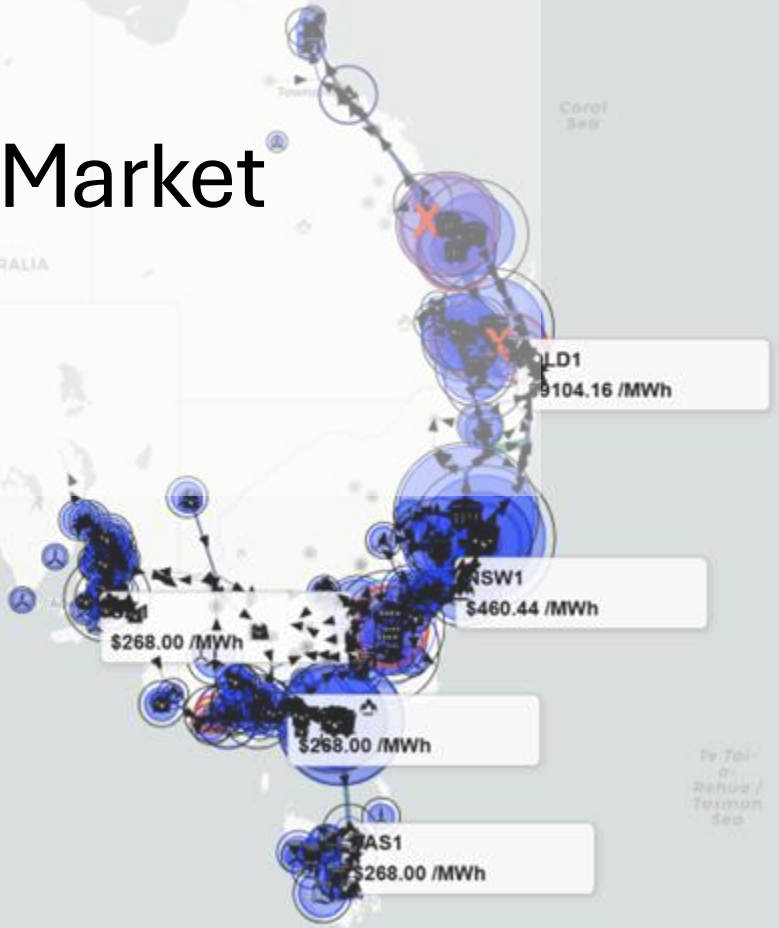
Modelling Price Outcomes in the Australian NEM

