Using TIMES for integrated generation and transmission expansion planning in South Africa

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Overview

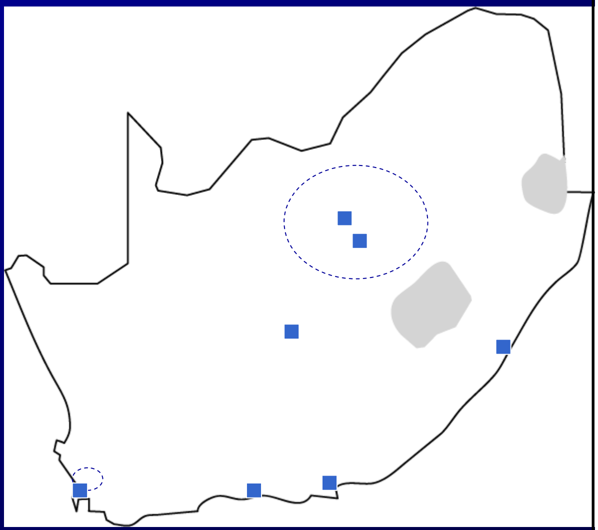
- Background
- Areas of focus:
  - Interface with ESKOM databases
  - Grid representation
  - Reliability

Background: South African Electricity Sector

- 220 GWh
- 40 GW pk demand

- 95% ESKOM

- 91% From Coal
- 5% Nuclear
- 4% hyd/PS/diesel



Aim/Ambition

- Setup a 27 node/region TIMES model
- Integrate generation and transmission planning
- Model would be handed over to ESKOM planners

