# Electricity demand forecasting using regression, scenarios and pattern analysis

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# Outline

- Background
  - Electric Power System
  - Forecasting
- Study Objective
- Methodology
  - Regression, Pattern Analyses, Forecasting Using Scenarios
- Results
- Conclusion

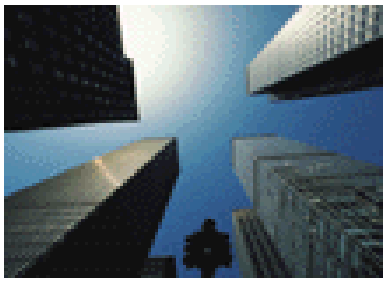
# Background: Electric Power System

## The Flow of Electricity

**Generation**

**Distribution**

**End Use**



**Transmission**

# Background: Electric Power System

- An electricity power system is a dynamic system which is balance of supply and demand
  - Demand for electricity changes as a function of time
    - Instantaneous (seconds, minutes)
    - Short term (hours, days)
    - Longer term (months, years)
- Electricity demand forecasts are important in
  - Generation capacity planning
  - System reliability considerations
  - Resource adequacy

# Principles of Forecasting

These are guidelines that can assist in producing more reliable forecasts

- Identify causality
  - Search for the cause and effect relationship, instead of over reliance on historical correlations.
- Be producible
  - Can be understood and replicated
- Be functional
  - Should fit the decision at hand
- Test sensitivity
  - Most forecasting methodologies are driven by key assumptions about the future
    - The impact of this uncertainty on the forecast should be conveyed
- Maintain simplicity
  - Only include as much information in the model as is necessary for accurate prediction

# Study objective

**To forecast national electricity demand patterns for a period of 20 years**

- Total annual consumption
- Understand seasonal effects
- No constraint on the supply of electricity was assumed

# Methodology

- Multiple linear regression
  - Relate factors that could influence annual electricity consumption within individual sectors.
- Pattern analyses
  - Description of the pattern of hourly, daily and weekly variation in electricity demand.
- Scenarios
  - Projection of input (“driver”) information used in the sectoral electricity demand regression models.
- Sectoral forecasts of annual electricity demand for each scenario
  - Obtained by inserting projected “driver” information into the regression models.
- Total annual electricity demand forecasts per scenario
  - Aggregation and adjustment of annual sectoral demand forecasts.
- Expected peak demand values for each scenario
  - Superimposed hourly, daily and weekly patterns on the total annual demand forecasts.

# Data

- Collected historical annual electricity demand data

- Disaggregated into annual demand per sector
  - Agriculture
  - Domestic
  - Commerce & Manufacturing
  - Transport
  - Mining

- Historical indicator information
  - Population
  - Gross Domestic Production (GDP)
  - Final Consumption Expenditure of Households (FCEH)
  - Various mining indices

# Regression Modelling of Sectoral Demand

- Multiple linear regression model

$$y = a_0 + a_1 x_1 + a_2 x_2 + \ldots + \varepsilon$$

- For each sector, $y$ was annual demand and $x_i$'s are "driver" information

- The process was to find values of $a_0$ , $a_1$ , $a_2$ … which would give the best prediction of demand (y) given the combination predictor ($x_i$) variables.

  - Ensure the predictor variables make logical sense, and they give a statistically valid model.