Comparing Nodal and Zonal Market Models in PyPSA

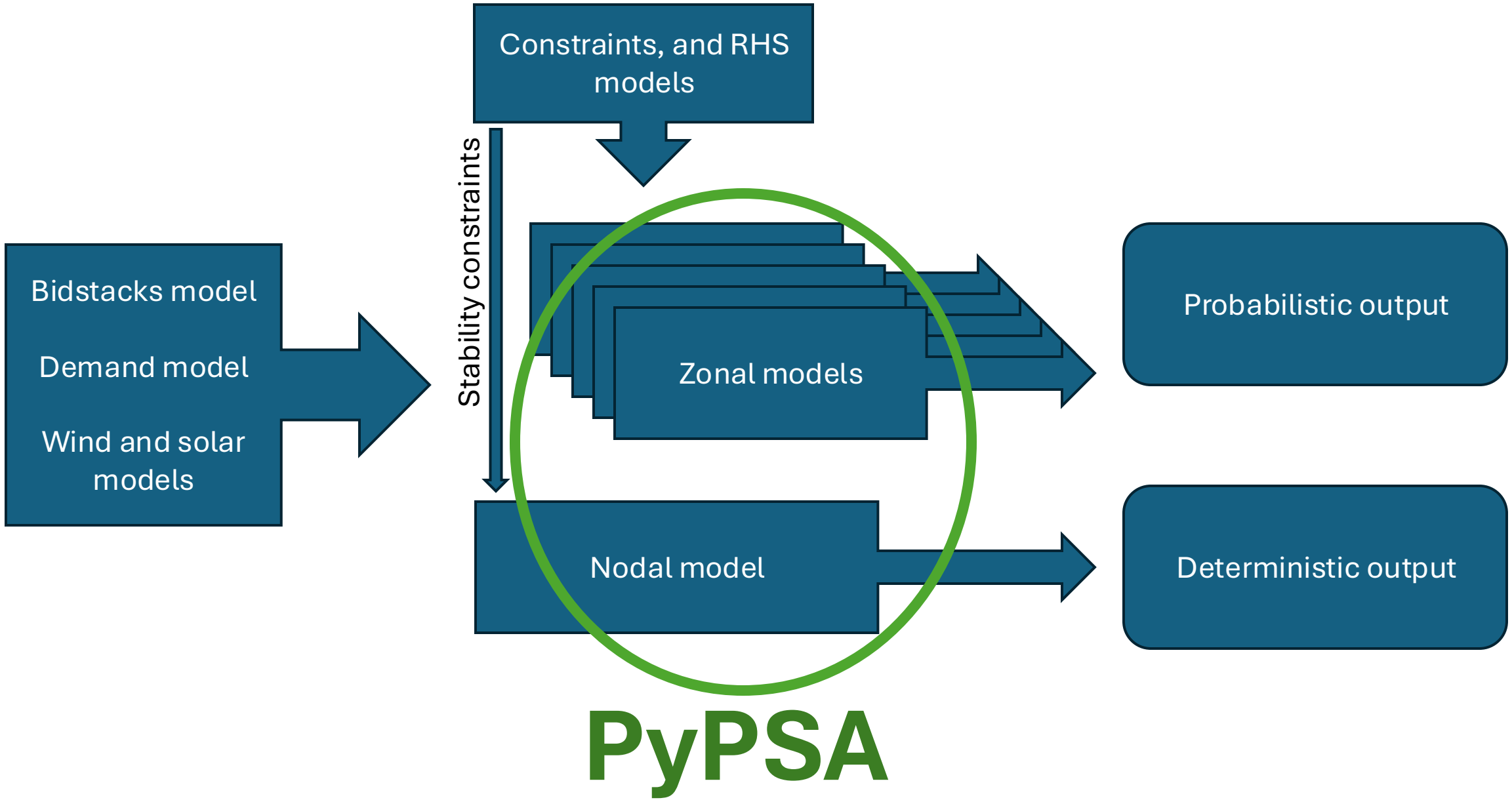
Tom Adams, PyPSA user meeting 2025

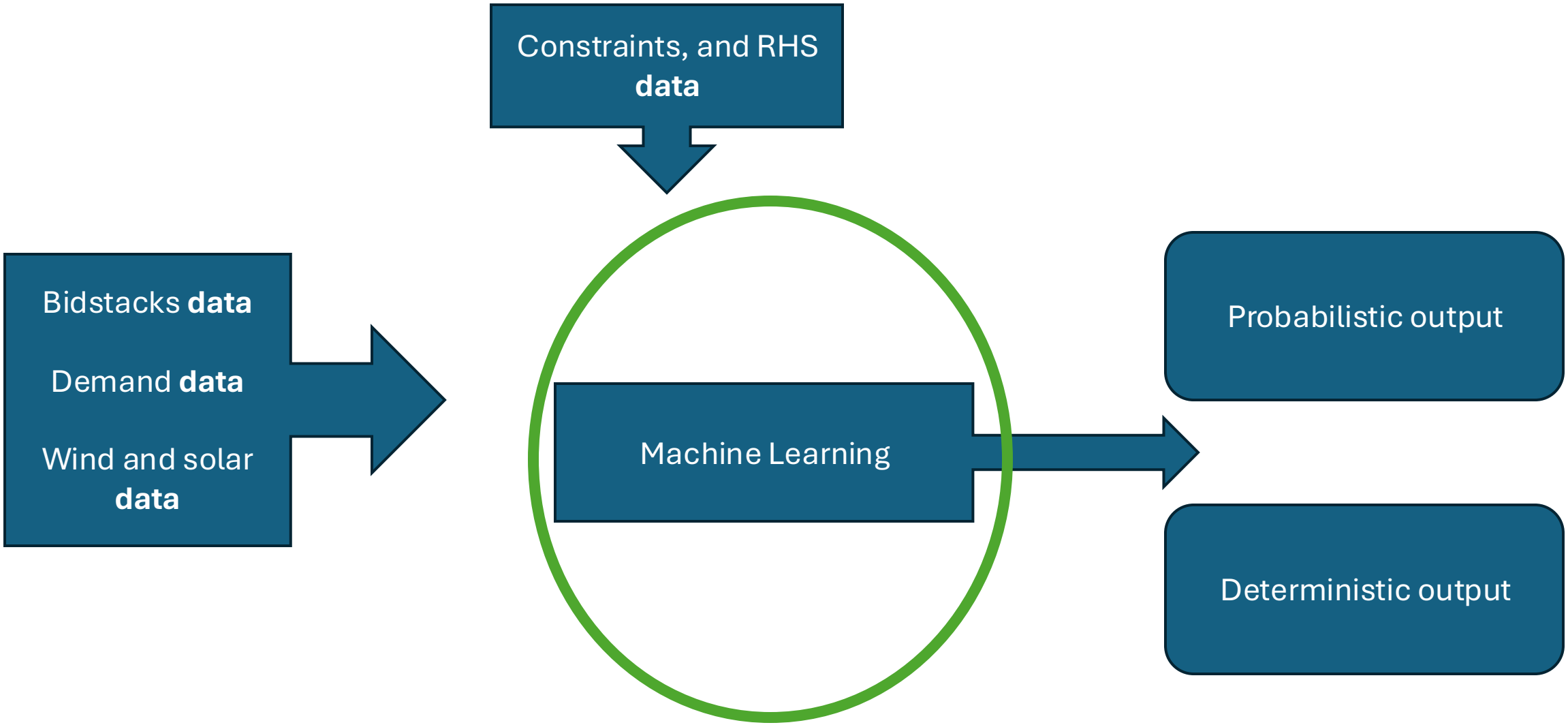


Haast Energy Trading

Purpose

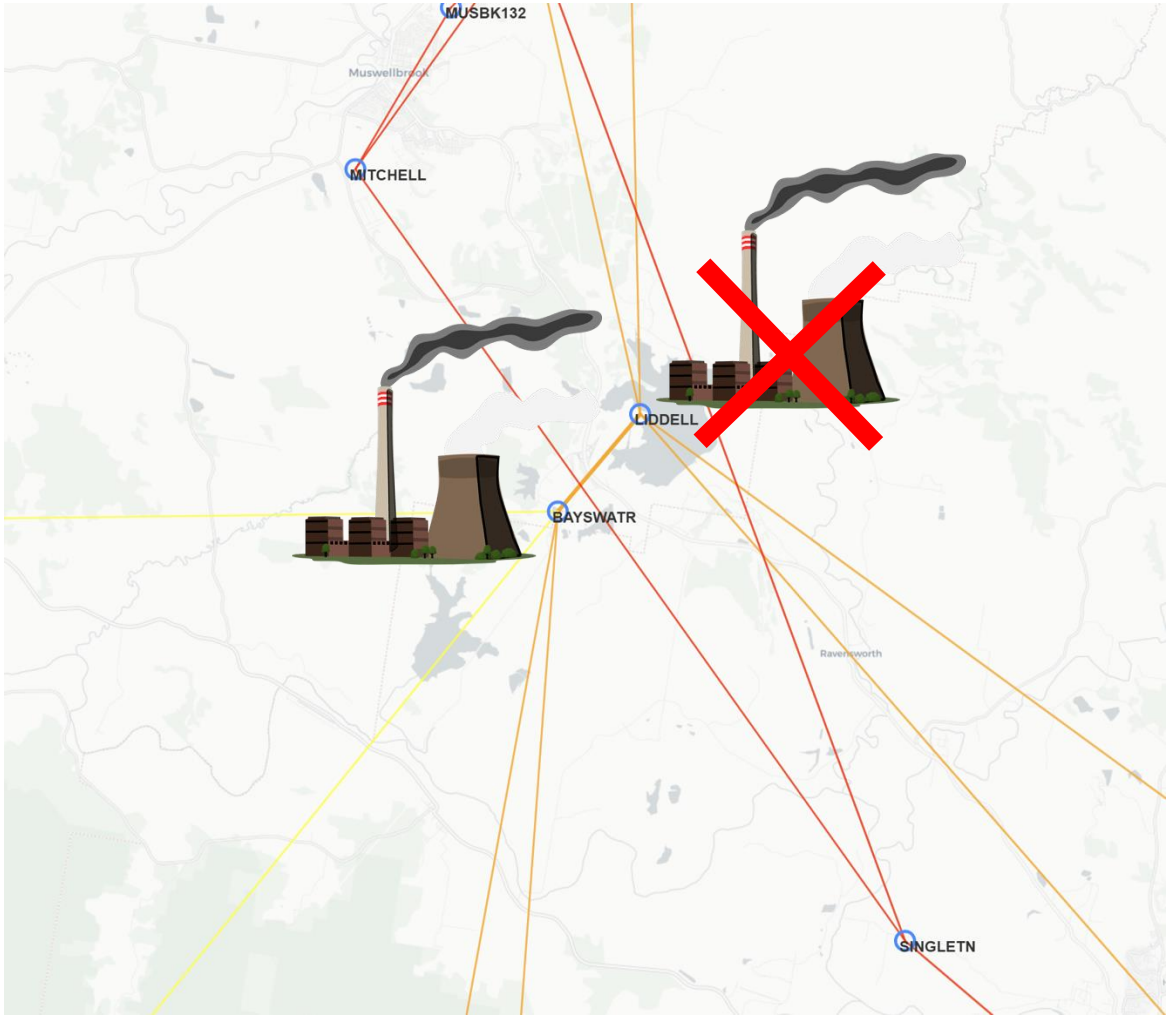
- **Explainable** week ahead prices in terms of:
  - Generator energy bids (*not SRMC!)*
  - Weather, wind and solar output
  - Demand
  - Plant outages
  - Line outages


