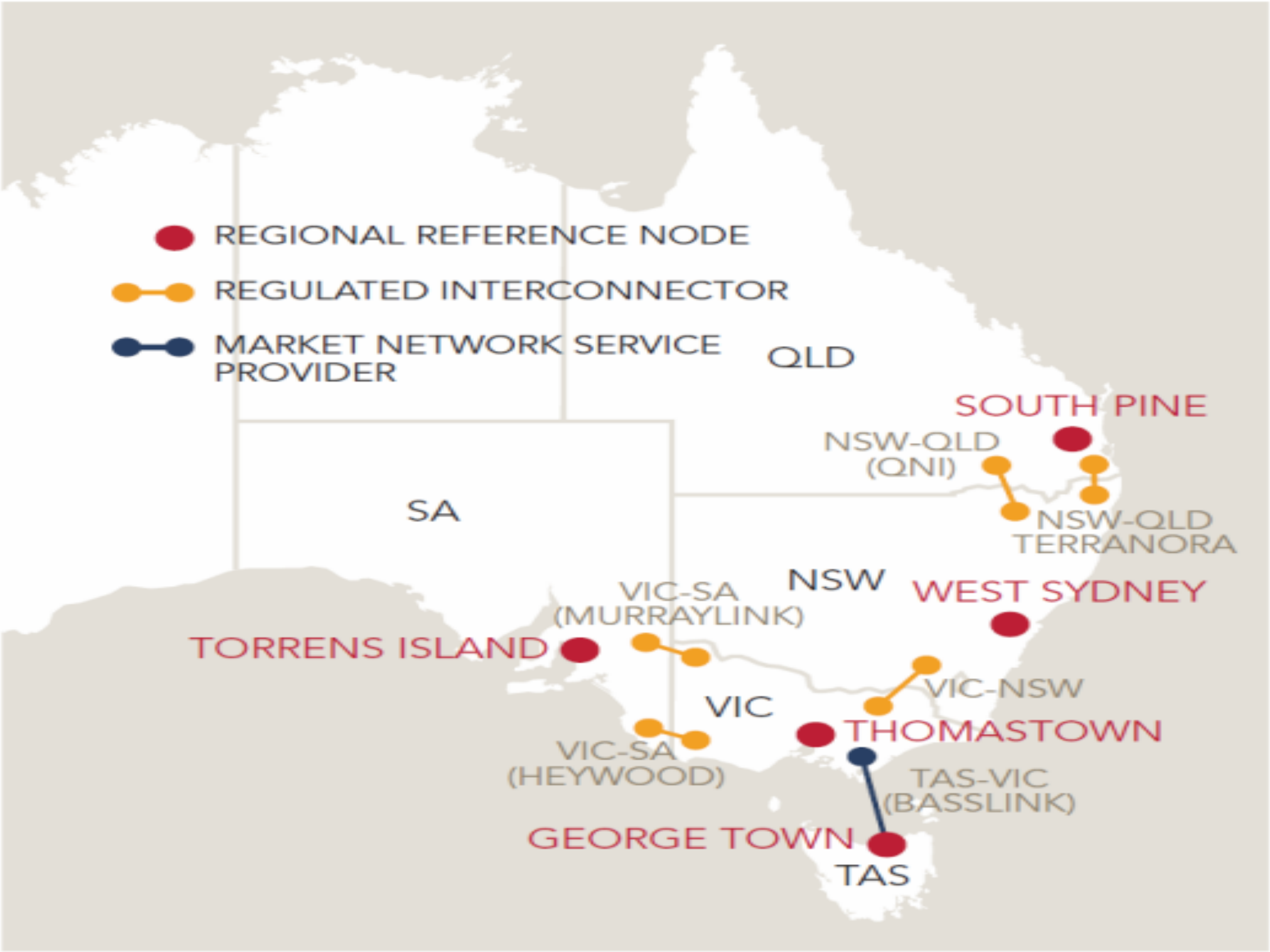
Calculation of Minimum Reserve Levels for the Australian National Electricity Market

23rd August 2011

Richard Bean and
Ben Vanderwaal

17th PSCC, KTH,
Stockholm

Australian National Electricity Market



ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Minimum Reserve Levels

- The Minimum Reserve Levels (MRL) project is undertaken periodically by the Australian Energy Market Operator (AEMO)
- Provides a measurement which can be used in the operation of the Australian National Electricity Market (NEM) to meet a specified reliability standard