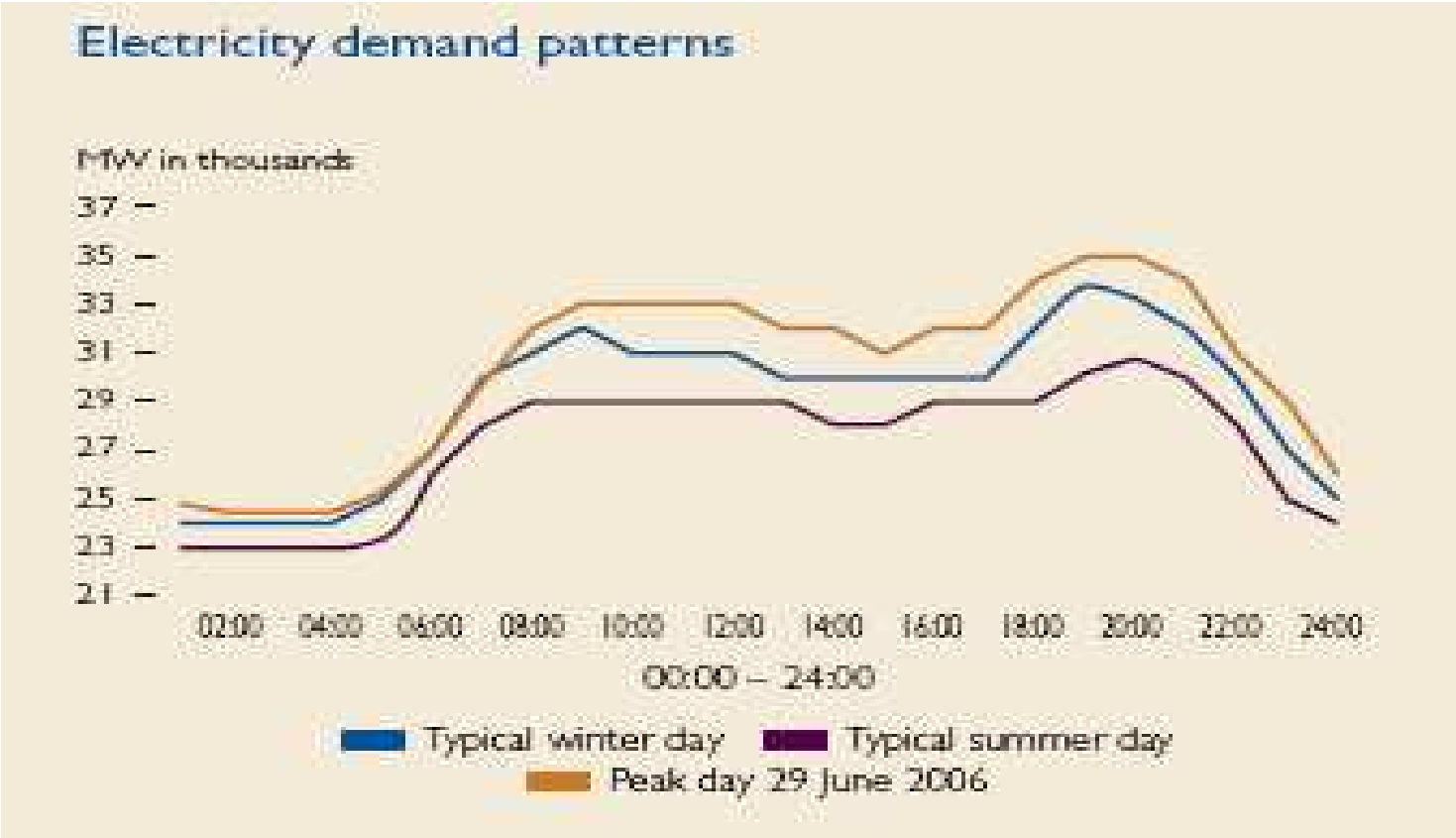
- Regression model was interpreted as a purely statistical (empirical) relationship, not a cause-and-effect relationship.

# Chosen Regression Models

- Summary of selected predictor variables per sector

| Electricity sector | Predictor variables |
|---|---|
| **Agriculture** | Log (FCEH) |
| **Transport** | GDP per capita, Coal production index |
| **Domestic** | FCEH, GDP per capita |
| **Commerce & manufacturing** | Population, GDP |
| **Mining** | Platinum production index, Coal production index, Gold or treated |

# Pattern Analysis




Sourced from Eskom Annual Report (2007)