Constraints, and RHS models
Stability constraints
Bidstacks model
Demand model
Wind and solar models
Zonal models
Nodal model
Probabilistic output
Deterministic output
PyPSA

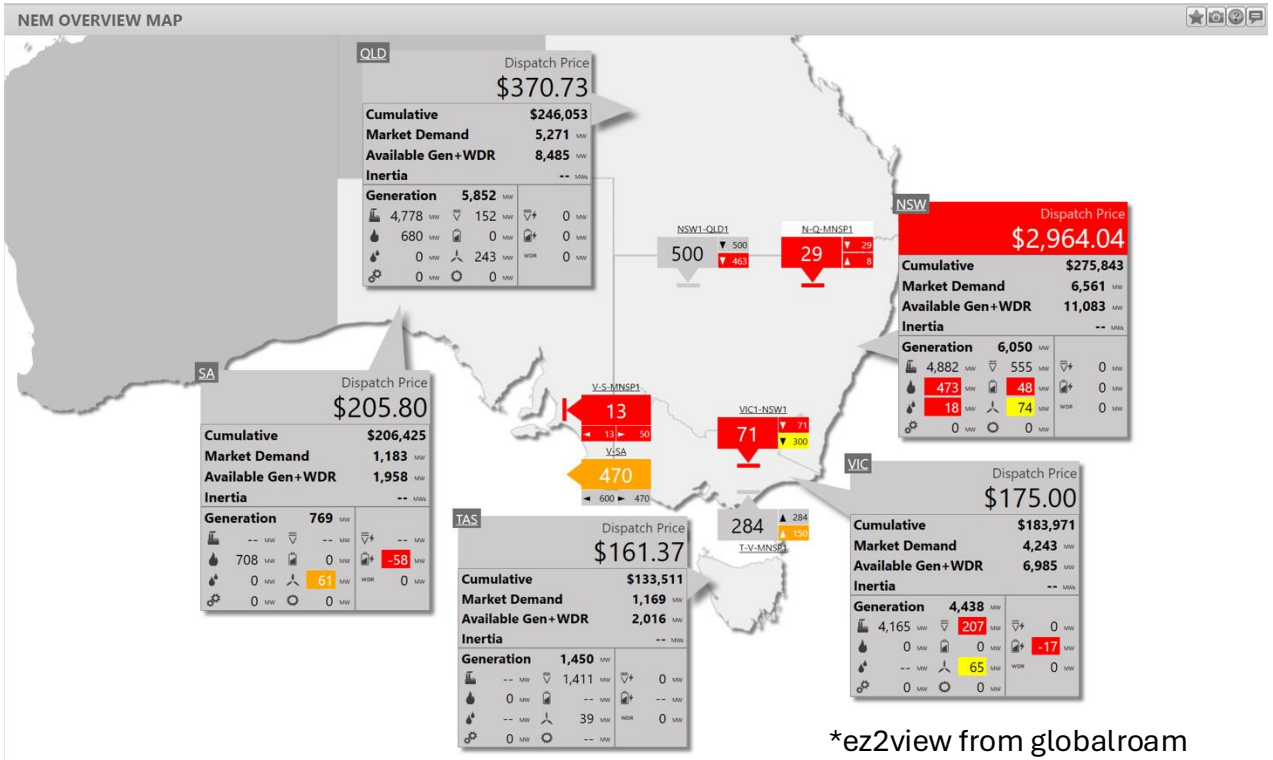

Constraints, and RHS **data**
Bidstacks **data**
Demand **data**
Wind and solar **data**
Machine Learning
Probabilistic output
Deterministic output

Why not AI?

Why use PyPSA at all?

