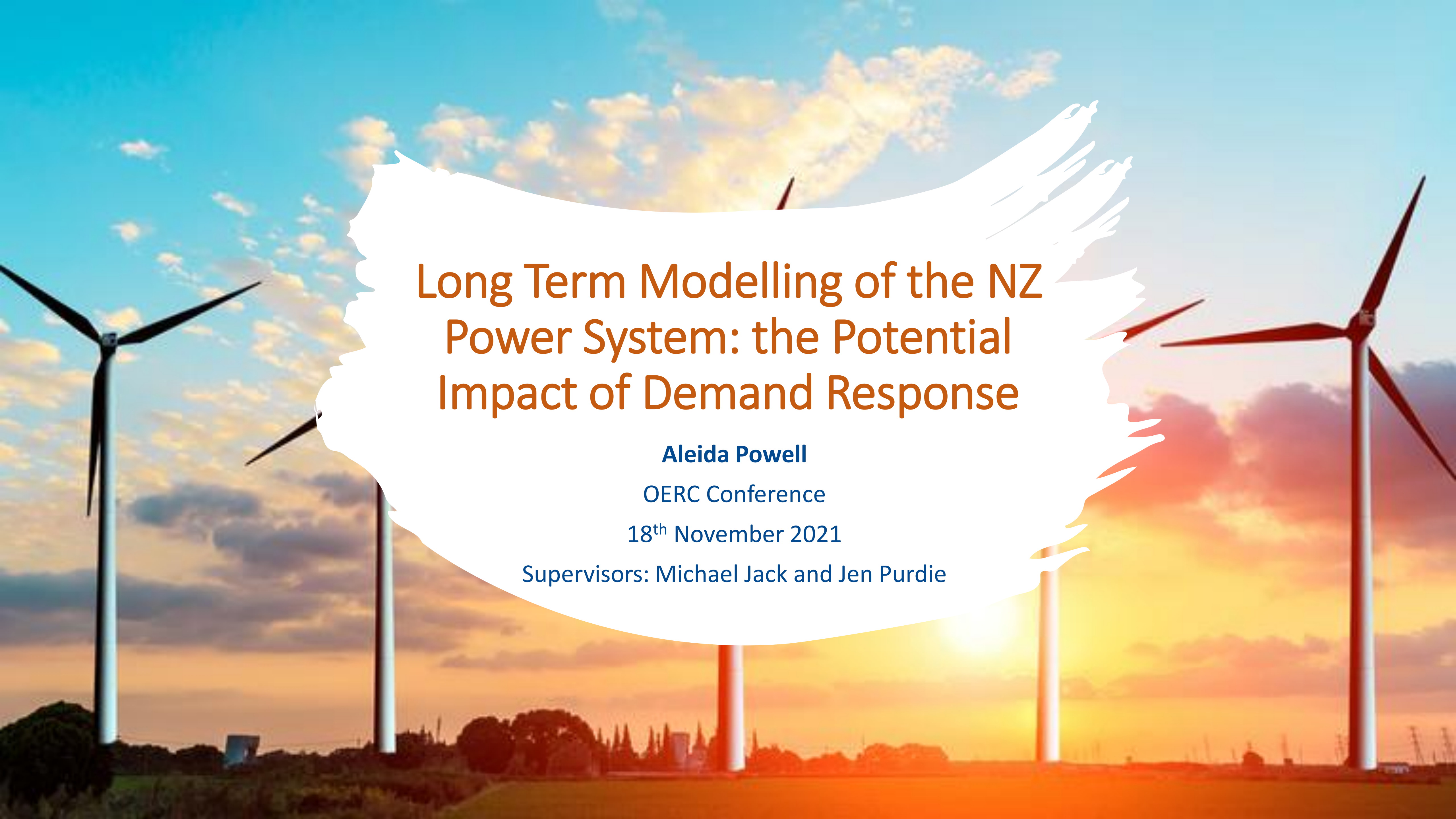

Long Term Modelling of the NZ Power System: the Potential Impact of Demand Response