Reliability Standard

- "Unserved energy (USE) cannot exceed 0.002% of the annual energy consumption for the associated region or regions per financial year."
- Interpretation: *expected* unserved energy (over all demand levels) cannot exceed 0.002% in each region for next two financial years

Simulation of market

- Monte Carlo time sequential simulation of market, “2-4-C”, taking into account:
  - Ramp rates
  - Outage rates
  - Constraint equations
  - Interconnectors
  - Bidding

Ramp rates

- Ramp rates measure the ability of generators to respond to changes in the supply demand balance
- Hydro: 120 – 200 MW / minute
- Gas turbine: 9 – 100 MW / minute
- South Australia region heavily depends on gas turbines

Outage Rates

- Measured over time at all generators in Australia (approximately 200 generating units)
- In a Monte Carlo simulation, should be "EFORd" (Demand Forced Outage Rates)
- Full and partial forced outage rates with deratings

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Constraint equations

- AEMO updates and revises a set of transmission constraint equations which are used for the system modelling. The equation terms are quantities such as demands in a particular region, line flows, and generator dispatch
- Ensure system security is maintained in the event of any one network element failing

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Interconnectors

- Interconnectors have associated inter-regional loss factors (IRLFs)
- IRLFs model losses on the interconnectors using a piecewise linear approximation to the losses in the dispatch engine

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Bidding

- Bids are developed for each of the approximately 200 generators in the NEM by examining the generation and associated regional pool price of each generator over the most recent twelve month period
- Each generator has a set of ten price / capacity pairs which indicate how much capacity a generator will offer at a given price

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Wind

- Wind was not considered in the simulation, but methods such as ELCC (effective load carrying capability) of Garver or the peak periods method discussed by Milligan and Porter can be used to estimate the capacity value of wind where necessary
- This is particularly relevant to South Australia

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Unserved Energy Estimation

- Unserved energy estimates are derived by convolving the supply and demand curves (Li 2005)

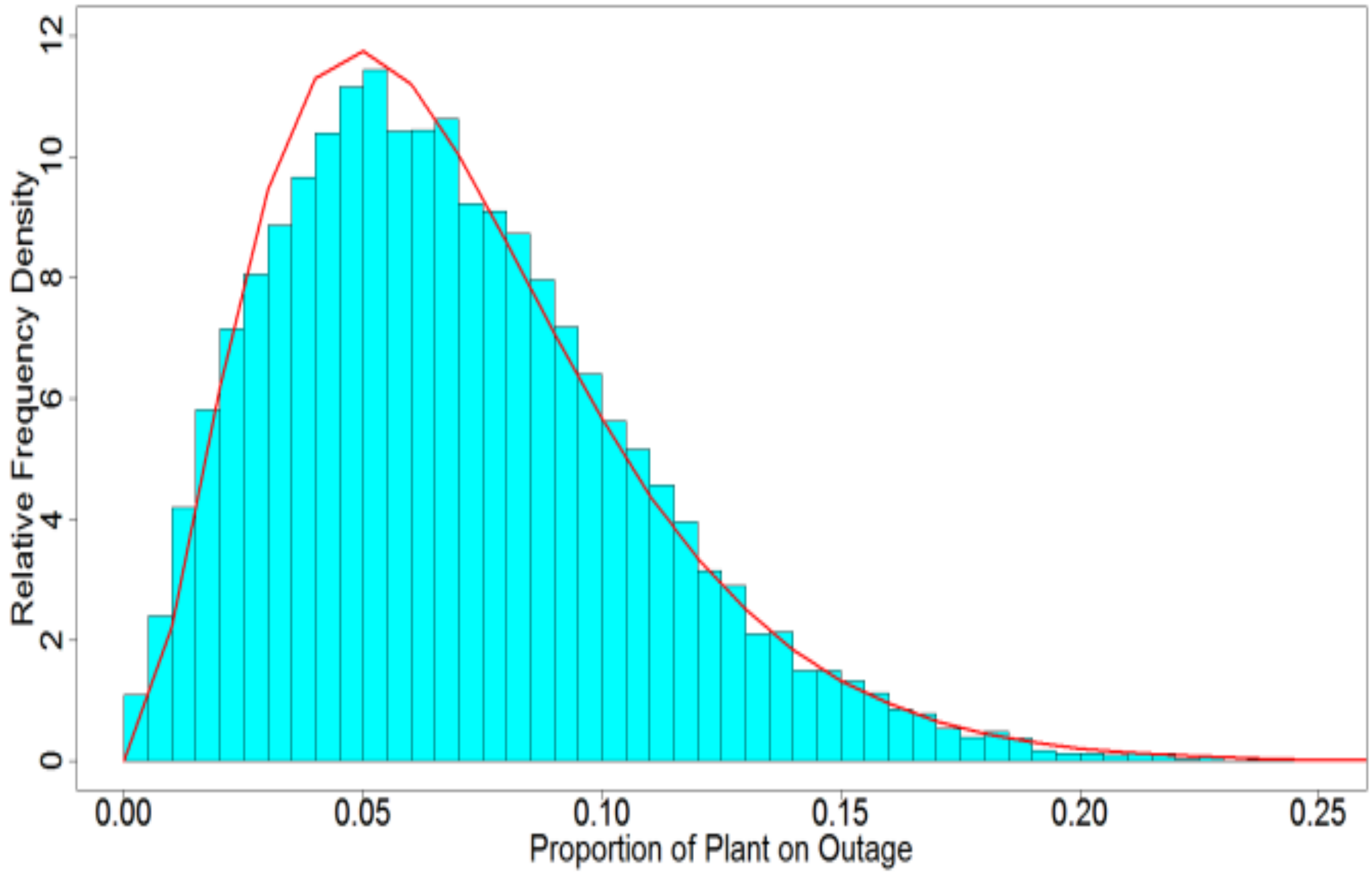
1. *Create a discrete generation probability distribution*
2. *Create a discrete load probability distribution*
3. *Perform a convolution between the two distributions*