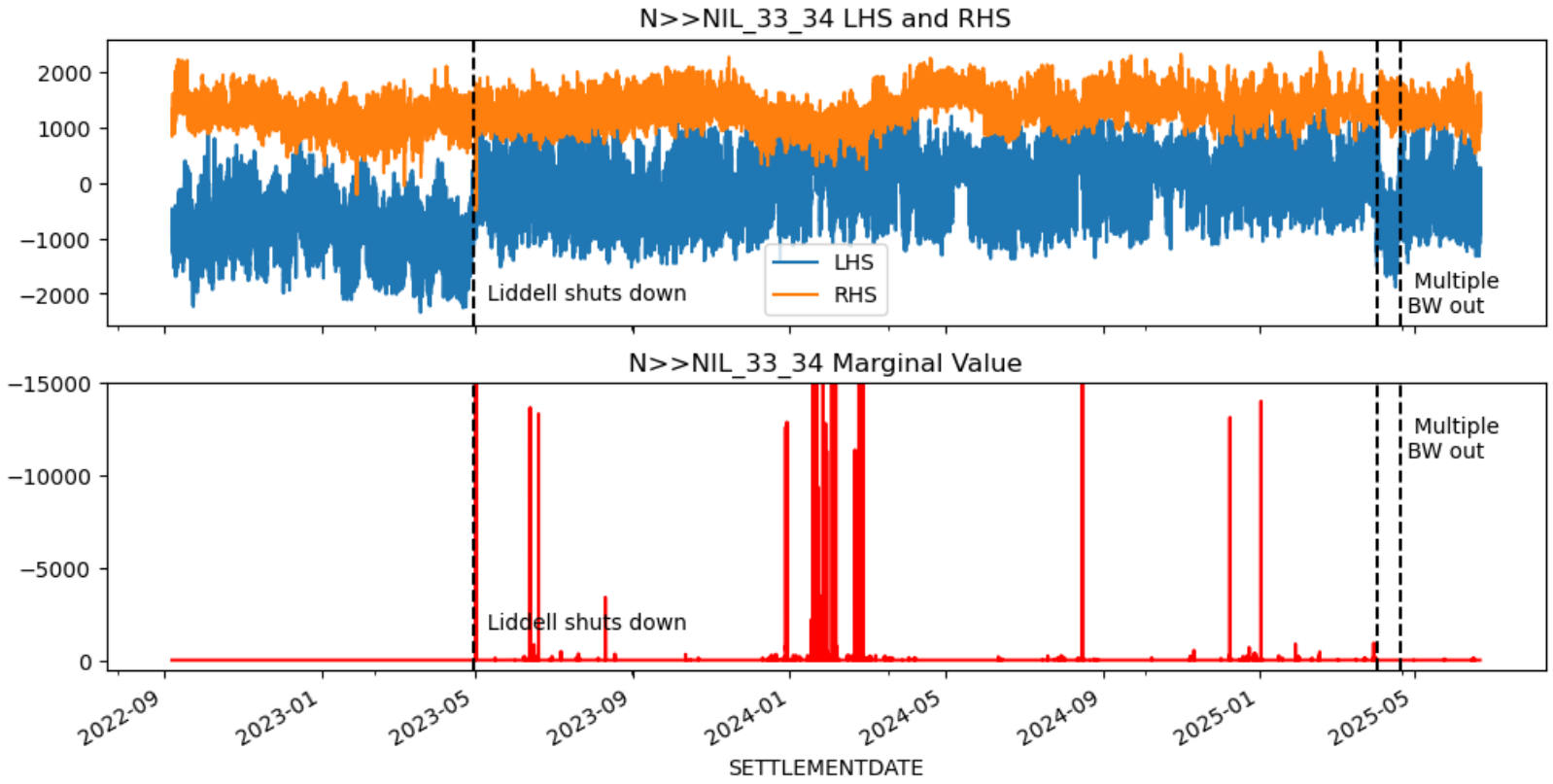


1st May 2023



*ez2view from globalroam

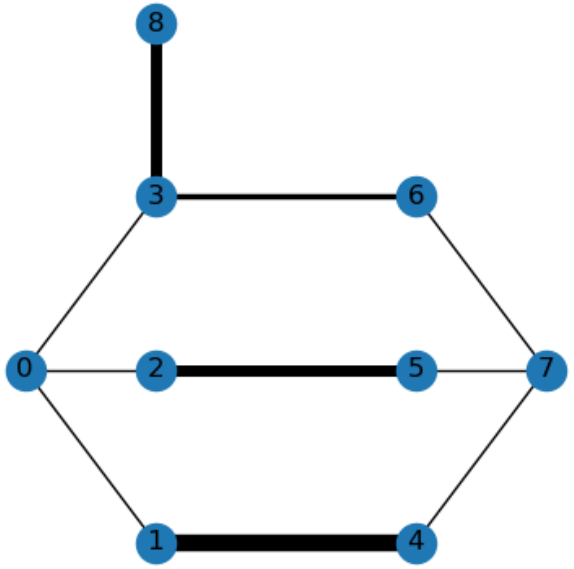
Why use PyPSA at all?

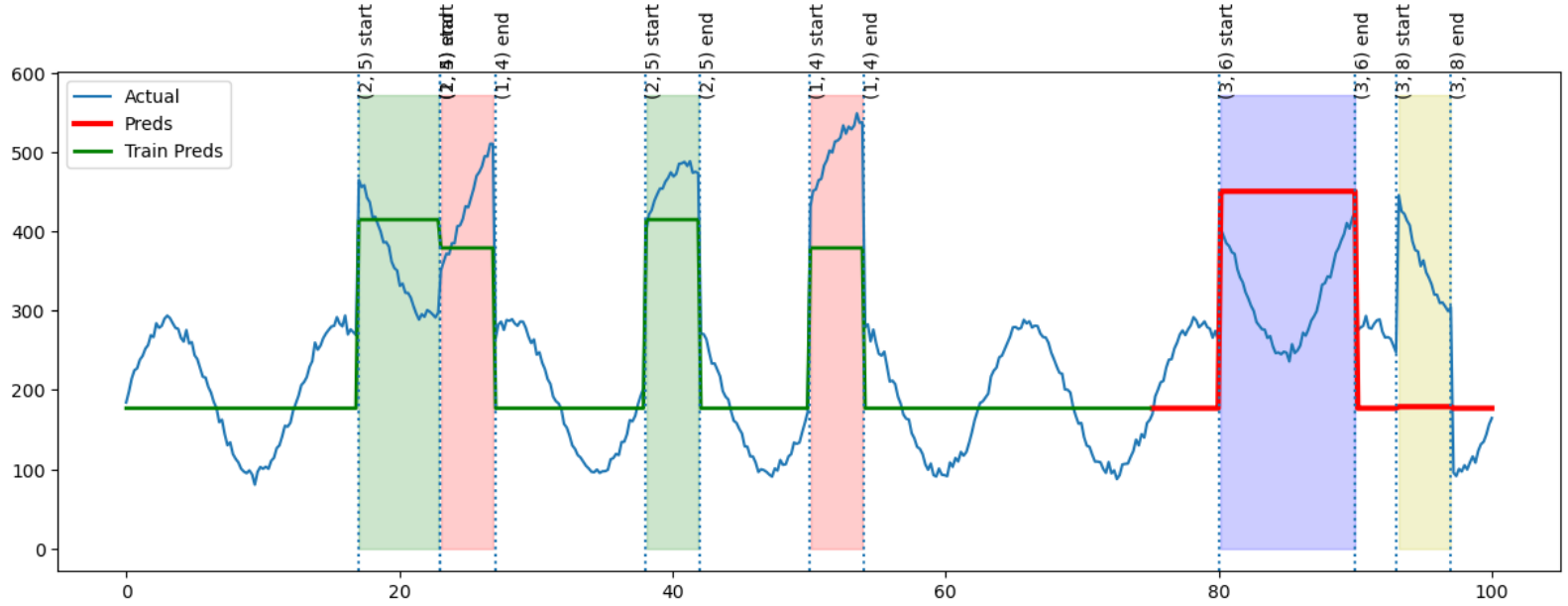


Out of sample events are happening all the time – generators closing, opening, new lines being added, lines being taken out for maintenance etc.

What about GNNs?