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OERC Conference

18th November 2021

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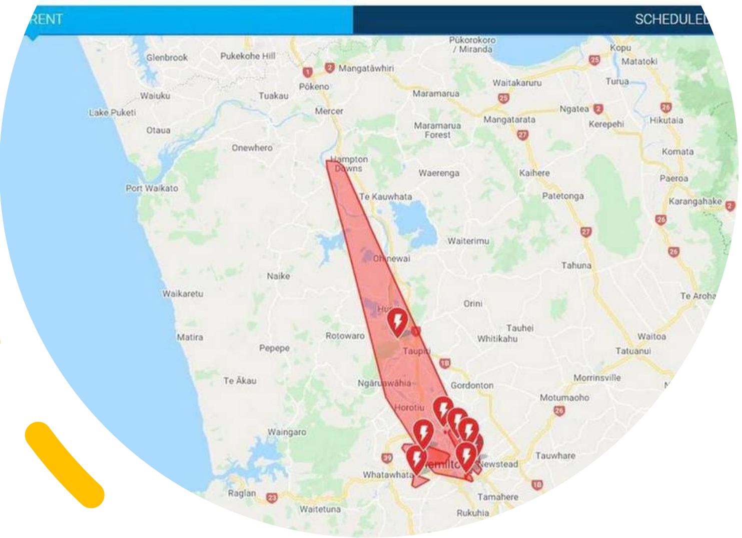
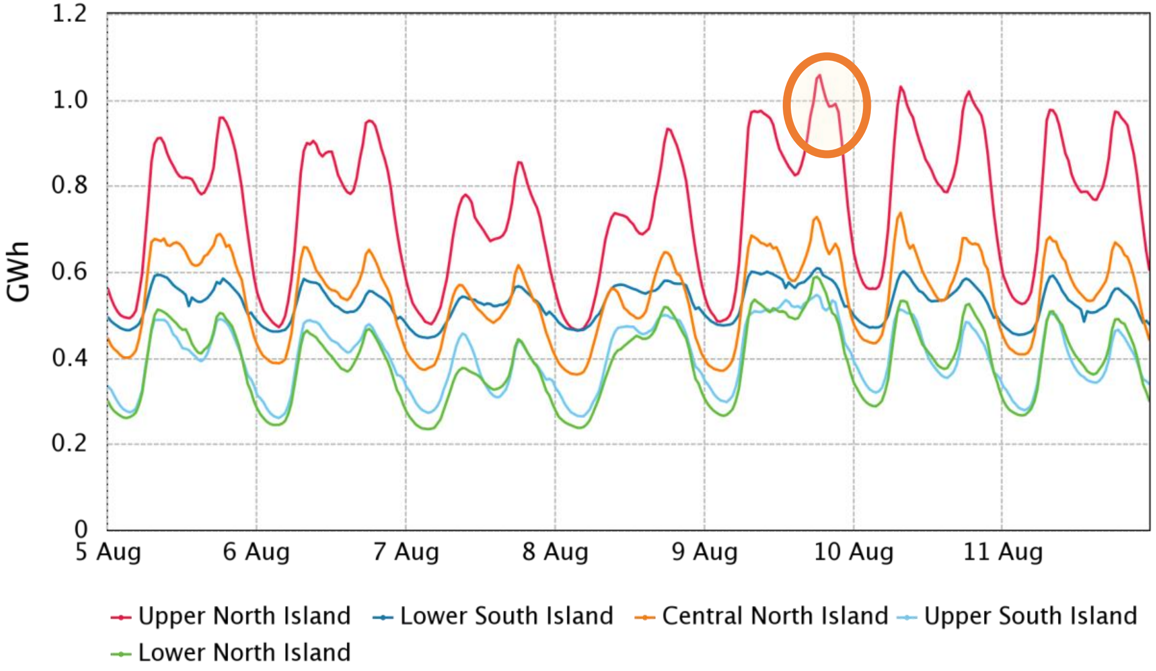
The future of the power system:

- To mitigate climate change NZ has set emission reduction targets.
- Electricity to become 100% renewable
- Electrification of transport, process heat etc.
- BUT renewables are variable (mismatch of supply and demand)
  - Supplying peak demand is a barrier to a 100% renewable system





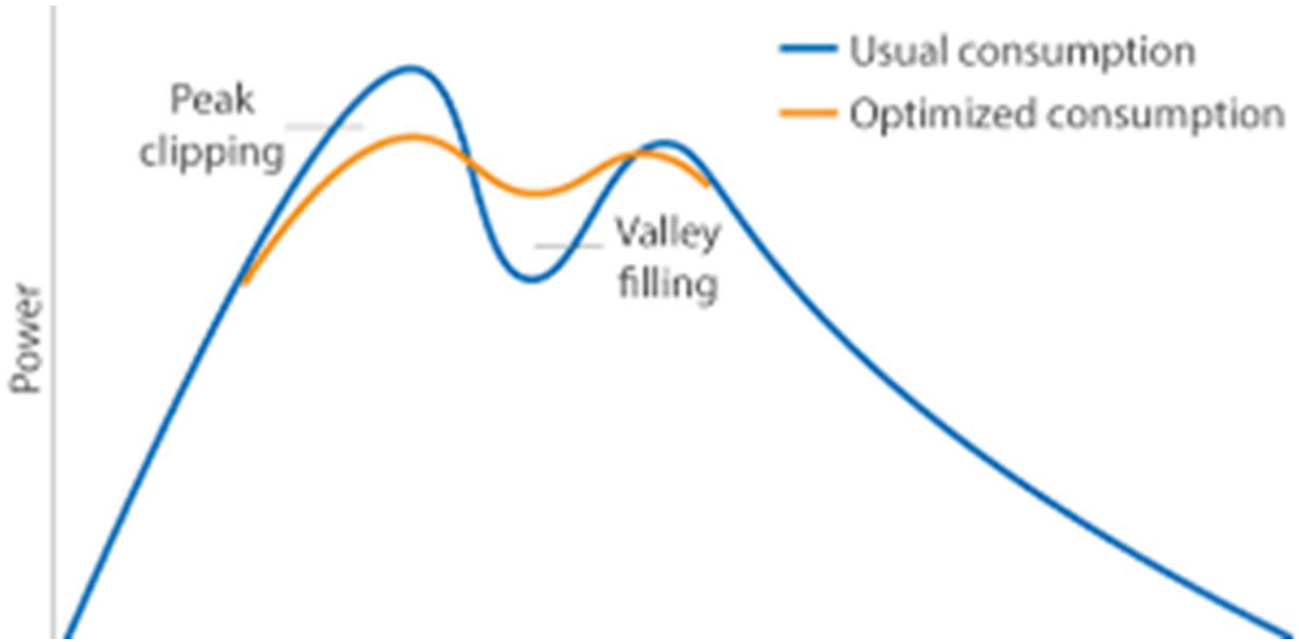
emi.ea.govt.nz/r/cei1u

How do you solve the problem of peak demand?