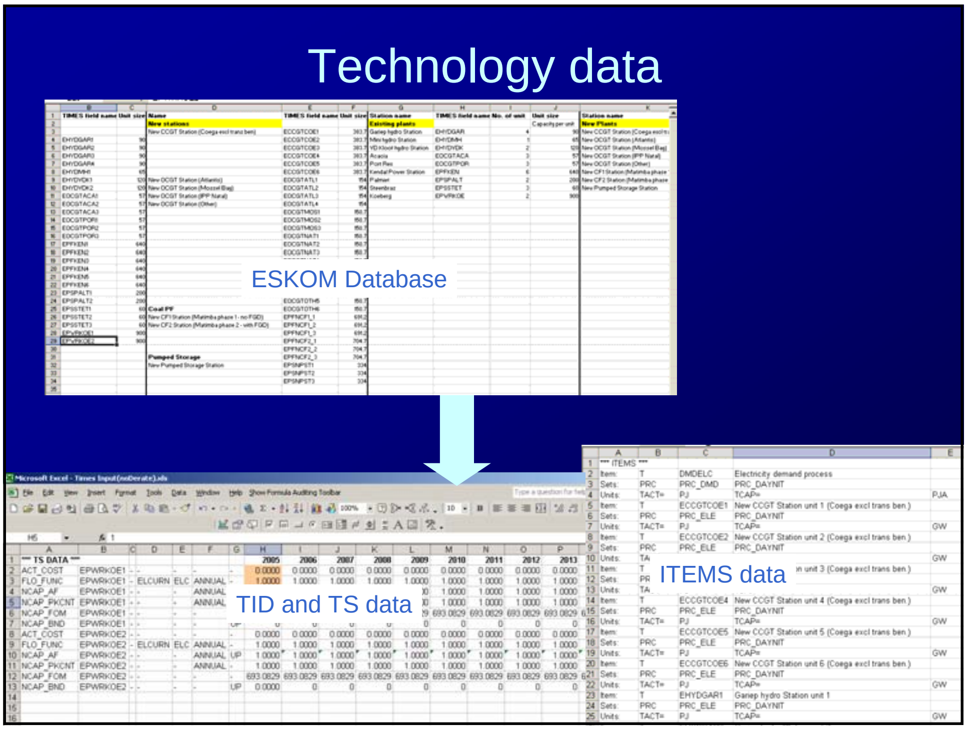
The plan

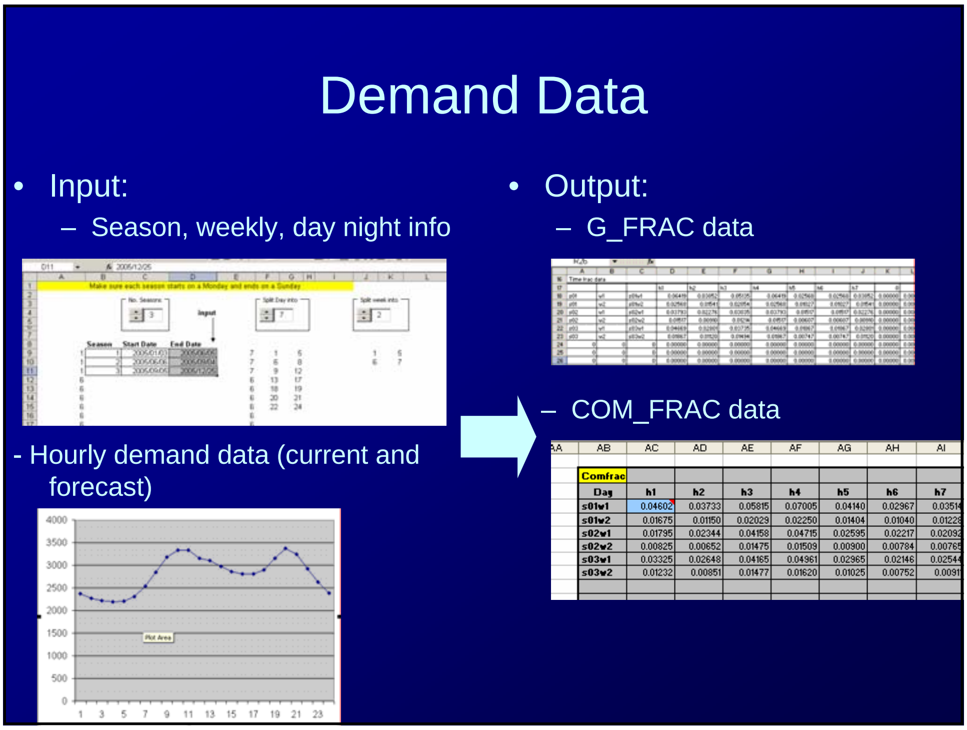
- Interface with ESKOM data
- Representation of grid
- Representation of outages/reliability

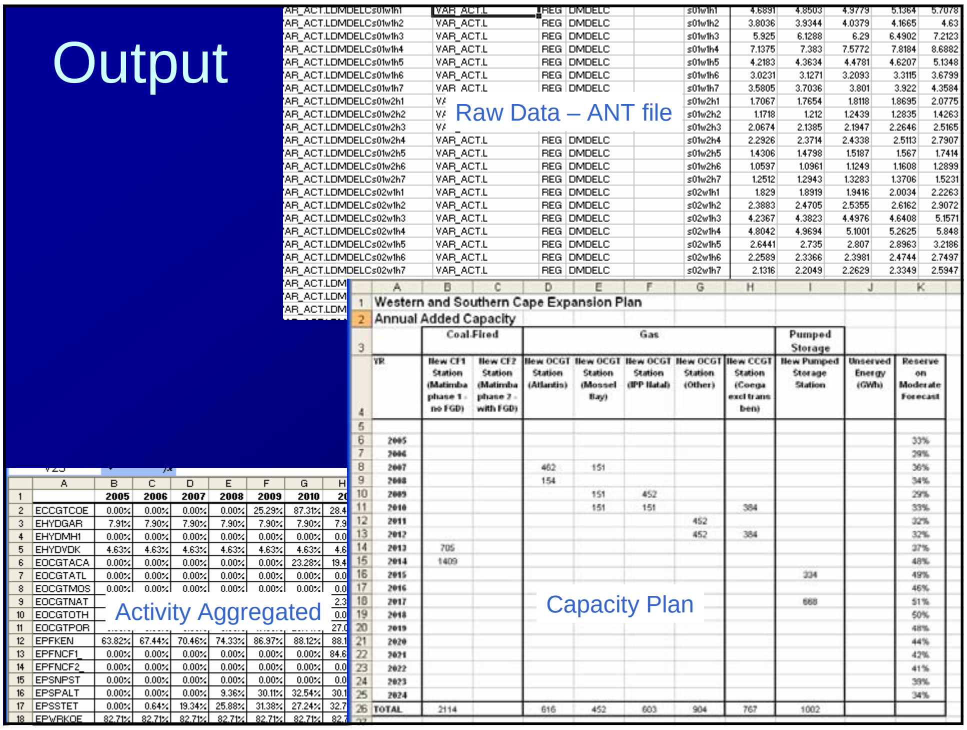
- Start with smaller model
- Compare with EGEAS on 1 node
- Expand/explode model into 6 nodes
- Expand for SA model 27 nodes?