- Train simple graph network on price data with (2,5) and (1,4) out, infer impacts of (3,6) and (3,8) outages

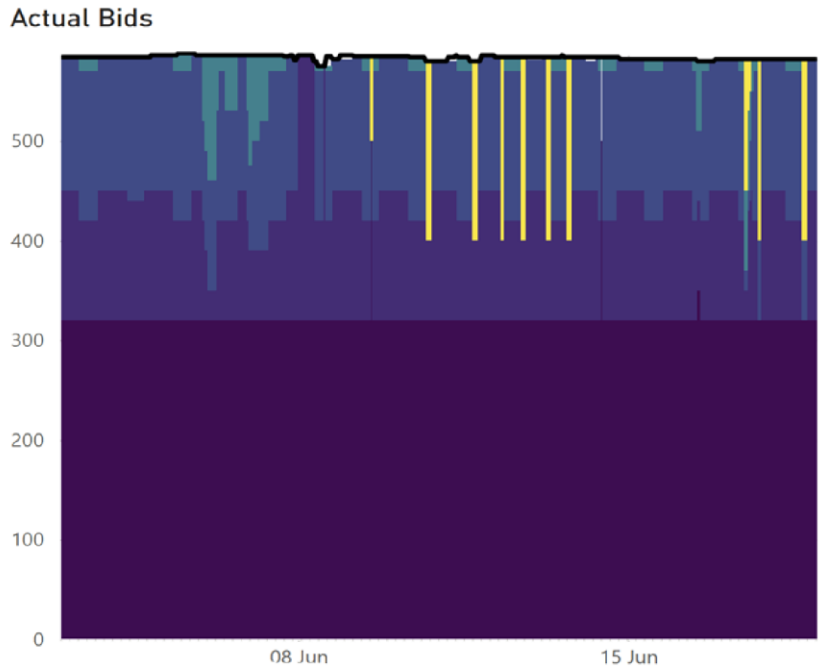


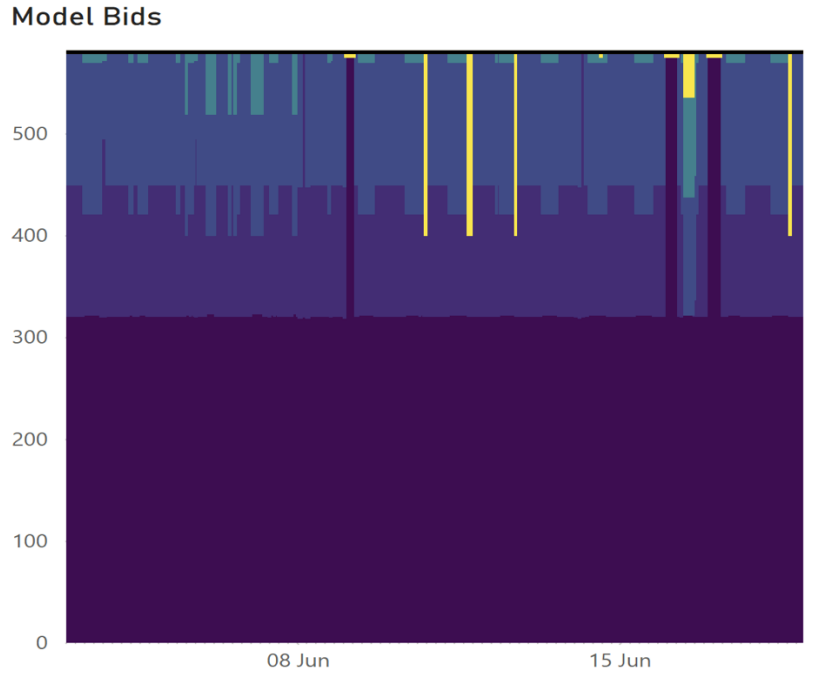


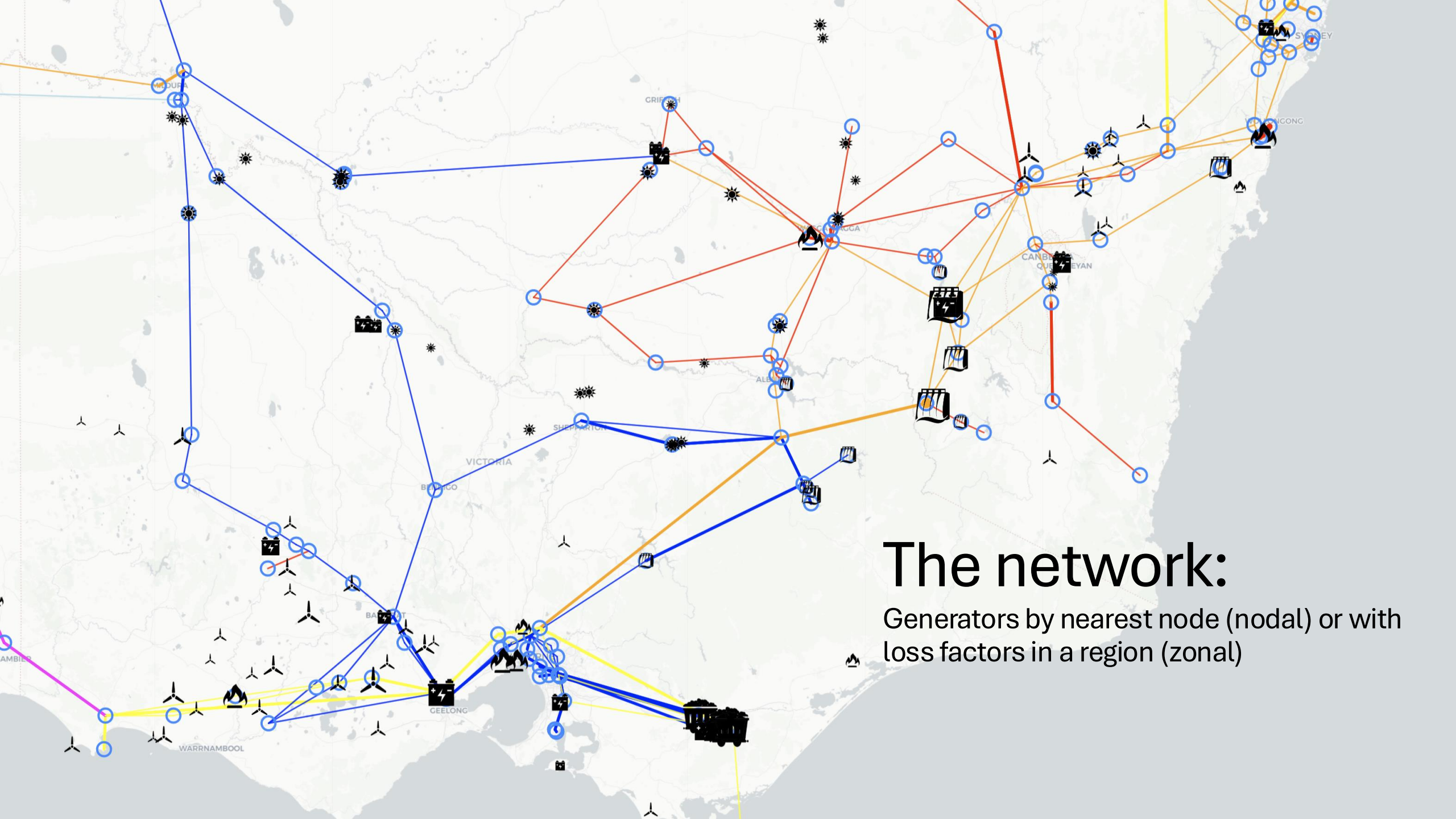
- Works on simple cases
- In reality taking one line out is such a small change to the overall network configuration it tends to get lost in the convolution

PyPSA inputs

- Bidstacks model predicts power offers in 10 bands per gen
- Other models for upcoming plant and line outages, demand, uncurtailed wind and solar output
- Feed these **stochastic** inputs into a **deterministic** PyPSA market dispatch model







The network:

Generators by nearest node (nodal) or with loss factors in a region (zonal)

Nodal or zonal?