- Over build renewable generation capacity
  - Expensive!
- Build large energy storage facility (Lake Onslow)
  - Expensive!
- Increase the flexibility of demand to better match the renewable generation
  - Cheap!

Demand Response (DR):

- What is it?
  - Changing consumption in response to a signal or price incentive to reduce demand when the system is under stress
- Already occurring worldwide, including in NZ
- Previous studies have outlined benefits, constraints and technical/theoretical potential



Project Aim:

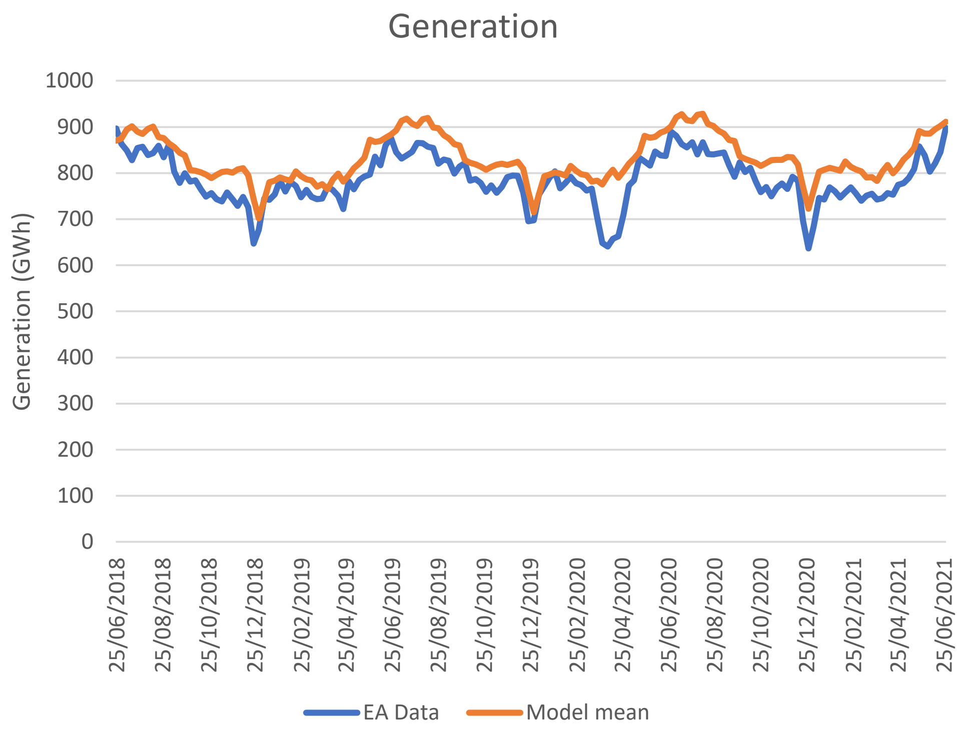
- Use the LPCon model to model scenarios of increased demand response in a 100% renewable NZ Power System.
- What are the consequences of suppling 20% of peak demand with DR?

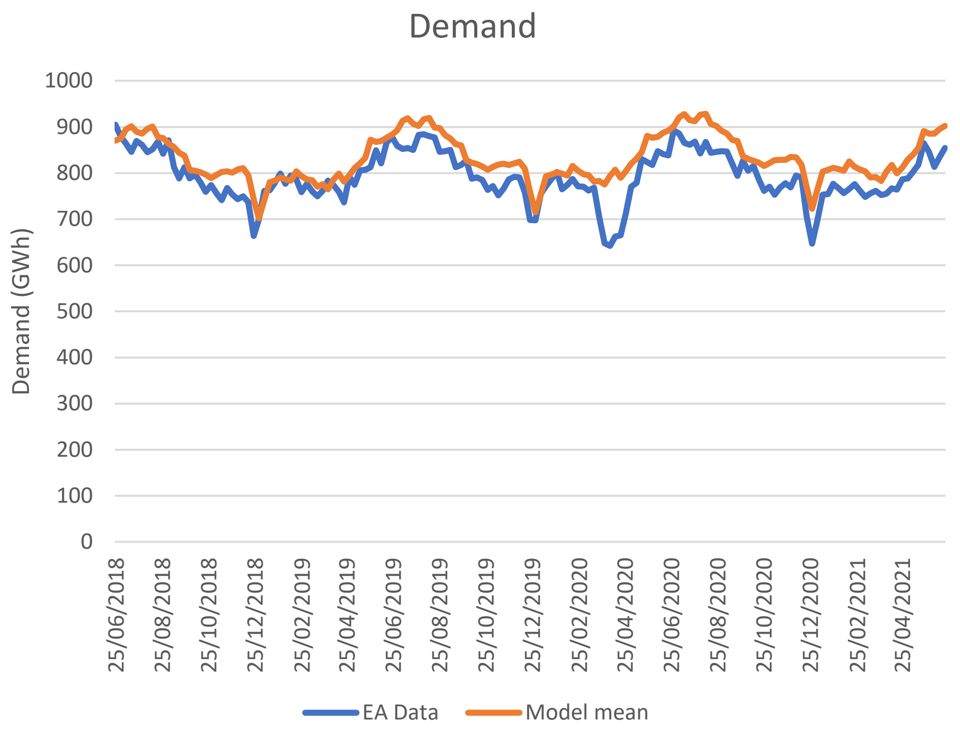
The LPCon Model

- Created by Grant Telfar, owned by Meridian Energy Ltd.
- Model predictions out to 30 years
- Two-phase power system optimisation and simulation model
    1. OPT – Constructive Dual Dynamic Programming (CDDP) algorithm
    2. SIM – Coin-OR linear programming solver
- Two Scenarios: Revolution (100% renewable in 2033's) and Evolution
- Model inputs: hydrological histories, climate predications, demand predictions, EV uptake and battery use predictions, planned outages, Transpower's future upgrades etc….

