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

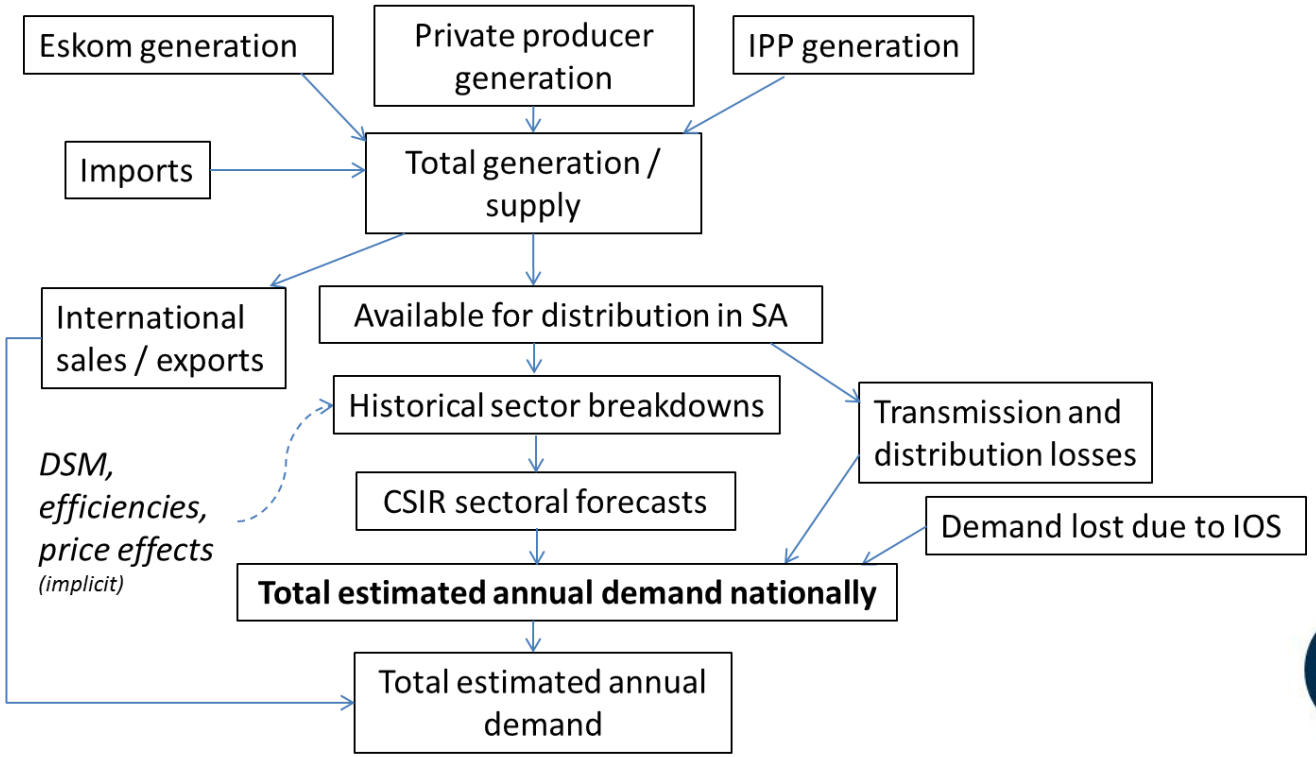
This presentation briefly describes the following (for more details refer to the report on the IRP website):

- 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



our future through science

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

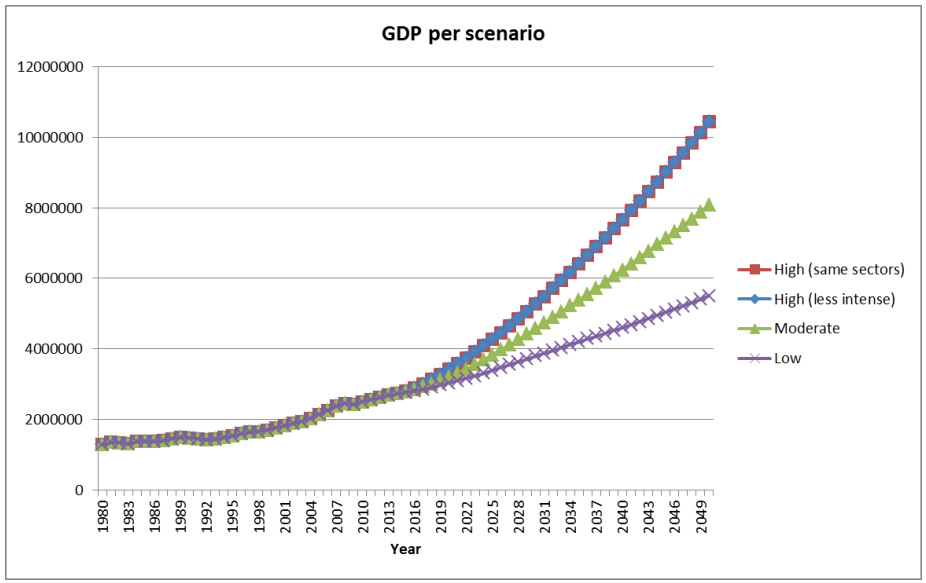
- Criteria used to assess models:
  - Statistical goodness-of-fit statistics: adjusted R^2, RMSE, residual patterns
  - Residual patterns acceptable and coefficients statistically significant
  - Logical set of “forecast drivers”
  - Measures of multi-colinearity: condition index < 30
  - Stability with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