ESKOM data

- Technology/process data
  - Existing + new Generation capacity
  - Existing + new Transmission capacity
- Demand data
  - Base year demand (for every hour in the year)
  - Demand projection over study period


Technology data
ESKOM Database
TID and TS data
ITEMS data


Demand Data
• Input:
– Season, weekly, day night info
- Hourly demand data (current and forecast)
• Output:
– G_FRAC data
– COM_FRAC data



Representation of Outages

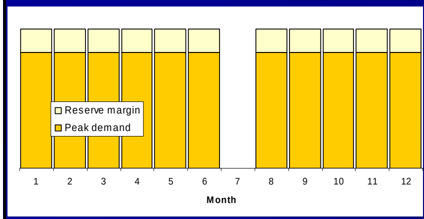
- 2 kinds of outages:
  - Planned (POR),
  - Unplanned/forced (FOR)
- TIMES deals with this specification using:
  - Planned Outages: NCAP_AFA parameter
  - Reserve margin (COM_PKRSV - set exogenously)
  - Cost of unserved energy cannot easily be traded-off against reliability

Principle:

Capacity de-ration:

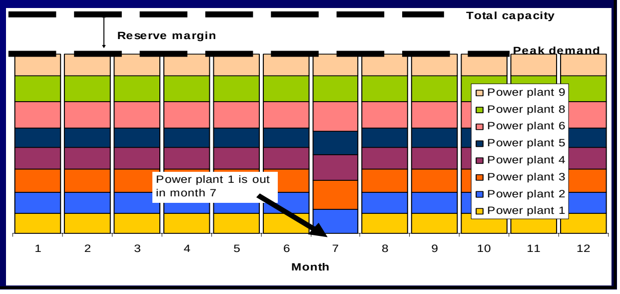
If plant is out for maintenance for 1 out of 12 time periods, set AVAILABILTY parameter to 11/12

One single power unit:



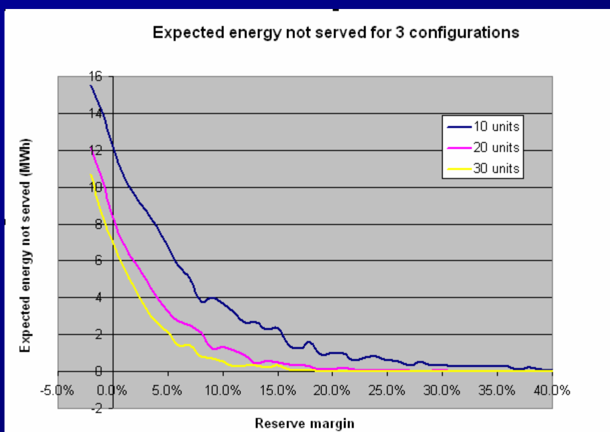
In the case of one power plant: however high the reserve margin, demand will not be met when plant is out.

