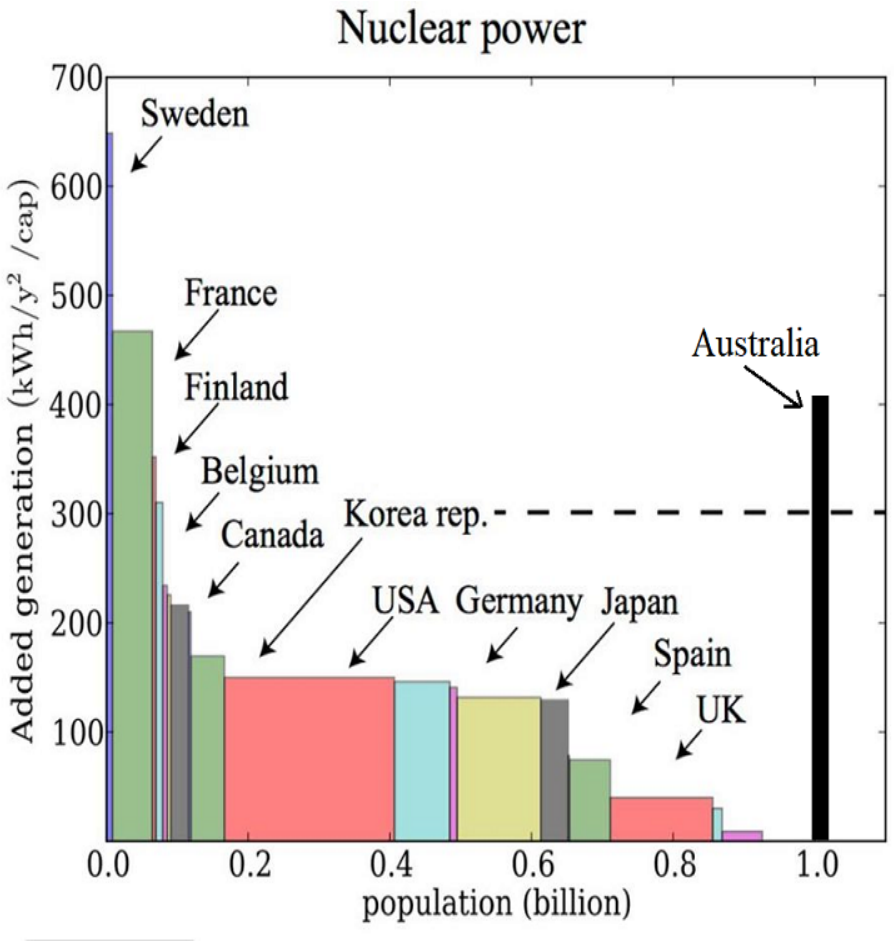
1. **Grid** – use existing to the maximum extent, site at nodes,
2. **Cooling** – proximity to cooling resource, once through, evaporative, hybrid cooling, dry cooling
3. **Foundations** – bearing capacity, differential settlement, faults and joints, water ingress, overall stability
4. **Transport** – equipment delivery, port, commute, bridge loads and clearances, rail and road
5. **Population** – density, workforce talent, community benefit, nimbys
6. **Local Risks** – airports, fuel terminals, upstream dams and lakes