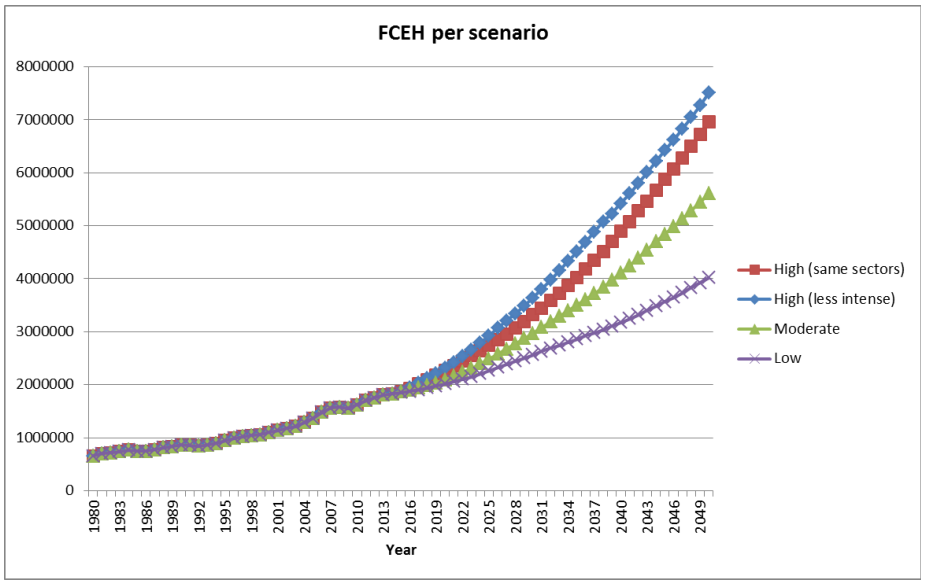
Sector regression models

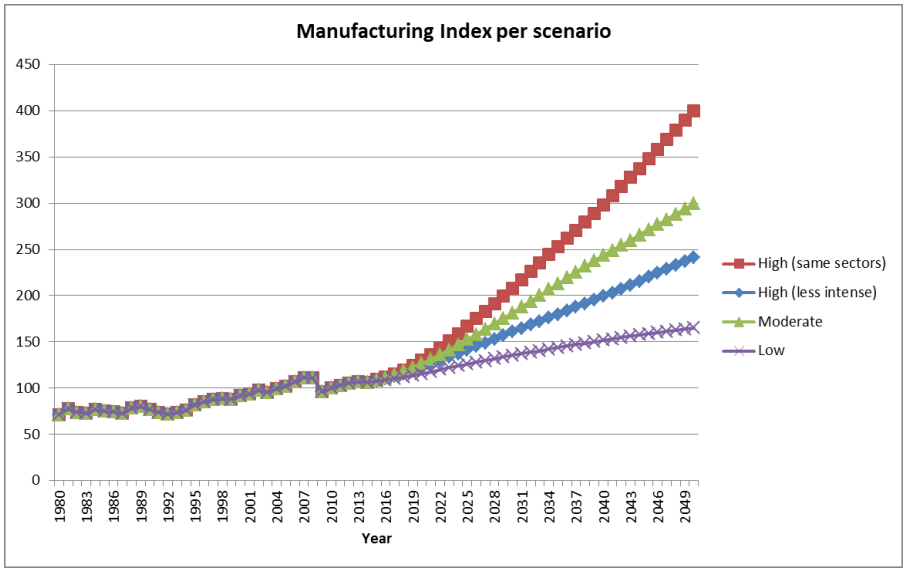
- Sectoral regression models used for IRP 2015/6 forecasts:

Electricity sector	**Model used (*Note: the "predictor variables" indicated in bold in each model*)**	**Adjusted R^2**	**Condition index**
Agriculture	-47339 + 3725.82×ln(**FCEH**)	Adjusted R^2 = 0.97	N/A if only 1 variable in model
Transport	975.24 + 45.61×**mining index excluding gold**	Adjusted R^2 = 0.74	N/A if only 1 variable in model
Domestic	-410694 + 31840×ln(**FCEH**) + 2339.48***recession**	Adjusted R^2 = 0.97	CI = 1.4
Commerce & manufacturing	11000 + 0.02259×**FCEH** + 687.14368 × **manufacturing index**×***correction factor***	Adjusted R^2 = 0.9691	CI = 21.27
Mining	21784 + 75.868× **mining production index (excl. gold)** + 0.05268×**gold ore treated**	Adjusted R^2 = 0.55	CI = 6.3

Four economic scenarios used as “driver” inputs

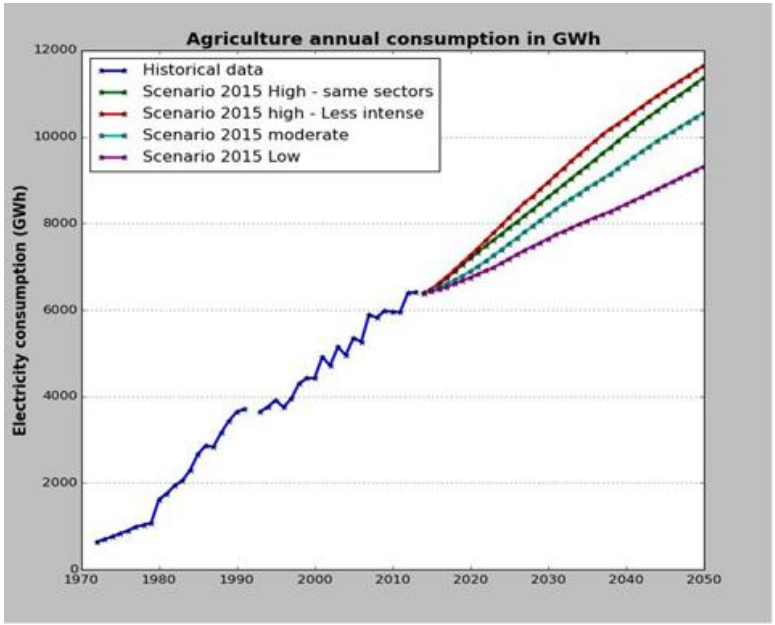


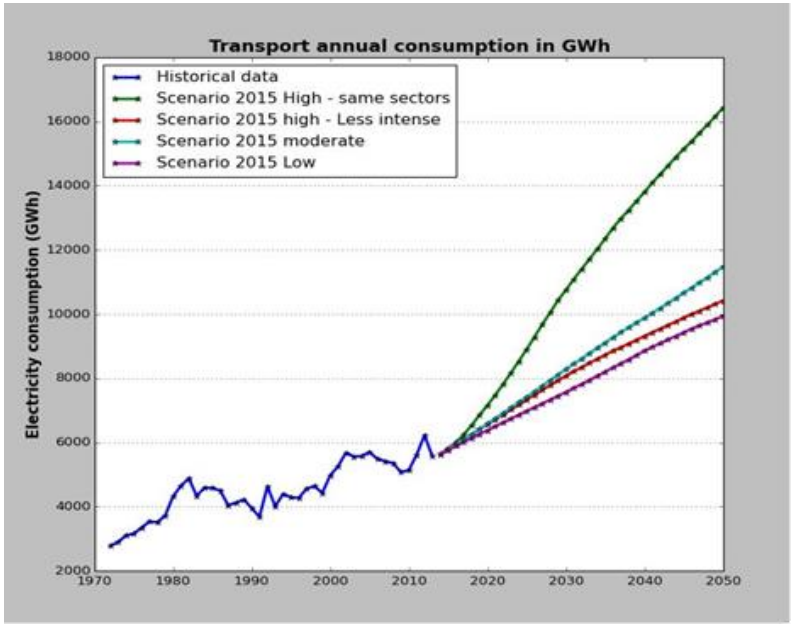


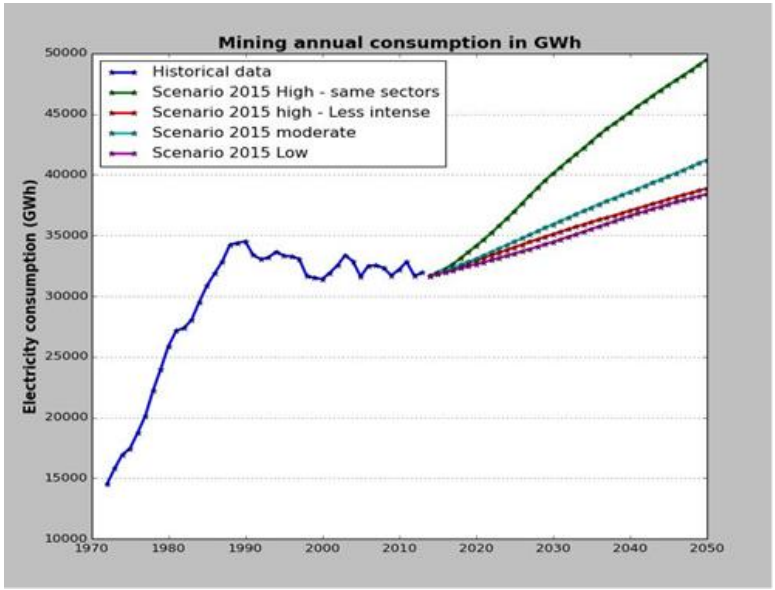


CSIR
our future through science

Sector forecasts obtained from regression models

