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Forecasting Daily Peak Electricity Demand in Australia with an Economic Based Evaluation

Workshop on Empirical Methods in Energy Economics, 24th June 2010

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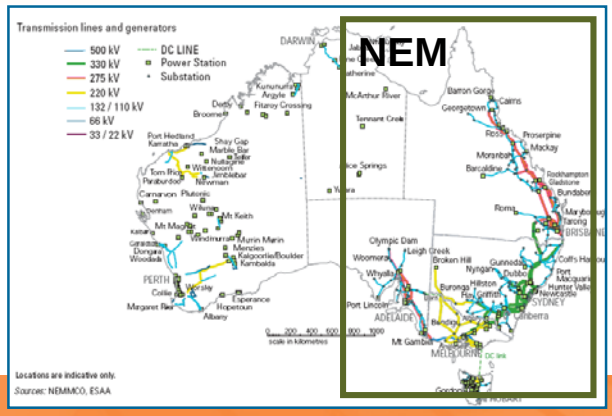
Background

Medium-Term Forecasts in Australia

- The Australian Energy Market Operator (AEMO) is responsible for managing power system security and reliability.
- Task: Allocate capacity to each region to meet 10%POE demand plus Minimum Reserve Levels, according to the Reliability Standard.
- Purpose: Take and coordinate appropriate measures:
  1. Response of markets participants
  2. Contracting of additional reserve capacity is required



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Research Questions

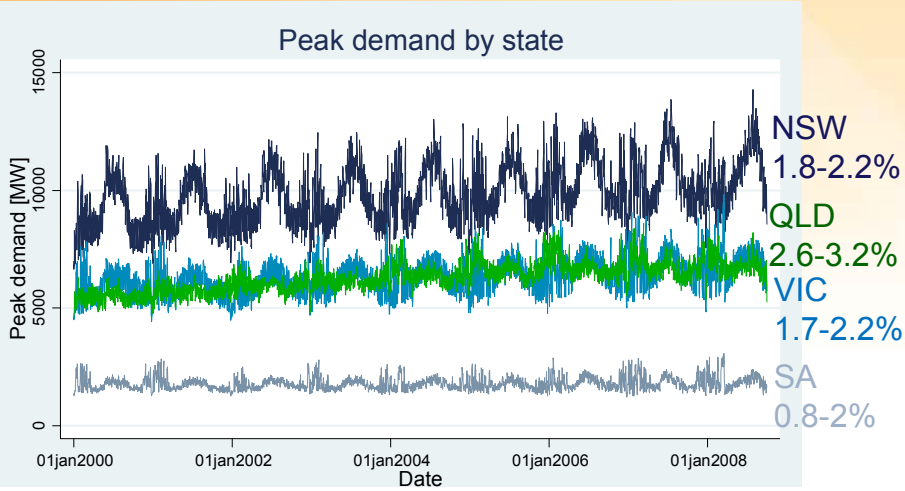
- What is the impact of accounting for spatial temperature variability on regional daily peak demand forecasts?
- What are the features of resampling techniques required for medium-term forecasting to describe the uncertainty of future temperatures in the estimation of a density forecast of peak demand?
- What can be gained by using economic based measures i.e. that the forecast would adequately advice its purpose, compared to using only statistical measures?

Aim:

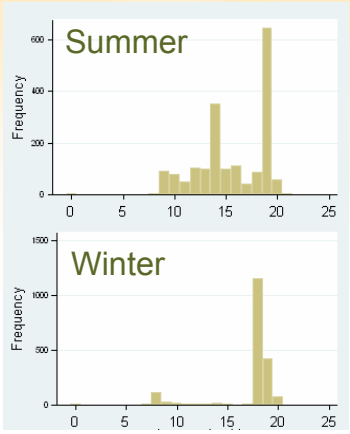
Develop an econometric model and resampling techniques for medium-term forecasting of daily peak electricity demand which successfully combines the dynamics of short- and long-run models AND evaluate these forecasts according to provide more informative measures to market participants.

Data

- Trends, annual growth and time of the peak



Time of the day



Dataset: regional electricity demand and temperatures with half-hour resolution are transformed into a series of maximum daily demands and daily heating, cooling degrees in four NEM states (Queensland, Victoria, South Australia, New South Wales). Model based on the period 2000-2005.