available at www.eskom.co.za



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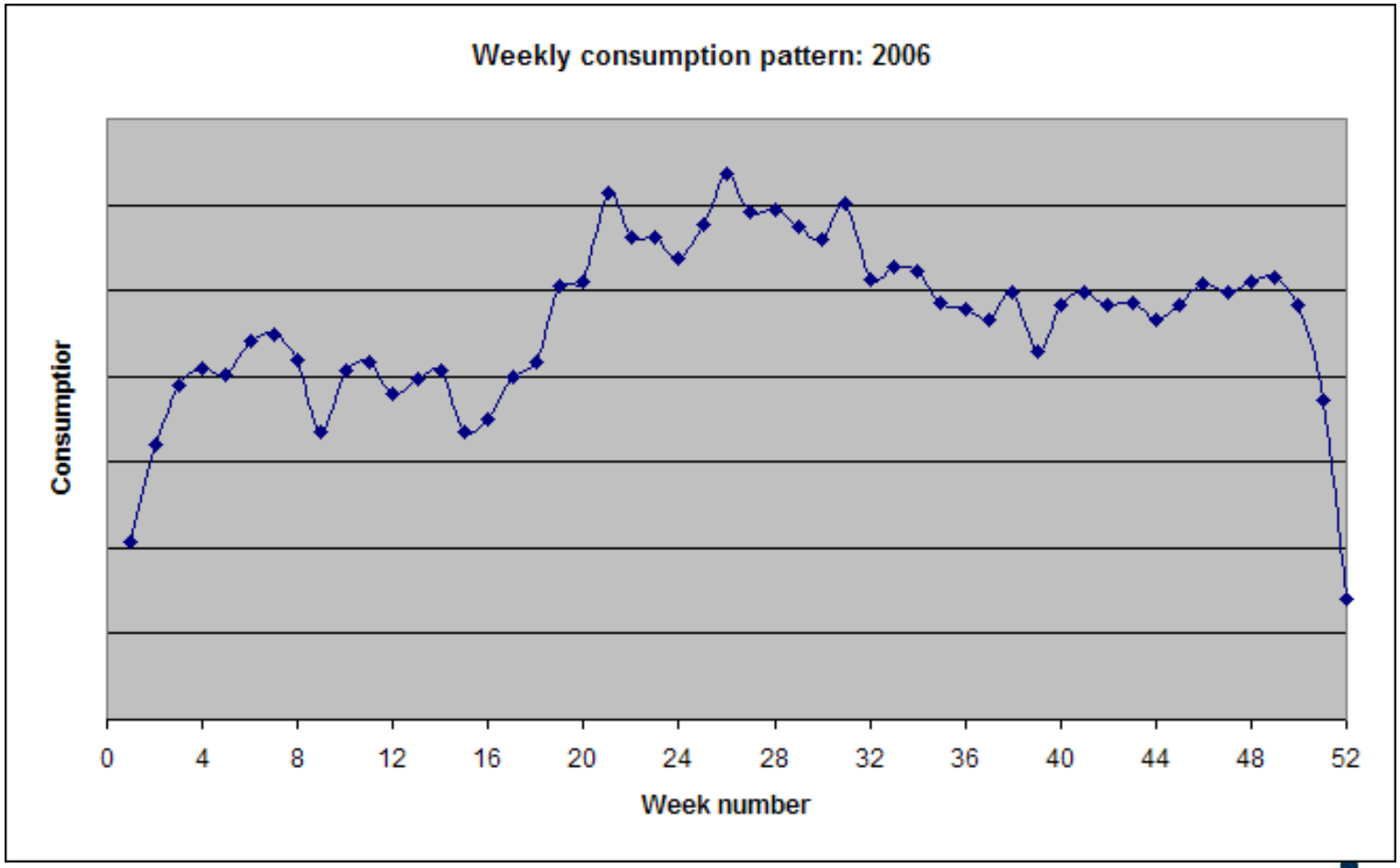
# Pattern Analysis

- Determination of hourly, daily and weekly fluctuations in electricity demand.

- Determined the pattern for a particular year (2006), instead of finding an “averaged” pattern for a year.

  - Avoids excessive smoothing of the data, which reduces peaks and troughs.

# Pattern Analysis







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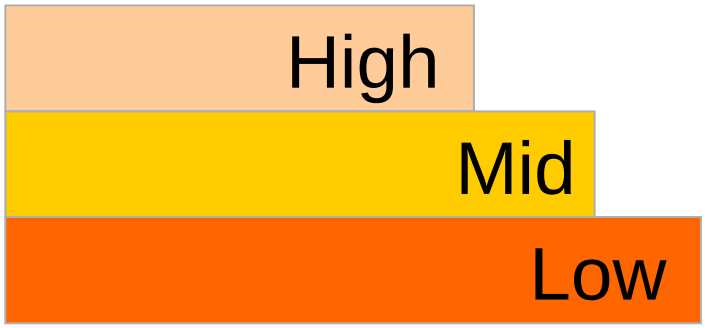
# Forecasting Using Scenarios

- Development of scenarios was based on various aspects relating to economic, social and political factors.
- Four descriptive scenarios were developed, ranging from the most to the least positive
- These were later consolidated into three: High, Mid, Low scenarios