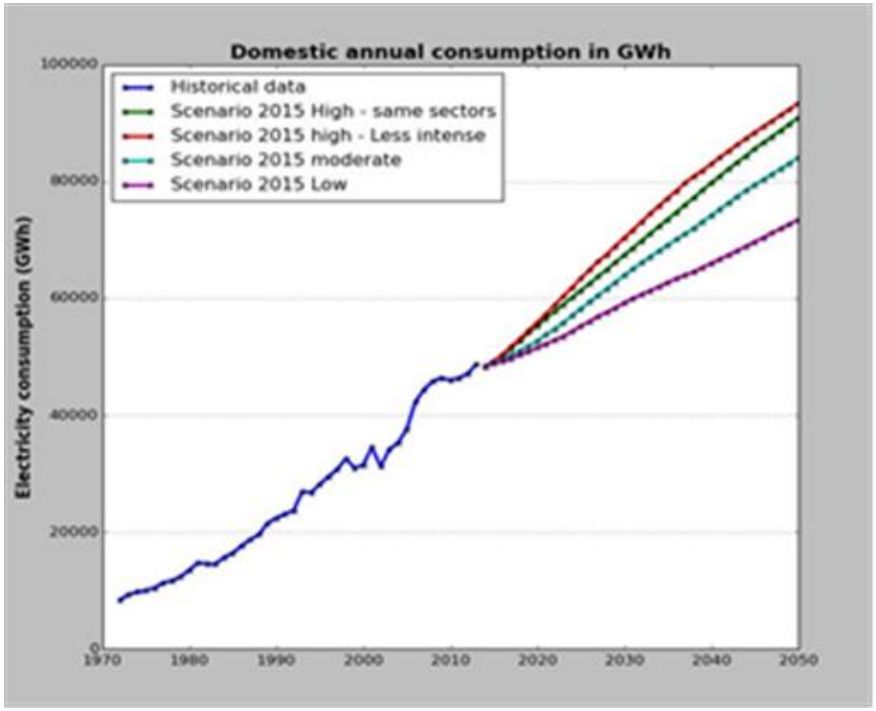


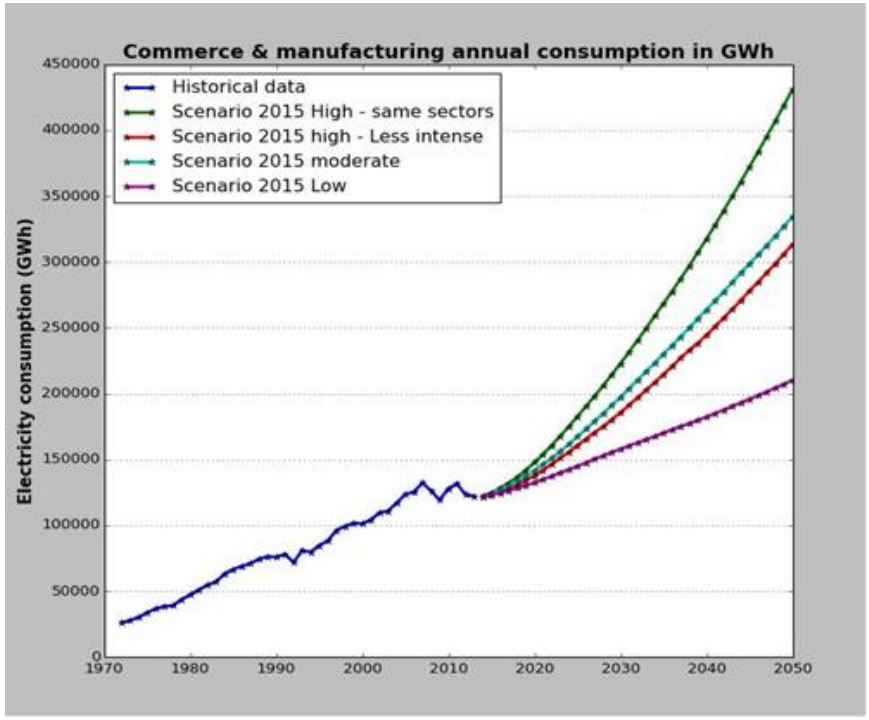




our future through science

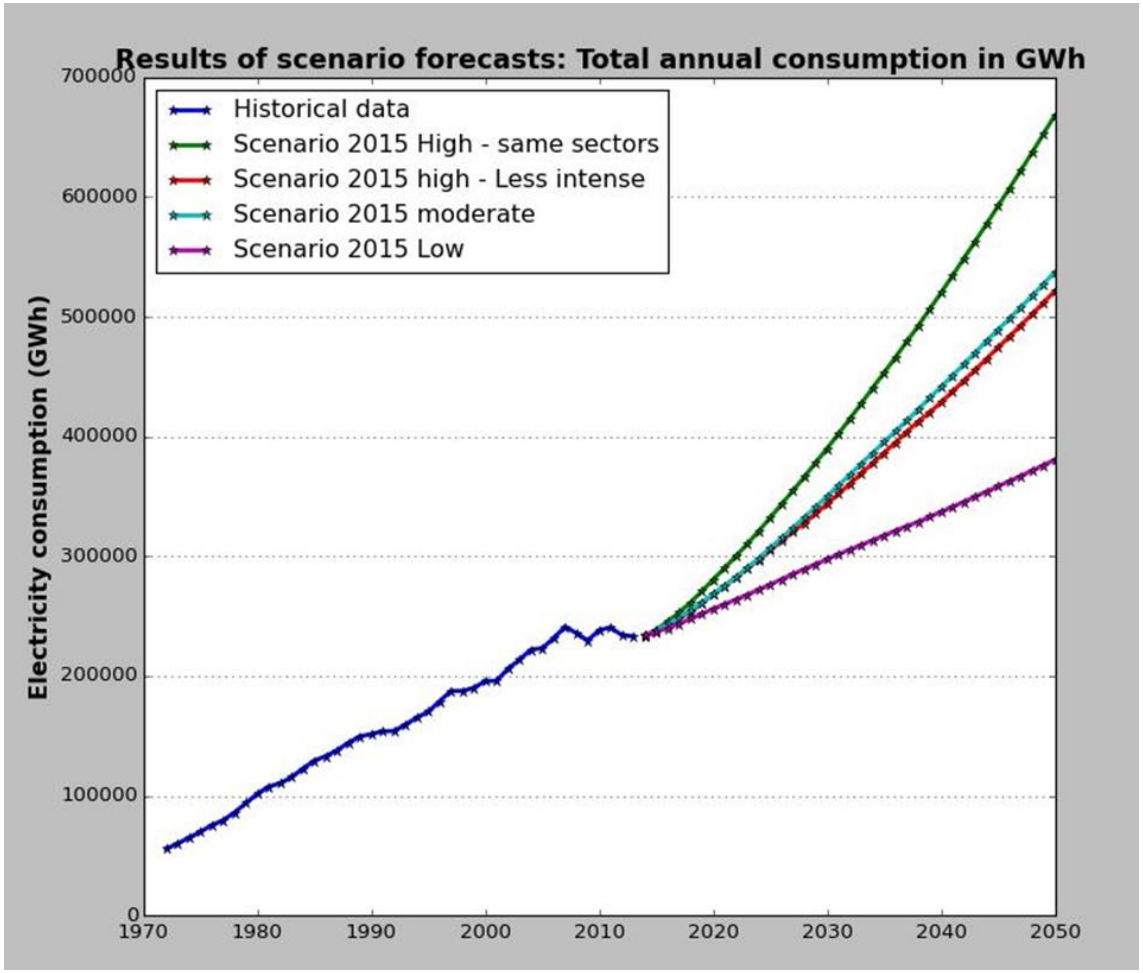
Sector Forecasts (…2)





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%

Contact details:

Renée Koen

Decision Support and Systems Analysis Research Group

Built Environment Unit

Council for Scientific and Industrial Research (CSIR)

Tel: + 27 12 841 3045

E-mail: rkoen@csir.co.za

our future through science