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Forecasting daily Peak Electricity Demand in Australia with an economic-based Evaluation

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Summary

The aim of this research is to develop a suitable econometric model and resampling techniques for medium-term forecasting of daily peak electricity demand which should successfully combine the dynamics of short- run and long-run models. Furthermore, we propose to evaluate these forecasts according to their purpose with the idea of providing more informative measures to market participants.

Seasonal Autoregressive Distributed Lag Models (ARDL) have shown to adequately model peak demand on a daily basis, where accounting for any diversity of local weather in main population centres provides an improvement in forecast accuracy.

This poster showcases a two-years ahead forecast of electricity peak demand in Queensland, which is the largest NEM state in Australia.

Methodology

1. Data requirements: half-hourly aggregated electricity demand and temperatures of representative sites of subregions. In the long run, annual population for each subregion and other economic variables such as gross state product, population growth, prices of substitute products, among others.
2. Building up a times series based on historical data with daily maximum demands and daily heating and cooling degrees.
3. The generalised ARDL model below has shown to fully capture the effect of key determinants on peak demand in individual seasons, where serial correlation can be often eliminated. This would not be possible with a single forecast model for peak demand at any time of the year.

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

The peak demand at time t is $peak_t$. dow_t, moy_t, hdays_t are vectors with dummy variables for the effects day of the week, month and holidays respectively. $HDD_{i,t}$, $CDD_{i,t}$ are daily total of heating and cooling degrees at time t and site i, which are interacted with its population share pop_i. The final specification for the model of each state and season was decided upon diagnostic tests for heteroscedasticity and serial correlation. The ARDL model was estimated for each season using data of years 2000 to 2005 and the following two years of data (2006/2007) were saved for the forecast evaluation.

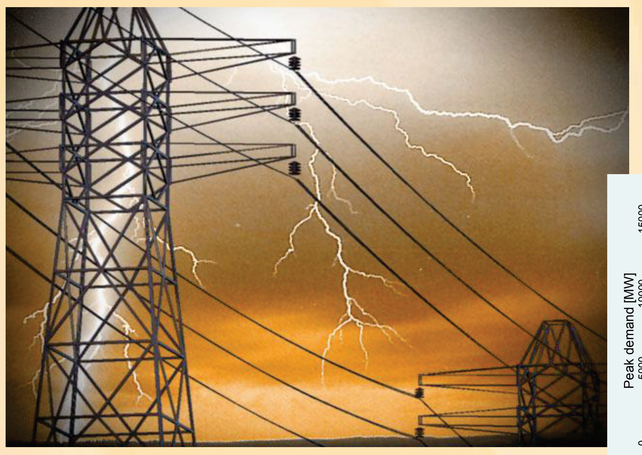
4. Forecasts are calculated iteratively by combining the four seasonal ARDL models. The forecast distributions are produced by resampling 1,000 years of potential temperatures from observed temperatures in the relevant seasons. Any autoregressive conditional heteroscedasticity, always present in summer across states, was modelled with residuals block bootstrapping.
5. To evaluate the forecast performance, a comparison of statistical measures is undertaken given that actual temperatures are certain:
   - Root Mean Squared Error (RMSE) [MW]: accuracy
   - Mean Average Percentage Error (MAPE) [%]: relative accuracy
   - Theil Inequality Coefficient: forecast stability

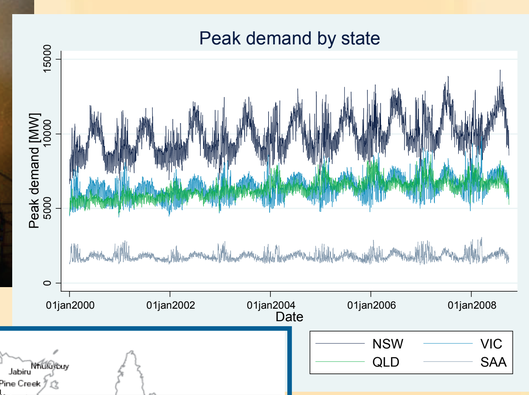
Density forecasts are used then to study the potential implications on decision making: probabilities of misleading actions taken.