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Explaining changes in USE

- Mazumdar and Gaver: the distribution of the proportion of plant unavailable in a given region can be approximated closely by a beta distribution.

Queensland capacity on outage



Demand forecasting

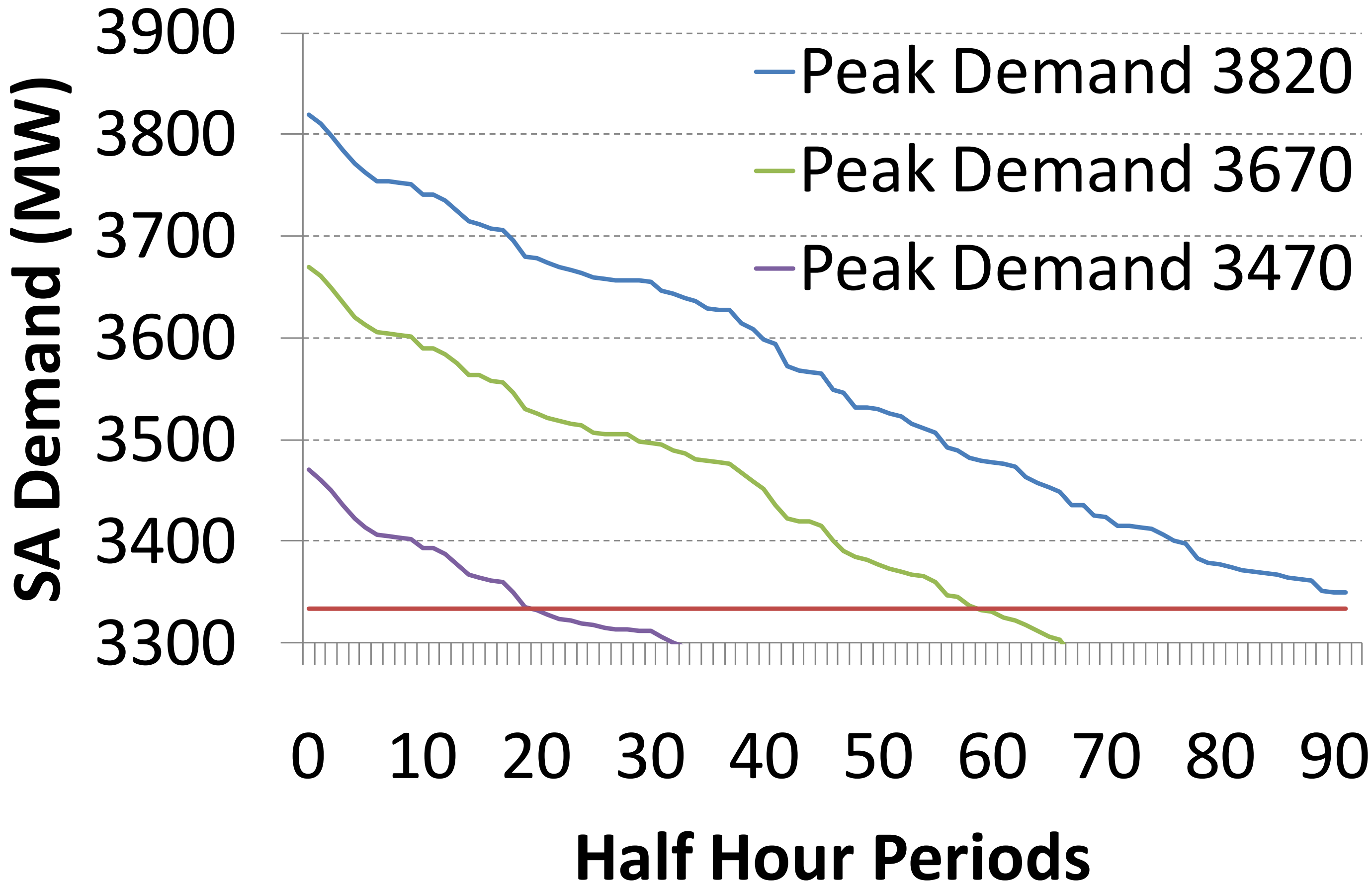
- Forecasts are prepared for each region on a “probability of exceedence” (POE) basis
- For example, the 10% POE demand is expected to be exceeded in 10% of years
- Energy is assumed to be the same over all POEs