8 units:

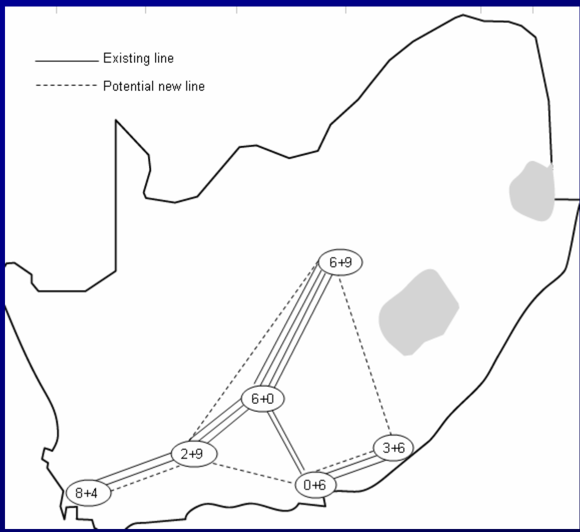


With more power plants to supply the demand, the outage of one power plant less of a problem

Expected unserved electricity for different configurations



The 6 node model



Simulated outage – forced outage

- Proposed methodology
  - Separate problem into Master (investment) and slave (operation) problems.
  - Solve master problem for specified reserve margin
  - Solve operational problem for given investment plan and set of random outages using external scheduling of forced outage with Monte Carlo sampling
  - Adjust reserve margin in Master problem based on results of slave problem.

Monte Carlo sampling

	A	B	C	D	E	F	G	H	I
1	TABLE ANCAP_AF								
2		2005	2006	2007	2008	2009	2010	2011	2012
3	'REG'.'EHYDGAR1'.'s01w1h1'.'UP'	1	1	1	1	1	1	1	0
4	'REG'.'EHYDGAR1'.'s01w1h2'.'UP'	1	1	1	1	1	1	1	1
5	'REG'.'EHYDGAR1'.'s01w1h3'.'UP'	1	1	1	1	1	1	1	1
6	'REG'.'EHYDGAR1'.'s01w1h4'.'UP'	1	1	1	1	1	1	1	1
7	'REG'.'EHYDGAR1'.'s01w1h5'.'UP'	0	1	1	1	1	0	1	1
8	'REG'.'EHYDGAR1'.'s01w1h6'.'UP'	1	1	1	1	1	1	1	1
9	'REG'.'EHYDGAR1'.'s01w1h7'.'UP'	1	1	1	1	1	1	1	1
10	'REG'.'EHYDGAR1'.'s01w2h1'.'UP'	1	1	1	1	1	1	1	1
11	'REG'.'EHYDGAR1'.'s01w2h2'.'UP'	1	1	1	1	1	1	1	1
12	'REG'.'EHYDGAR1'.'s01w2h3'.'UP'	1	1	1	1	1	1	1	0
13	'REG'.'EHYDGAR1'.'s01w2h4'.'UP'	0	1	1	1	1	0	0	1
14	'REG'.'EHYDGAR1'.'s01w2h5'.'UP'	1	1	1	1	1	1	1	1
15	'REG'.'EHYDGAR1'.'s01w2h6'.'UP'	1	1	1	1	1	0	0	1
16	'REG'.'EHYDGAR1'.'s01w2h7'.'UP'	1	1	1	1	1	1	1	1
17	'REG'.'EHYDGAR1'.'s02w1h1'.'UP'	1	1	1	1	1	1	1	1
18	'REG'.'EHYDGAR1'.'s02w1h2'.'UP'	1	1	1	1	1	1	1	1
19	'REG'.'EHYDGAR1'.'s02w1h3'.'UP'	1	1	1	0	1	1	1	1
20	'REG'.'EHYDGAR1'.'s02w1h4'.'UP'	1	1	1	1	1	1	0	1
21	'REG'.'EHYDGAR1'.'s02w1h5'.'UP'	1	0	1	1	1	1	0	1
22	'REG'.'EHYDGAR1'.'s02w1h6'.'UP'	1	1	1	1	1	1	1	1
23	'REG'.'EHYDGAR1'.'s02w1h7'.'UP'	1	1	1	1	1	1	1	1
24	'REG'.'EHYDGAR1'.'s02w2h1'.'UP'	1	0	1	1	1	1	0	1

Future Alleys to Explore

- Outage representation:
  - Further experimentation with current method
  - Bender's Decomposition
  - Balerieux and Booth
- Grid representation:
  - 27 nodes?
- Consolidating interface:
  - Smoothen addition of new stations
- Incorporate Stochastics?