QLD1

SA1

NSW1

VIC1

TAS1

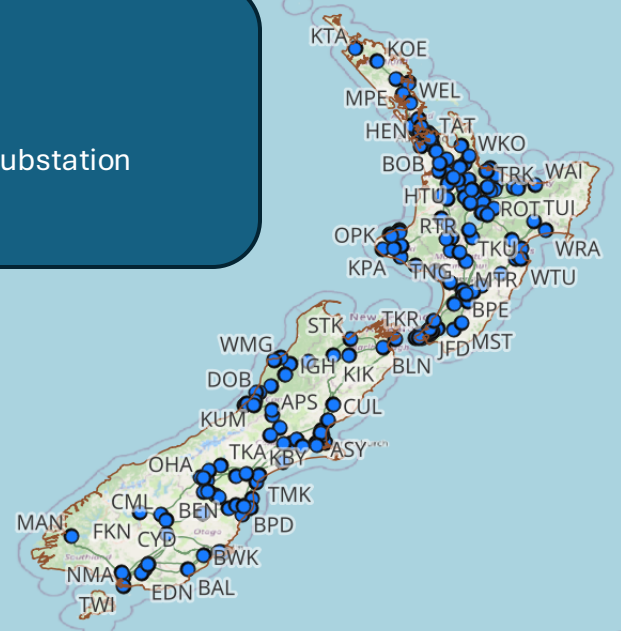
Aus

Pseudo-zonal: 5 zones with generator-level loss factors

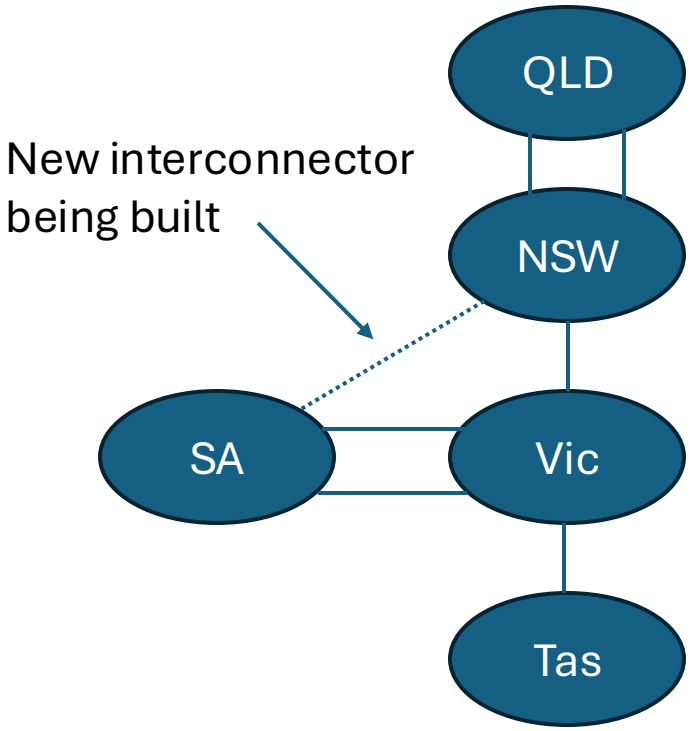
Nominal interconnectors

NZ

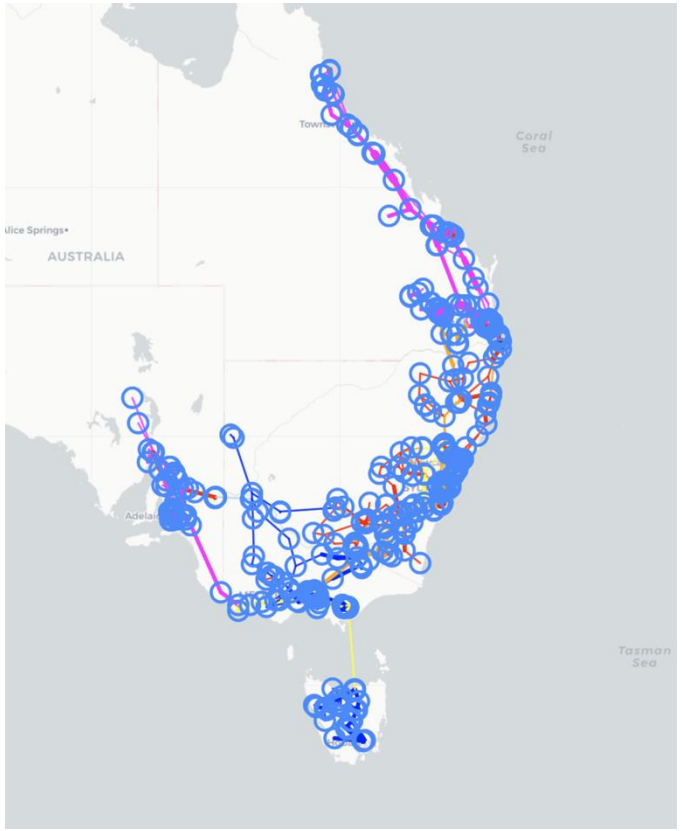
Nodal: 216 nodes, one for each substation