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Method

- A generalised ARDL model is estimated for each season:

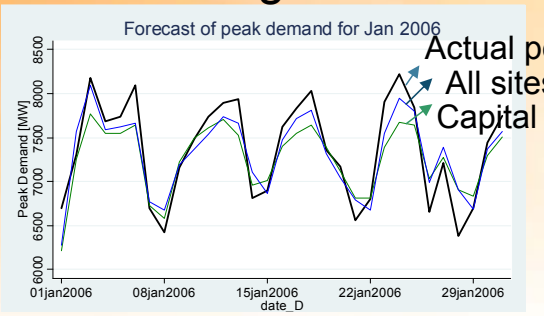
$$peak_t = \alpha_0 + \beta_0 t + \boldsymbol{\delta_1 dow}_t + \boldsymbol{\delta_2 moy}_t + \boldsymbol{\delta_3 hdays}_t + \sum_{n=1}^{8} \beta_n peak_{t-n} + \sum_{n=1,7} \boldsymbol{\vartheta_n dow}_t \cdot peak_{t-n}$$
$$+ \sum_{i=1}^{6} \sum_{n=0}^{8} \left(\gamma_{i,n} pop_i \cdot HDD_{i,t-n} + \varphi_{i,n} pop_i \cdot CDD_{i,t-n} \right) + u_t$$

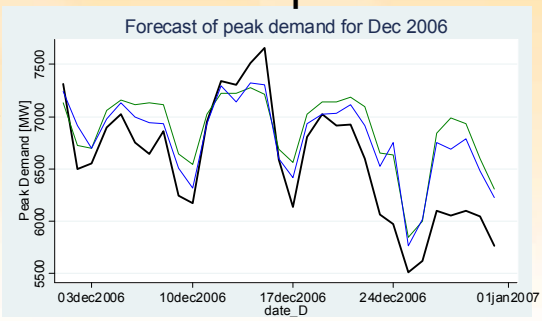
Where $peak_t$: peak demand on day t, *dow*: dummies day of the week, *moy*: dummies month, *hdays*: dummies for holidays, pop_i: population share at site i

- Diagnostic test: final specification for each season
- Forecast peak demand using actual values of exogenous variables. Statistical evaluation criteria: RMSE, MAPE, Theil Inequality Coef.
- Produce density forecasts: upon 1000 samples of daily blocks of historical temperatures. Account for any serial correlation or ARCH effects in the error term.
- Evaluate likely implications on decision making as a set of outcomes (use 10%POE and 90% POE values)
  - Assessing benefits or costs associated: market simulations

Results: Queensland

- Gain of using weather information from multiple sites





Seasonal Models:

- Multiplicative seasonality of peaks
- Log specification is preferred (heteroscedasticity)
- ARCH effect only present in summer
- Serial correlation only present in autumn

Statistical Accuracy:

- Root Mean Squared Error (RMSE): 740-2100MW
- Mean Average Percentage Error (MAPE): 5-6.6%
- Theil Inequality Coefficient: 0.05-0.13

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Results: Queensland

- Decision making

Forecasts of daily peak demand

Other input info:
- energy capacity
- maintenance outages
- wind power forecasts

Medium Term Projected Assessment of System Adequacy

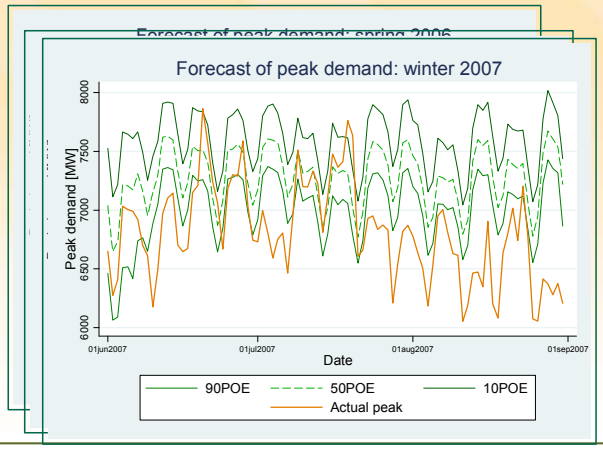
Projections of reserve levels at daily peak:

Are minimum reserve levels, according to reliability standards, met?

Actions to take:

Voluntary market response e.g. rescheduling of maintenance

Market intervention required: contracting for additional reserve



CASES:

- Overpredictions i.e. 90POE>peak (π=0.57)
  - Unnecessary actions may have been taken
- Underpredictions i.e. 10POE<peak
  - Required contracted reserves may have not been established (no cases): scheduled capacity-peak<500MW), otherwise
  - Contracted reserve is insufficient (π=0.07)

Conclusions

- A time series of peak demand can be modelled in four seasonal ARDL models which provide good statistical accuracy for the medium-term.
- Density forecasts:
  - Low probability of underpredicting peak demand: it adequately advises decision making in terms of contracting reserve supply.
  - Higher probability of overpredicting peak demand: it may advise unnecessary market response.
- Future work:
  - Economic based evaluation measures into one figure for the market
  - Improving current resampling techniques
  - Modelling the long-run trend.

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Thank you!