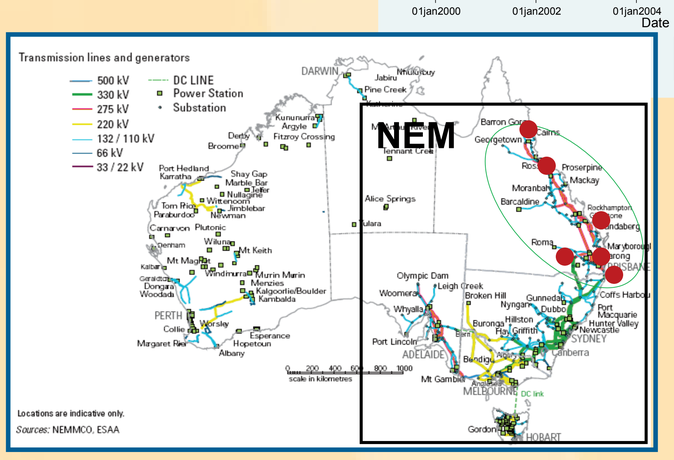
Conclusions and further work

A time series of peak demand can be modelled in four seasonal ARDL models which provide good statistical performance for medium-term forecasting. The density forecasts present a low probability of underpredicting peak demand, which implies they can adequately advise decision making in terms of contracting reserve supply. However, they show about 50% probability of overpredicting peak demand, which may indicate the need for market response when it will not be required.

Future work includes aggregating any economic based evaluation measures into one figure for the market, improving the current resampling techniques and modelling the long-run trend.





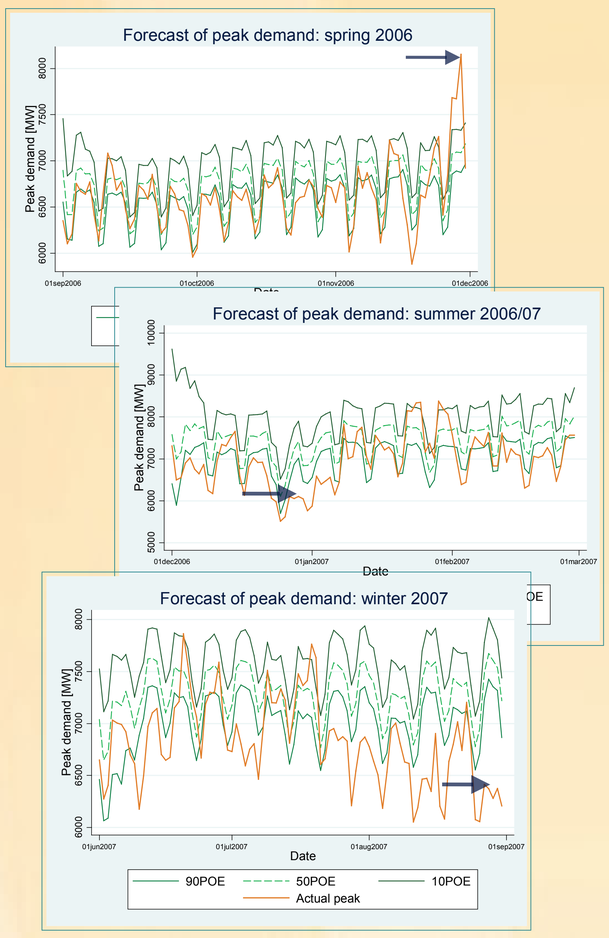


Queensland currently exhibits the largest annual growth rate in peak demand (2.5-3.2%) in Australia.

Decision making process following the forecasting

Forecasts of daily peak demand by state

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

FORECAST EVALUATION

Guided by
1. MAPE = 5-6.6%
2. RMSE = 740-2100MW
3. Theil Inequality Coef = 0.049-0.13 and…

4. Economic based measures:

Bad decisions taken as a result of the forecast:

- 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): sched.capacity-peak<500MW), or
  - Contracted reserve is insufficient (π=0.07): otherwise

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