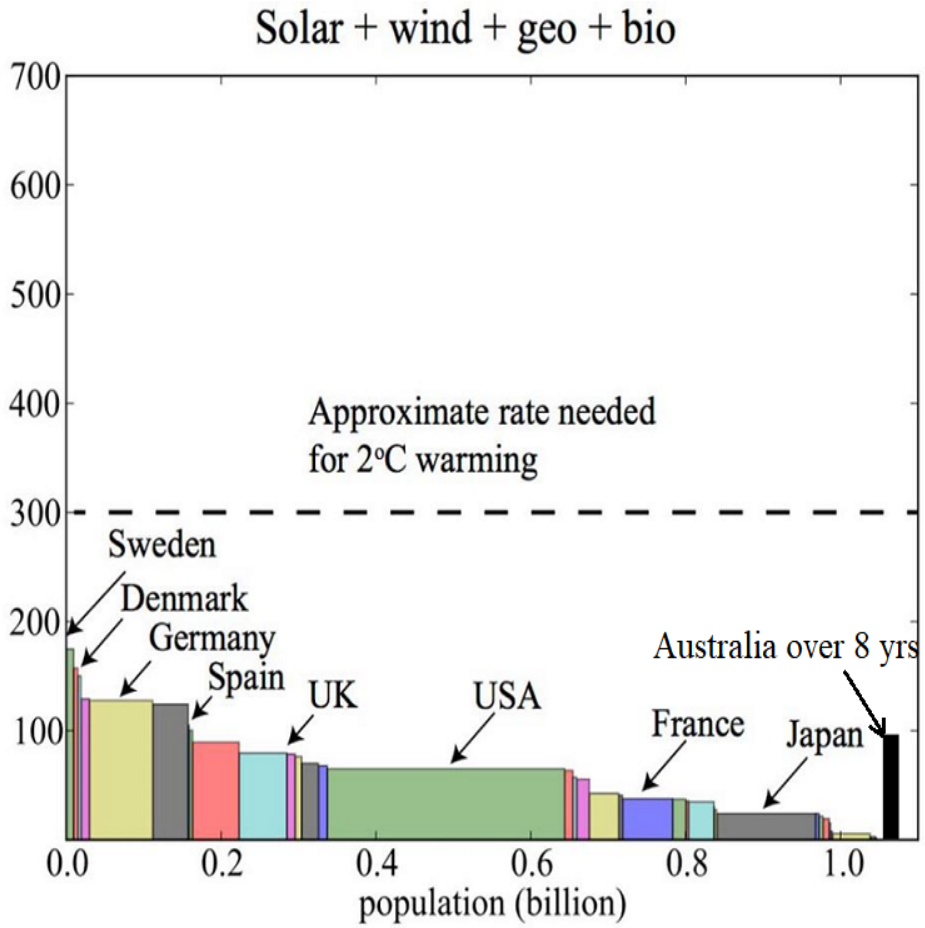
# Number of 300MW nuclear generators

| State | Require | Potential |
|---|---|---|
| NSW/ACT | 30 | 74 |
| Victoria | 18 | 30 |
| Queensland | 28 | 33 |
| South Australia | 4 | 8 |
| **NEM Total** | **80** | **145** |
| | | |
| Western Australia | 6 | 12 |

# How long would it take? - For 24GW should take 21 years

- Anticipated construction duration for BWRX 300 nth of a kind is 36 – 48 months
- Estimated 50% less construction material per MW compared to large reactors
- Operating on multiple projects France deployed 2.86GW/yr. to create 63GW in 22 years.




Source: World Bank & BP Statistical Review, picture by Carl Hellensen


# Conclusions

1. Variable  wind and solar generation(VRE) does not have a track record of achieving deep carbon emissions reductions or providing low cost energy on a system wide basis.

2. VRE drives up the costs of the most expensive part of our energy delivery – namely transmission and distribution plus system services and storage. These costs significantly exceed the low cost benefits of wind and solar generators

3. At high levels of emissions reductions nuclear energy with VRE run into problems.

4. A system where nuclear energy provides the dominant source of generation is the least cost option providing energy at around half the cost of a 100% renewable system

https://nuclearforclimate.com.au/

# Q&A

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# Thank you

- If you have any further questions, please contact Natalia
- Nkontsevaya@engineersaustralia.org.au

# Essential Polling 28-9-2021

"In a fascinating development, 50 per cent of Australians support the idea while 32 per cent are opposed"

## Support for nuclear energy in Australia

Sep 28, 2021 Comments

*Q. To what extent do you support or oppose Australia developing nuclear power plants for the generation of electricity?*

| | Total | Gender | | Age Group | | | Federal Voting Intention | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Male | Female | 18–34 | 35–54 | 55+ | Labor | TOTAL: Coalition | Greens | TOTAL: Other |
| Strongly support | **20%** | 29% | 10% | 14% | 19% | 25% | 16% | 30% | 12% | 20% |
| Somewhat support | **30%** | 30% | 30% | 33% | 27% | 31% | 26% | 35% | 26% | 27% |
| Somewhat oppose | **15%** | 14% | 16% | 19% | 14% | 13% | 19% | 12% | 13% | 13% |
| Strongly oppose | **17%** | 16% | 17% | 14% | 21% | 16% | 20% | 8% | 37% | 24% |
| Unsure | **18%** | 10% | 27% | 21% | 18% | 16% | 19% | 15% | 11% | 15% |
| TOTAL: Support | **50%** | 59% | 41% | 47% | 47% | 55% | 42% | 65% | 38% | 47% |
| TOTAL: Oppose | **32%** | 31% | 33% | 32% | 35% | 28% | 39% | 20% | 50% | 37% |
| Base (n) | **1,094** | 539 | 555 | 341 | 368 | 385 | 366 | 397 | 101 | 130 |