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Demand forecasting (cont'd)

- Demands are "grown" by taking an historic half-hourly load trace reference year (2005-06) such that the peak demand and energy of the input year are adjusted to be the same as the peak demand and energy forecast of the target year
- Also, the gradient of top demand periods should match the input data

Extrapolating unserved energy



ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Extrapolating unserved energy (cont'd)

- At highest demand points, the scaling of the input trace effectively multiplies the demand value of the input trace by a constant factor
- Assume a straight line as a good approximation to peak demand periods against time – historically true

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Extrapolating unserved energy (cont'd)

- Estimated USE = $\frac{c}{p}(p-u)^2$
- Where *u* is an "effective availability" parameter, *c* relates to the gradient of the top demand points, and *p* is the peak demand in the reference year

Development of MRLs

- Remove or add plant from each region, simulating the system with 5%, 10%, 50% and 90% POE demands, until the expected unserved energy in each region was 0.002% of the energy in that year or less

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Development of MRLs (cont'd)

- Want to remove plant with the average outage rate of plant in the region
- Want to affect constraint outcomes as little as possible
- Some subjectivity concerning number of plants to remove
- 100 iterations for each POE level, due to time constraints

Reserve sharing

- Between the South Australia and Victoria regions, capacity can be transferred between the regions
- Capacity can be subtracted from one region and added to another while meeting reliability standard

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Application of MRLs

- Used as inputs to two processes:
  - Medium Term Projected Assessment of System Adequacy
    - determines if capacity of system is sufficient to meet reliability standard over next 2 years – MRLs as a buffer to the 10% POE forecast peak demand
  - Supply Demand Calculator
    - forecasts when reliability standard will not be met

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Conclusion

- MRL numbers are used in daily adequacy assessments to help market operator decide on system intervention
- Confidence intervals would be ideal as outage data has a large degree of uncertainty

ROAM CONSULTING
ENERGY MODELLING EXPERTISE

Conclusion (cont’d)

- Automating the process of removing and adding plants to remove subjectivity and speed up process
- Top demand periods may be better approximation by shifted Rayleigh distribution (Diesendorf and Martin)

Conclusion (cont'd)

- POEs across regions: assumed that once in every 10 years, each region will experience 10% POE demand simultaneously – a less likely outcome
- USE extrapolation should take this into account