Zonal

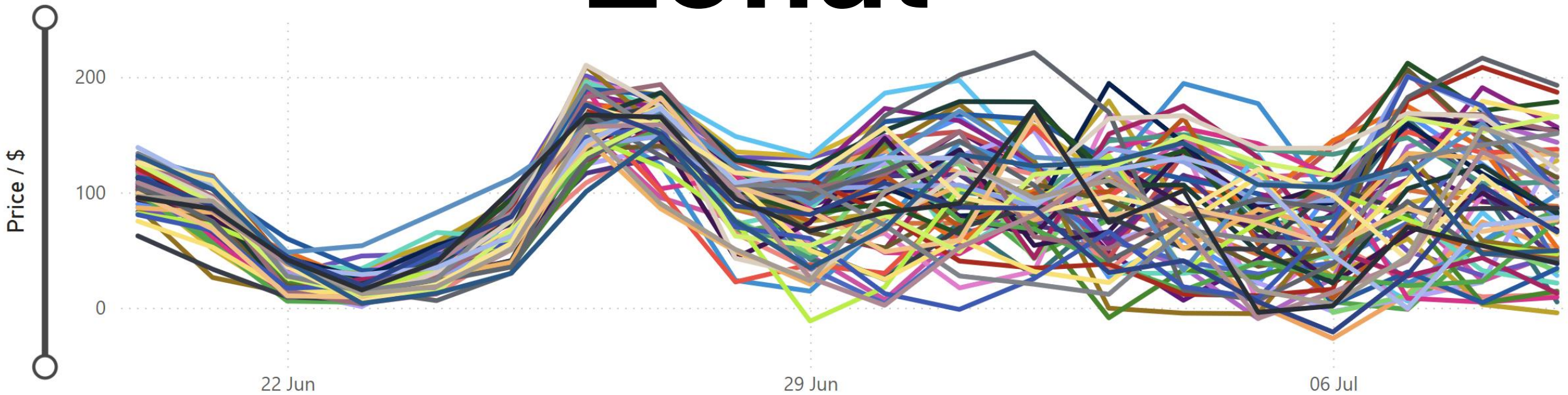

QLD
New interconnector
being built
NSW
SA
Vic
Tas

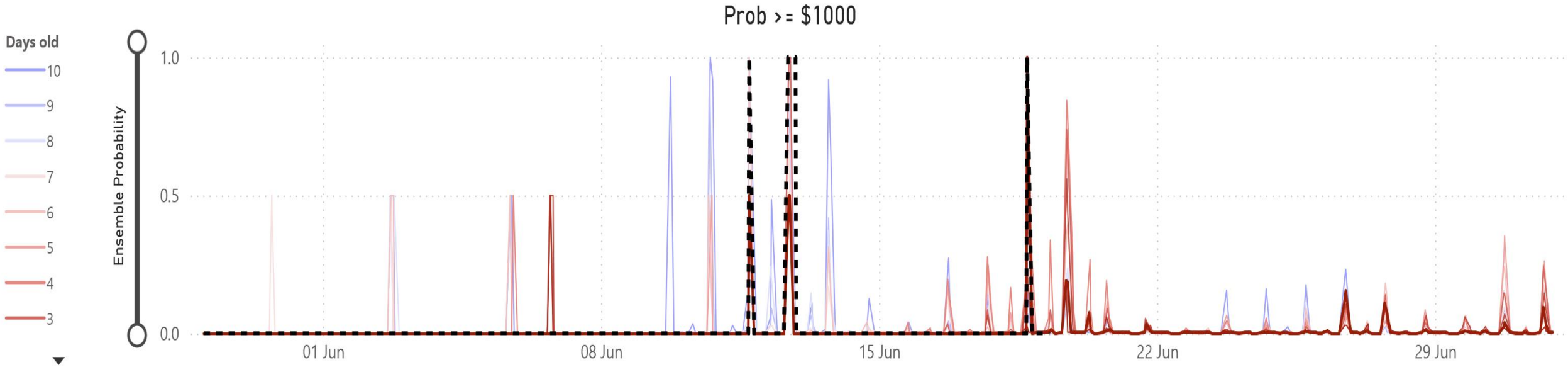
Nodal


AUSTRALIA
Coral Sea
Tasman Sea

Zonal	Nodal
Fast to solve *(1 week @30min resolution in 3 minutes)*	Slower to solve *(1 week @30min resolution in 15 minutes)*
Looks more like the market operator's model (NEMDE)	Can handle new scenarios, such as new lines or new line outages
Constraints supplied by market operator	Implicit n-1 thermal constraints
RHSs calculated statistically	RHSs calculated implicitly
Little network information required	Detailed network information required
High level perspective	Can dig into power flow

