Forecasts developed for the IRP 2015/6

Using regression models developed by the CSIR for predicting future patterns within electricity demand sectors

Presentation by CSIR forecasting team during IRP Public Consultation Workshops
Dec 2016 / Jan 2017
Background

The CSIR forecasting team has developed a methodology for long-term forecasting of annual national electricity demand

- The methodology was first developed in collaboration with BHP Billiton in 2003, and subsequently re-used and refined
  - Details regarding methodological aspects and the process of developing the methodology were published in the Journal of Energy in Southern Africa (JESA), November 2014 issue
- It has been used for providing additional forecasts in the previous IRP and its revision, and has now been used to provide a new set of forecasts for the 2016 IRP

This presentation briefly describes the following (for more details refer to the report on the IRP website):
- Methodology and assumptions used
- Forecasts produced
Key assumptions with regard to electricity patterns

• The forecasts were designed to determine estimated demand (which may not equal consumption) for electricity *without* considering supply constraints
  • Intended for use in strategic planning

• The forecasts cover the **total** requirement for electricity to be generated annually in order to meet the needs of South Africa
Key methodological considerations

• The forecasts are based on statistical models
  • Data-driven and based on historical quantitative patterns / relationships
    • Use data that is as up-to-date as possible so that recent patterns are also reflected
  • Assumption that the relationships will continue into the future
  • Using such models have advantages and disadvantages
    • The advantage is that one can quickly re-do forecasts for different scenarios
    • The disadvantage is the constraints imposed by available data

• Forecasts were developed in such a way that key parameters ("drivers") could be fed into the forecasting process
  • Future values of such "drivers" were based on scenarios
Overall methodology followed

- In developing the methodology, the CSIR approach was to collect historical data on electricity consumption from various sources in the public domain.
  - Maintained overall consistency between sources by ensuring sector breakdowns correspond to Statistics SA total.

- Total demand was broken down into usage sectors, as far as the data allowed.
  - Investigation showed that better models were obtained by modelling sectoral demand rather than total.
  - “CSIR Recommended” historical sector breakdowns (in time series format) were developed from a combination of data sources.

- Regression models were developed per sector.

- Scenario forecasts for “drivers” were fed into the sectoral models.

- Sectoral totals were aggregated and adjusted for losses to obtain total forecasted values.
  - Some adjustments could be made to totals, e.g. adding exports.
Statistical forecasting methodology chosen

- **Explanatory Forecasting**: Multiple regression models used
  - In order to translate changes in the “driver” variables in scenarios into electricity changes, not just unchanged extrapolations
  - **NOTE**: care must be taken not to over-interpret “drivers”
    - Predictors are not necessarily “causes” of consumption

- **Criteria used to assess models**:
  - Statistical goodness-of-fit statistics: adjusted $R^2$, RMSE, residual patterns
  - Residual patterns acceptable and coefficients statistically significant
  - Logical set of “forecast drivers”
  - Measures of multi-collinearity: condition index $< 30$
  - Stability with regard to scenario predictions
## Sector regression models

- **Sectoral regression models used for IRP 2015/6 forecasts:**

<table>
<thead>
<tr>
<th>Electricity sector</th>
<th>Model used <em>(Note: the “predictor variables” indicated in bold in each model)</em></th>
<th>Adjusted $R^2$</th>
<th>Condition index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>$-47339 + 3725.82 \times \ln(FCEH)$</td>
<td>Adjusted $R^2 = 0.97$</td>
<td>N/A if only 1 variable in model</td>
</tr>
<tr>
<td>Transport</td>
<td>$975.24 + 45.61 \times \text{mining index excluding gold}$</td>
<td>Adjusted $R^2 = 0.74$</td>
<td>N/A if only 1 variable in model</td>
</tr>
<tr>
<td>Domestic</td>
<td>$-410694 + 31840 \times \ln(FCEH) + 2339.48 \times \text{recession}$</td>
<td>Adjusted $R^2 = 0.97$</td>
<td>CI = 1.4</td>
</tr>
<tr>
<td>Commerce &amp; manufacturing</td>
<td>$11000 + 0.02259 \times FCEH + 687.14368 \times \text{manufacturing index} \times \text{correction factor}$</td>
<td>Adjusted $R^2 = 0.9691$</td>
<td>CI = 21.27</td>
</tr>
<tr>
<td>Mining</td>
<td>$21784 + 75.868 \times \text{mining production index (excl. gold)} + 0.05268 \times \text{gold ore treated}$</td>
<td>Adjusted $R^2 = 0.55$</td>
<td>CI = 6.3</td>
</tr>
</tbody>
</table>
Four economic scenarios used as “driver” inputs
Sector forecasts obtained from regression models

Agriculture annual consumption in GWh

Transport annual consumption in GWh

Mining annual consumption in GWh

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Sector Forecasts (...)2

[Graphs showing domestic and commerce & manufacturing annual consumption in GWh for different scenarios and historical data.]
National forecasts

• Total consumption forecasted by adding up consumption of all 5 sectors and adjusting for losses

Scenario:
Overall growth (2014 to 2050)
Avg year-on-year growth
Low scenario 62.8% 1.7%
Moderate scenario 129.9% 3.6%
High (same sectors) scenario 185.9% 5.2%
High (less intense scenario) 123.9% 3.4%
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