Global warming

Politics

Global Economy

Commodity Prices

South African Infrastructure

The People of South Africa

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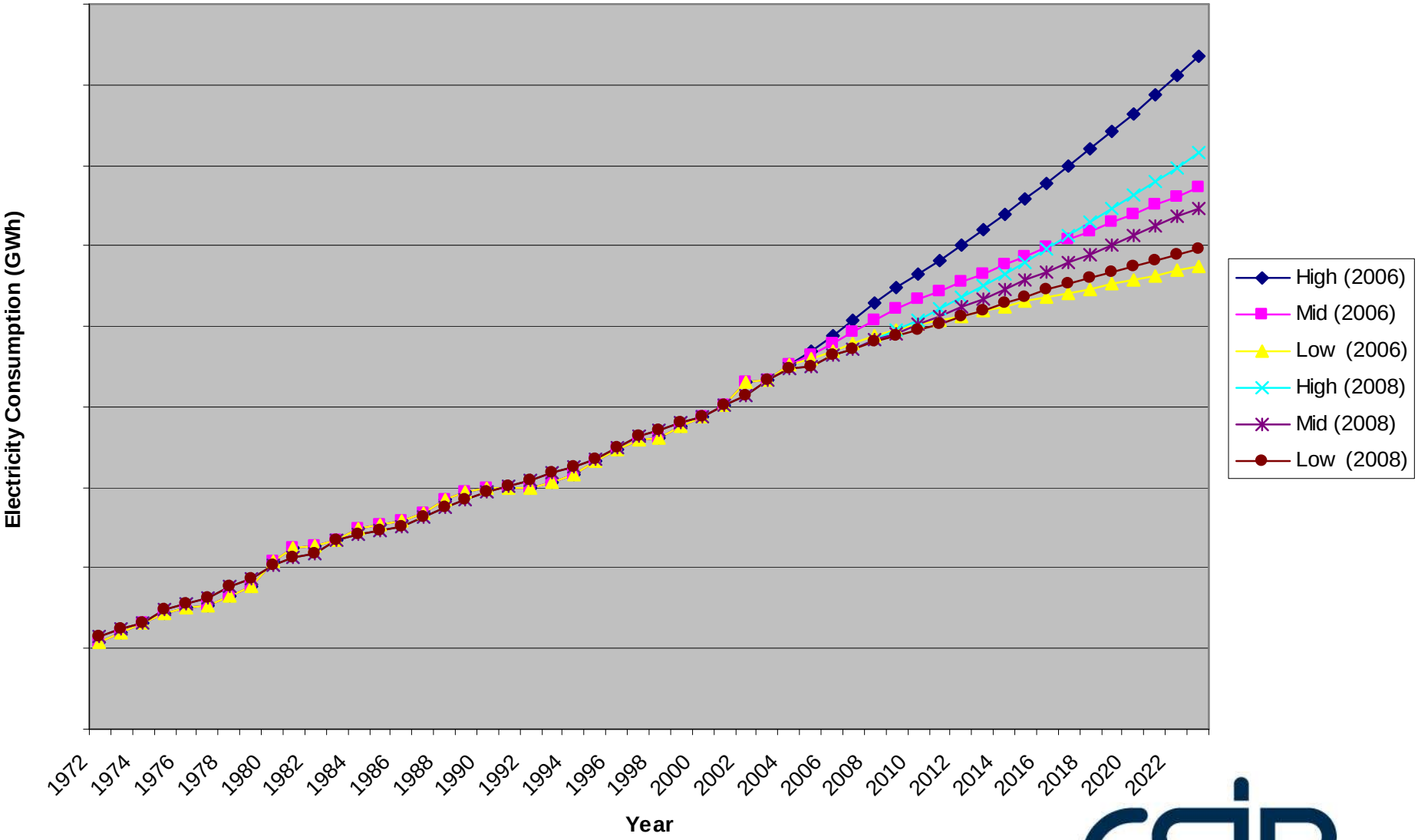
# Forecasting Using Scenarios

- Future values for the macro-level indicators of GDP growth and FCEH growth were quantified using scenarios.
- Projections of population and coal production index sourced.
- Forecasts of platinum production index and gold ore treated were obtained from historical data using time series models.
- Forecasts of predictor variables were inserted into the regression models to create 20 year forecasts of annual electricity demand per sector for each scenario.
- Then, the sectoral electricity demand was aggregated to obtain the Total Annual Electricity Demand for each scenario.

# Forecasting Using Scenarios

- For each scenario hourly, daily, weekly and seasonal consumption patterns were superimposed on Total Annual Electricity Demand to obtain Annual Peak Electricity Demand.

## Comparison of results of consolidated scenario forecasts: 2005 vs 2008





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# Concluding Remarks

- The methodology followed enabled us to produce reliable forecasts, given the available data and the assumption on unconstrained demand.
- The advantage of the explanatory method of forecasting over the time series methods is the incorporation of auxiliary information on possible factors that influence the consumption of electricity, instead of relying on the historical pattern to describe the future electricity demand.
- The use of scenario information proved advantageous in this situation as it enabled us to quantify the uncertainties about the future.
- The other usefulness of combining the three methods is that no additional information had to be sourced so that peak demand could be forecasted from total demand. All that was needed was to superimpose the underlying load profile on the total demand forecasts to derive the peak consumption.
- There is room for improvement.

# Acknowledgements


- Project team
  - Theo Stylianides
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  - Jenny Holloway
  - Renee Koen

*“If a man gives no thought about what is distant, he will find sorrow near at hand”*

*Confucius*