Phase 2: Simulation

- **Economic optimisation** of the NZ power system to find cheapest balance of supply and demand – **lowest cost solution** to supplying electricity at each node (166 nodes)
- **Supply:** hydro, solar, wind, thermal, batteries
- **Demand:** Regional demand predictions, EV uptake
- **Constraints:**
  - Line losses
  - Hydrolocial constraints: genearation, chain generation, reservoir release
  - Wind and solar constraints
  - Station limit (generation + reserve)
  - Thermal group generation constraints nodal phase angle line constraints





Validation of Model Results:

DR Modelling with LPCon:

- DR offered in as negative generation
- Three types of DR:
  - Energy DR (triggered by low water levels)
  - Peak DR (triggered by peak pricing)
  - Economic DR (triggered by peak demand)
- Peak DR is the focus of this study:
  - Change price it is offered in at
  - Change amount (MW) it is offered in at
- Iterative process: cannot set DR specifically, must find the 'Goldilocks' zone

Results:

Base Case

7.2 % of demand in peak hour in 30 year model run met by DR

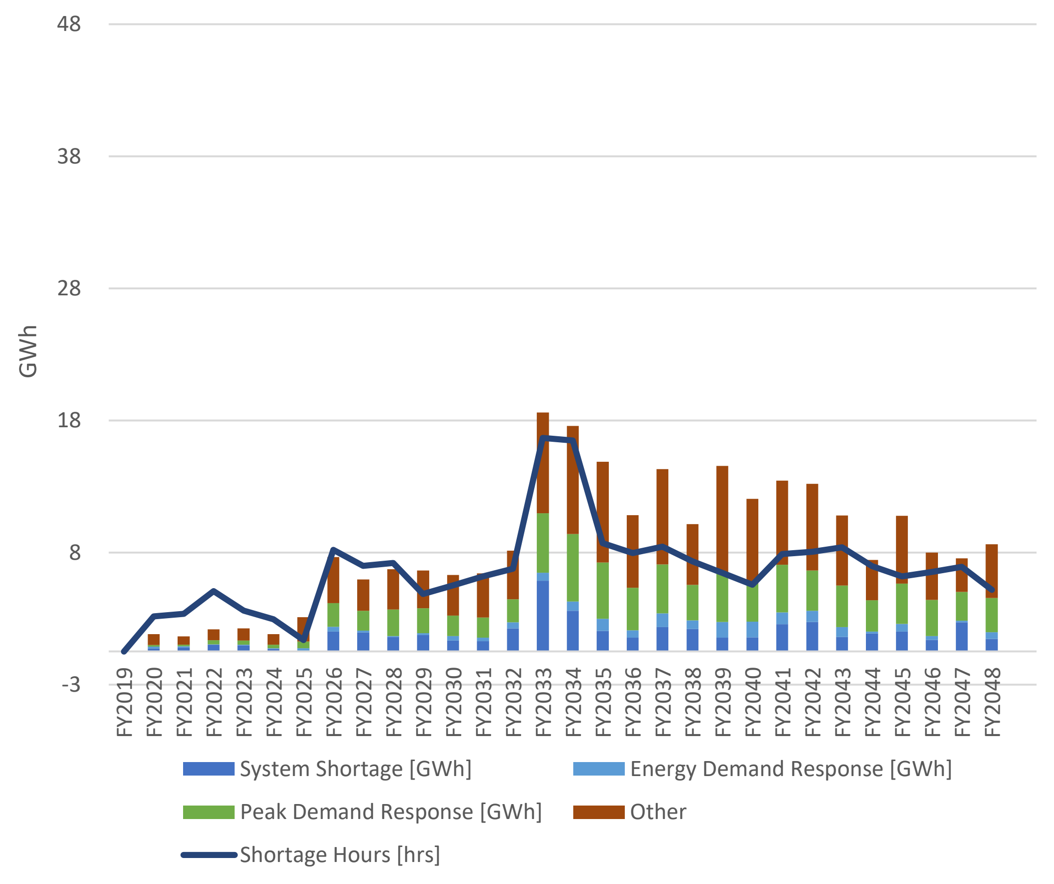
Increased DR Case

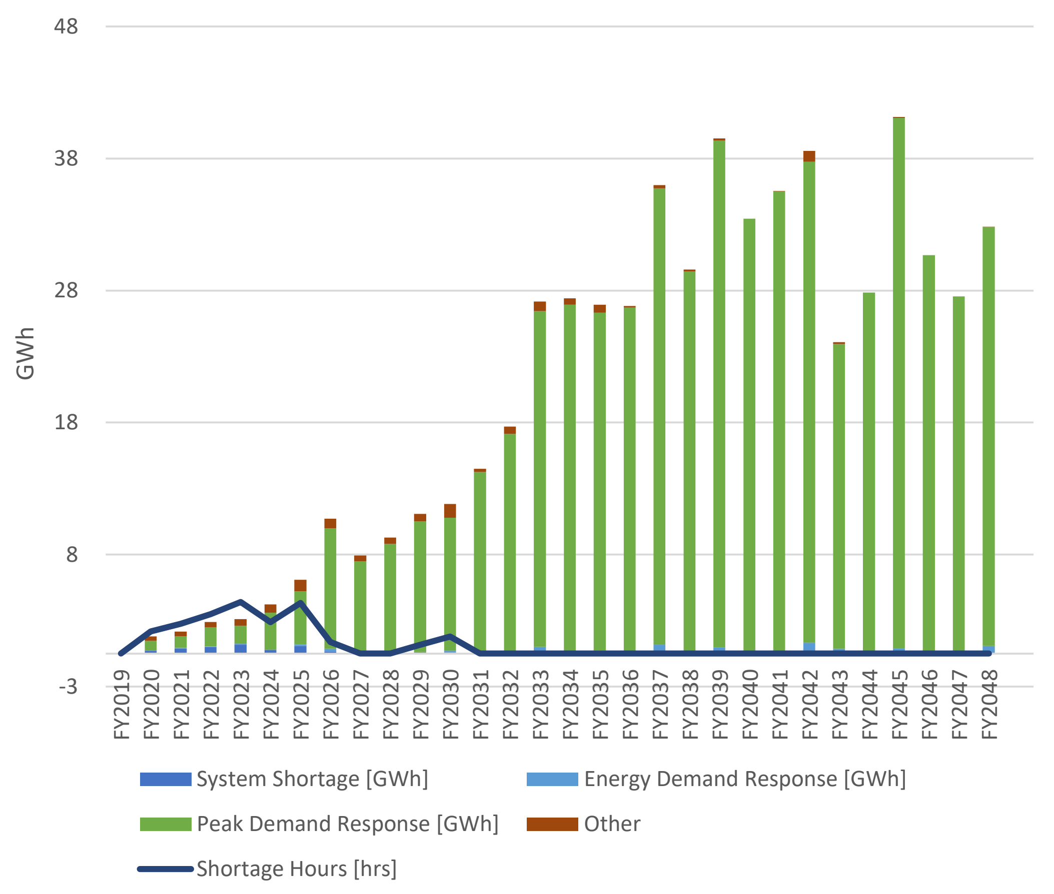
20.5 % of demand in peak hour in 30 year model run met by DR

1500 GWh less generation capacity

Results:

DR Summary 2018 - 2048:



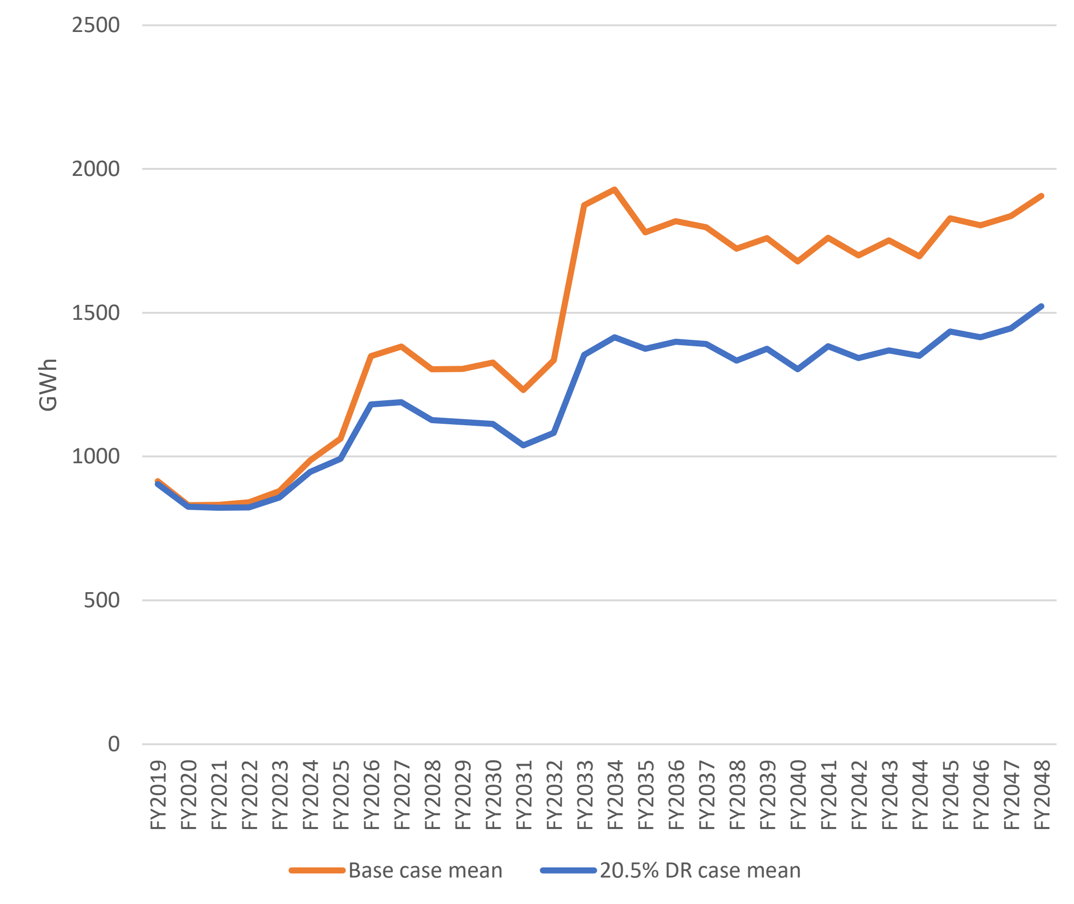


Base Case:

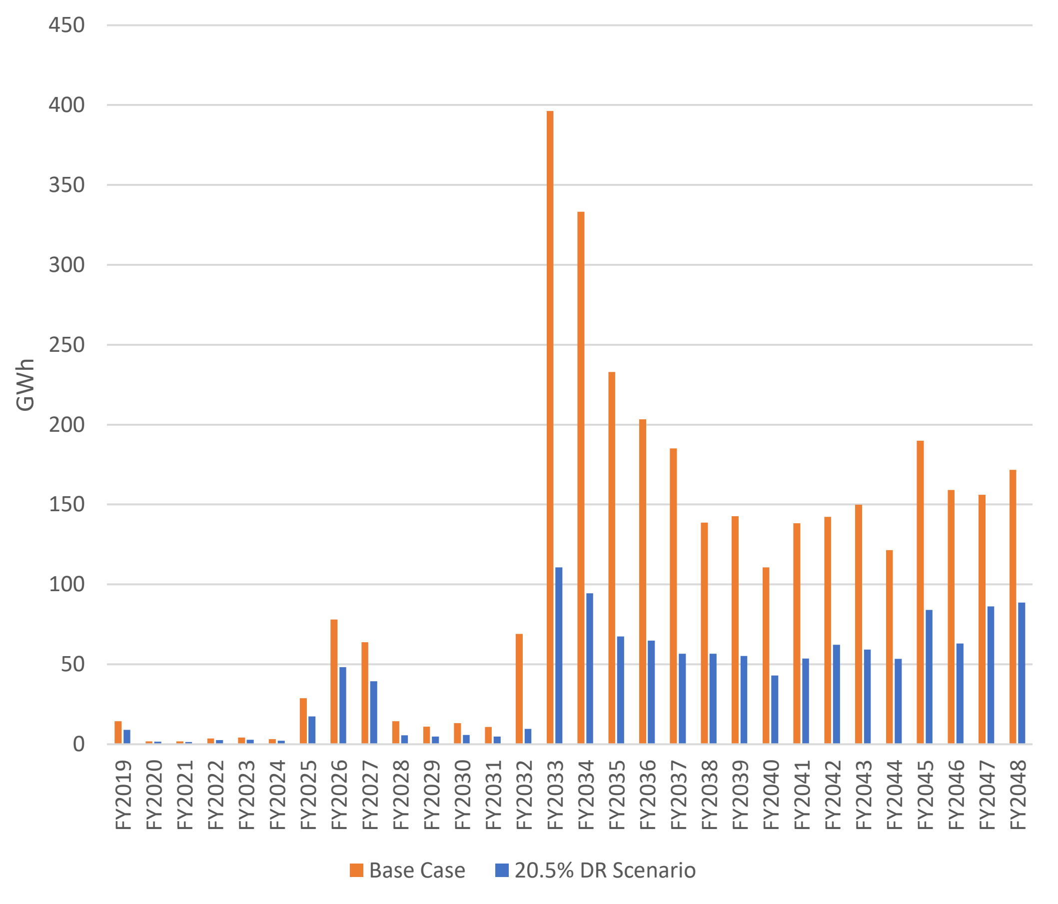
20.5 % Peak DR Case:

Results:

System Spill:



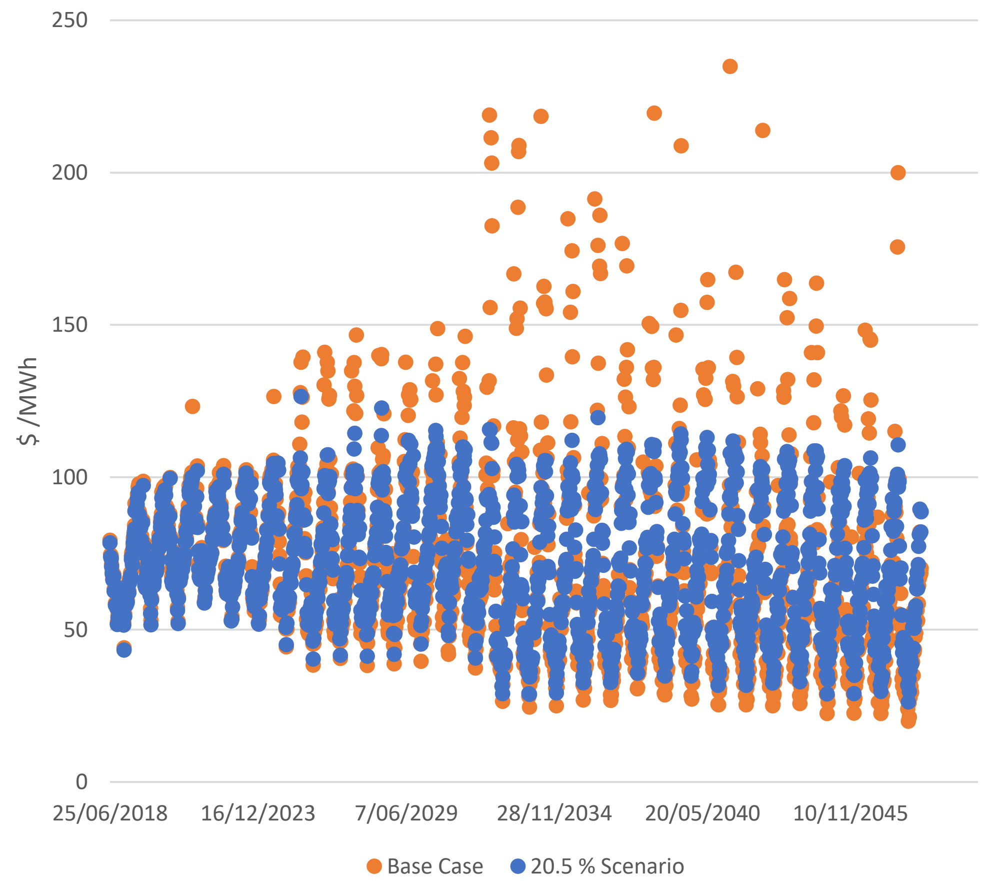
Total Spill

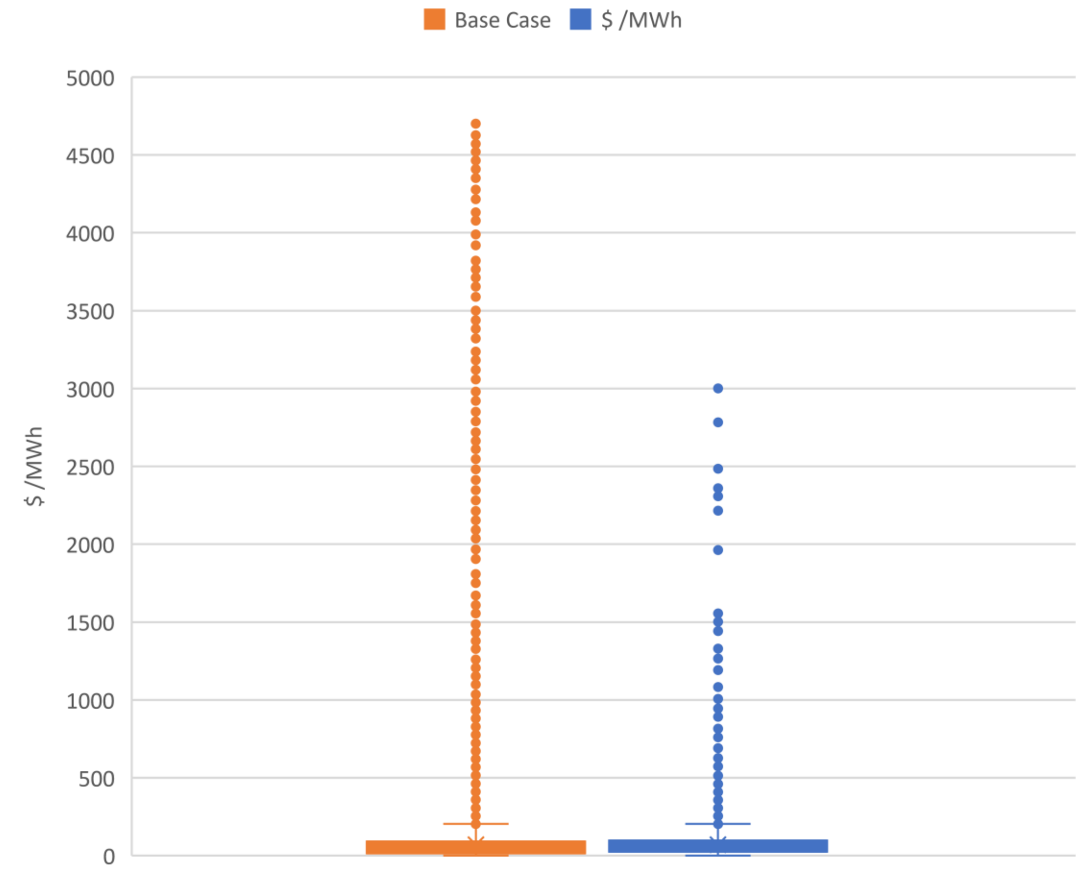


Wind Spill

Results:

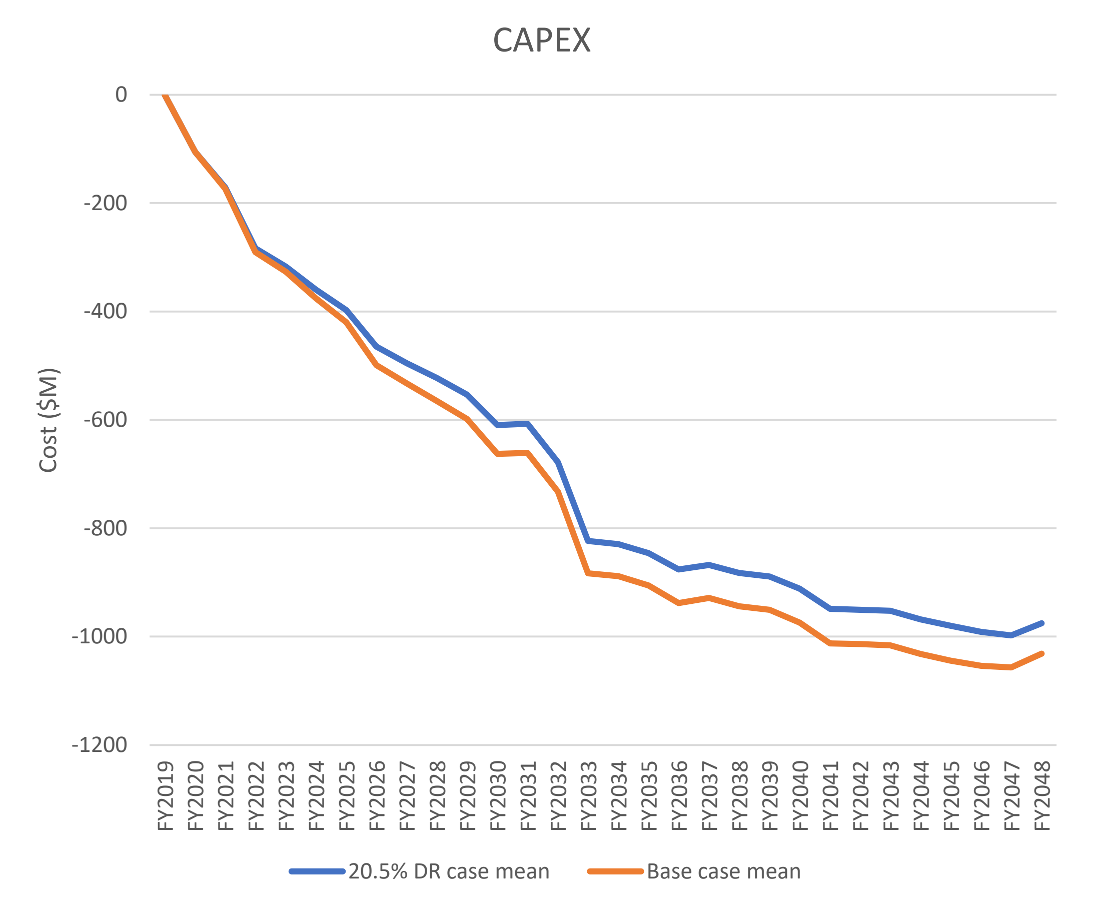
Time Weighted Average Price (TWAP):