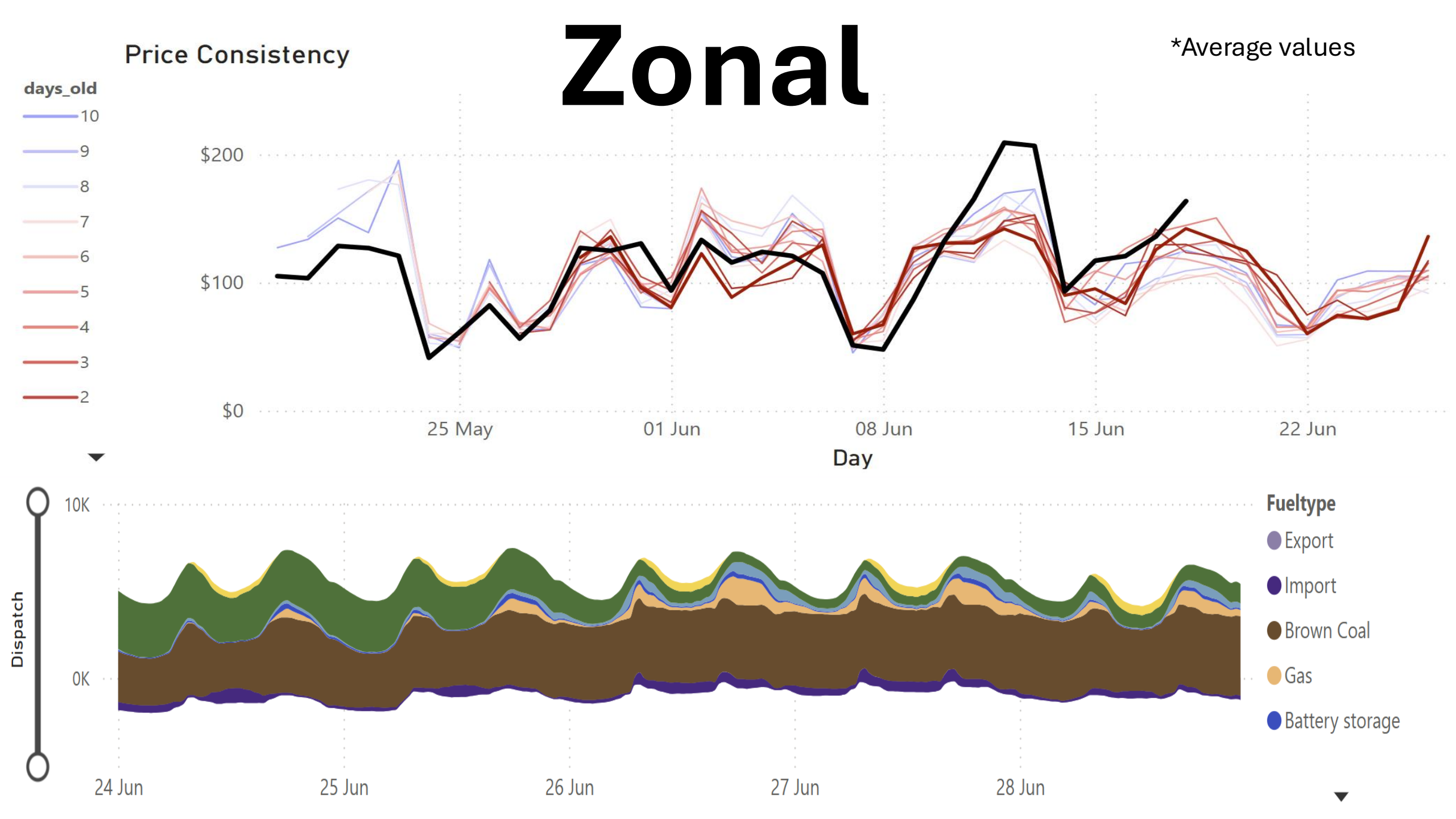
Zonal


Price / $
200
100
0
22 Jun
29 Jun
06 Jul

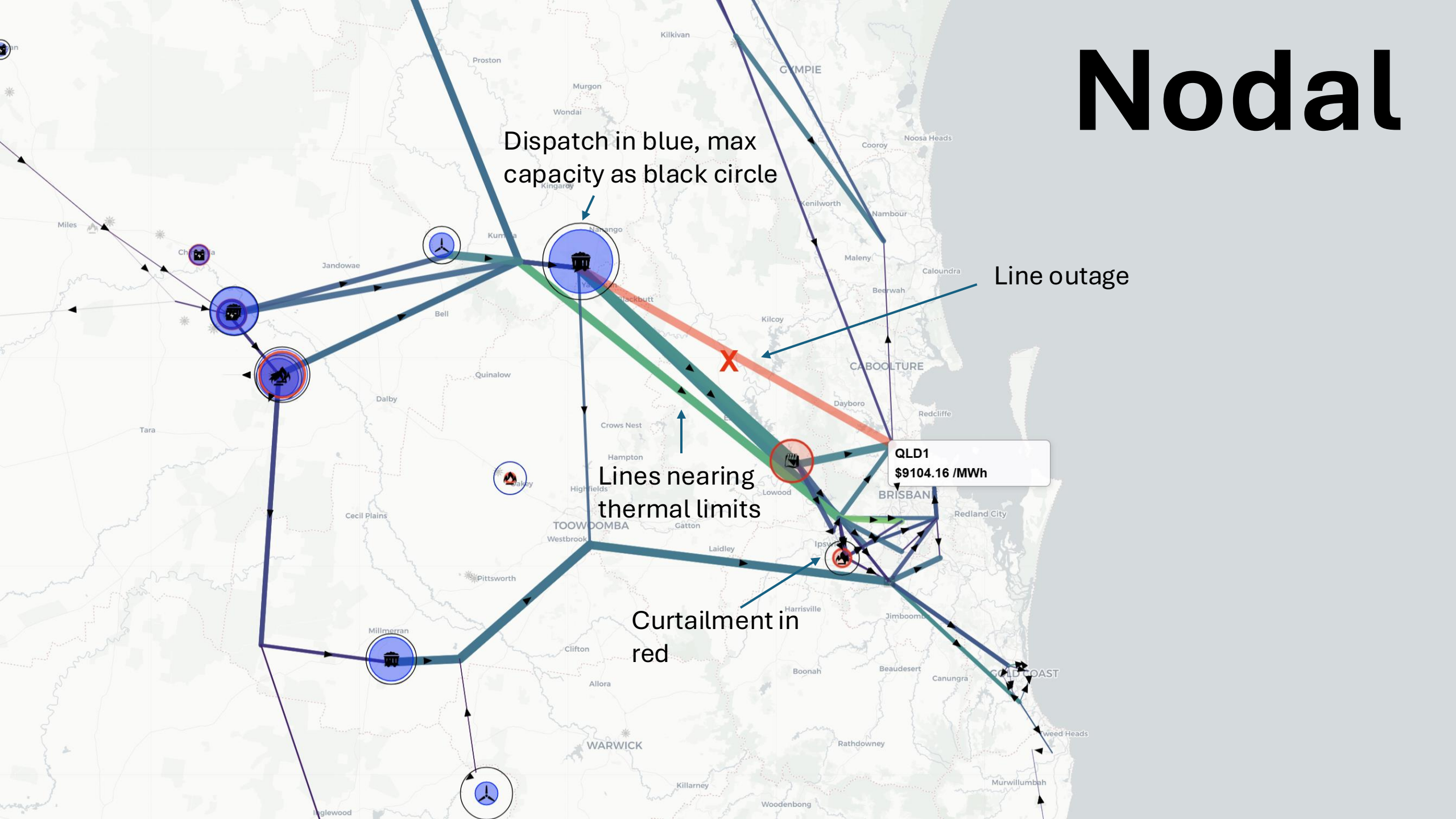

Prob >= $1000
Days old
10
9
8
7
6
5
4
3
Ensemble Probability
1.0
0.5
0.0
01 Jun
08 Jun
15 Jun
22 Jun
29 Jun

Zonal

*Average values



Nodal



Dispatch in blue, max capacity as black circle
Line outage
Lines nearing thermal limits
Curtailment in red
QLD1
$9104.16 /MWh
X
GYMPIE
CABOOLTURE
BRISBANE
TOOWOOMBA
WARWICK
GOLD COAST
Kilkivan
Proston
Murgon
Wondai
Kingaroy
Nanango
Kumbia
Jandowae
Bell
Miles
Tara
Quinalow
Dalby
Crows Nest
Hampton
Highfields
Cecil Plains
Westbrook
Gatton
Laidley
Lowood
Pittsworth
Millmerran
Clifton
Allora
Harrisville
Jimboomba
Boonah
Beaudesert
Canungra
Rathdowney
Killarney
Woodenbong
Inglewood
Tweed Heads
Murwillumbah
Redland City
Redcliffe
Dayboro
Kilcoy
Beerwah
Caloundra
Maleny
Nambour
Kenilworth
Cooroy
Noosa Heads

- Zonal:
  - Fast and accurate (depending on inputs)
  - Good for day-to-day decision making
  - Can be rerun quickly if something changes
  - Can be run several times for probabilistic results
  - Only uses PyPSA for data handling and solver
  - Requires building constraints manually, and tweaks to objective function
- Nodal
  - Good for really digging into tricky problems
  - Great if no constraint exists, e.g. lines down in storm
  - Good when statistical RHSs can’t be trusted
  - Uses PyPSA extensively, data handling with xarray, calculate constraints, solver.

Questions?