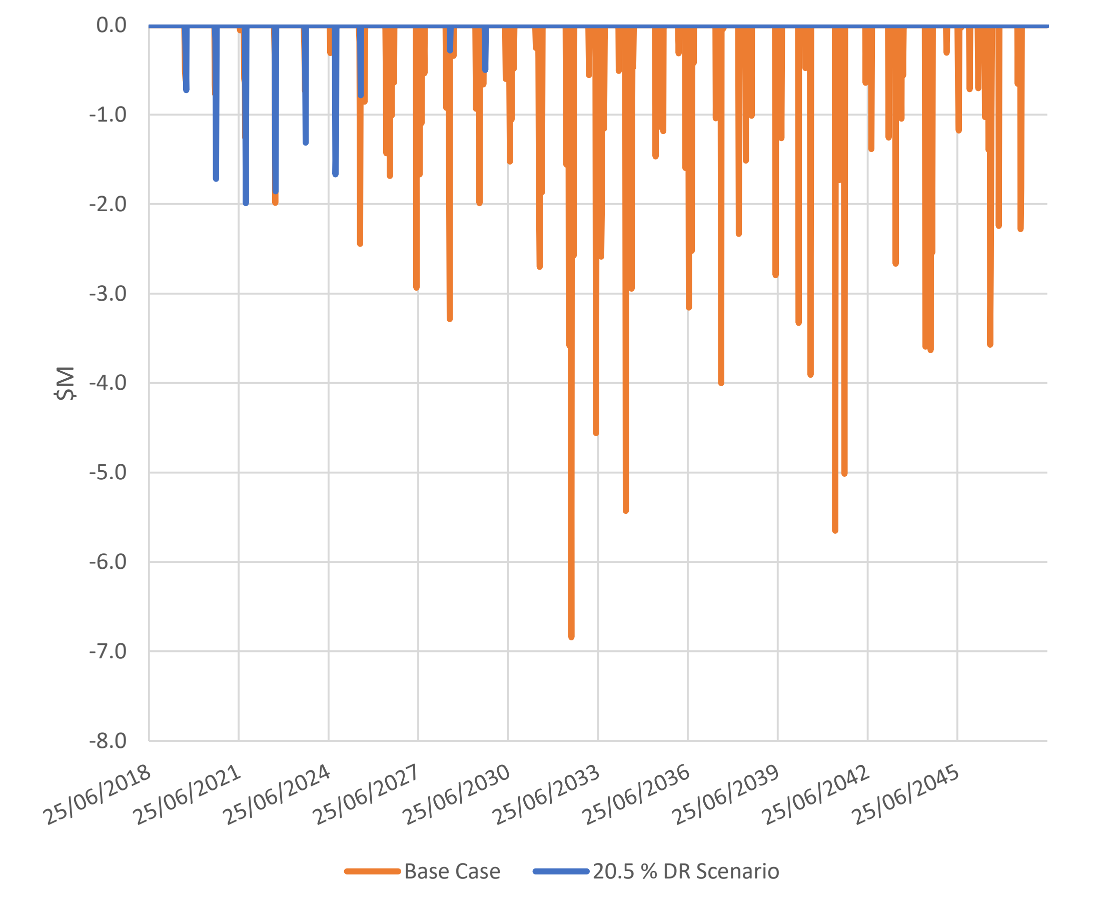




Results:

System Costs:

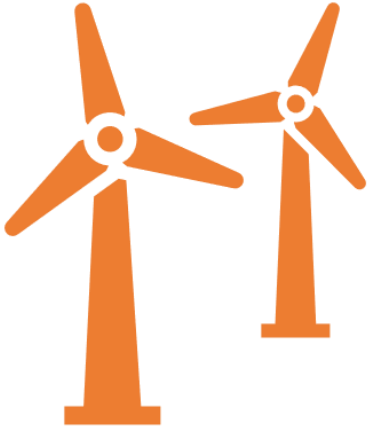




CAPEX Costs

VoLL Costs

Thank you



- Michael Jack
- Jen Purdie
- Grant Telfar