South Africa's Electricity Security :-
Recent Developments in the National Renewable Energy Landscape for the Generation of Electricity in South Africa

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

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Stellenbosch Forum

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UNIVERSITEIT STELLENBOSCH UNIVERSITY

science & technology Department: Science and Technology REPUBLIC OF SOUTH AFRICA

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RENEWABLE & SUSTAINABLE ENERGY STUDIES

UNIVERSITEIT STELLENBOSCH UNIVERSITY

The Centre for Renewable and Sustainable Energy Studies was established in 2007 to facilitate and stimulate activities in renewable energy study and research at Stellenbosch University.

The Department of Science and Technology has been funding the Renewable and Sustainable Energy (RSE) Hub at Stellenbosch University since its establishment in August 2006. The aims of the RSE Hub are to develop human capital, deepen knowledge, and stimulate innovation and enterprise in the field of RSE. Currently the DST is still sponsoring the work of the Centre with an annual grant administrated by the National Research Foundation.

Stellenbosch University was designated as the Specialisation Centre in Renewable Energy Technology as part of the Eskom Power Plant Engineering Institute (EPPEI). The research and teaching activities sponsored by Eskom focus on concentrating solar power (CSP) and wind energy and also includes the Eskom Chair in Concentrating Solar Power.

The Sasol Technology group sponsored the new facilities for the Centre for Renewable and Sustainable Energy Studies as well as the work and facilities of the Solar Thermal Energy Research Group at Stellenbosch University in support of their New Energy business unit.

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Outline

- Background of the SA Electricity Landsacpe
- Some Recent Developments and Debates in South Africa
- Renewable Energy IPP Procurement Programme
- RE Resources and Projects:
  - Concentrating Solar Power (CSP)
  - Wind Energy
  - Photovoltaic Systems (PV)
- Some Conclusions

Regulatory Environment (1)

- Department of Energy
  - Set policy for electricity, liquid fuels and gas
  - Develop and promulgate the IEP (Integrated Energy Plan – All Energy Sources) and the IRP (Integrated Resource Plan – Electricity Only), final approval by Cabinet
- NERSA – National Energy Regulator of South Africa
  - Implement the IRP by issuing Generation Licenses, etc.
  - Set tariffs for electricity, wholesale (Eskom) and retail (Municipalities)

Regulatory Environment (2)

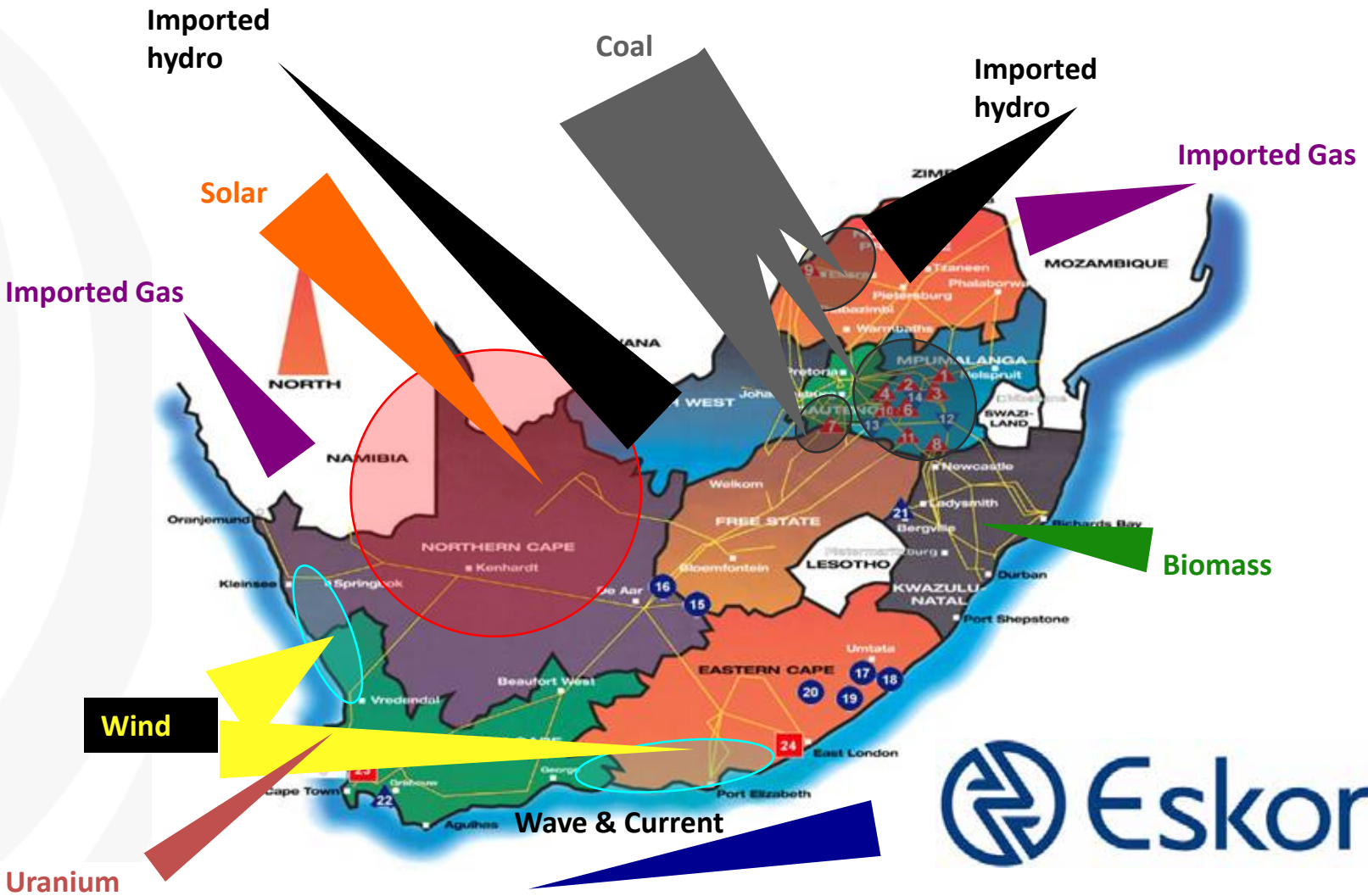
- Eskom (National Utility)
  - SOE (State Owned Enterprise) managed by the Department of Public Enterprises (DPE) (Now under the supervision of the National Treasury and the Deputy President)
  - Responsible for Gx, Tx, and Dx of electricity in South Africa
  - Generate 95% of the electricity in SA, 85% from coal-fired power stations
  - Procure electricity from Independent Power Producers (IPPs)
- Department of Environmental Affairs
  - Set and implement Environmental Legislation
  - Represent SA in negotiations on international Climate Change negotiations
  - Driver of a new Carbon Tax in South Africa

South Africa's Current Electricity Generation Capacity

Coal-fired (MW)	35 650
Hydro-electric (MW)	600
Pumped storage (MW)	1 400
Gas turbine (MW)	2 430
Nuclear (MW)	1 860
Wind energy (MW)	100
Total Eskom Generation Capacity (MW)	**42 040**
Independent Wind Farms (MW)	**650**
Independent PV Systems (MW)	**960**

Eskom

South African Electricity Landscape



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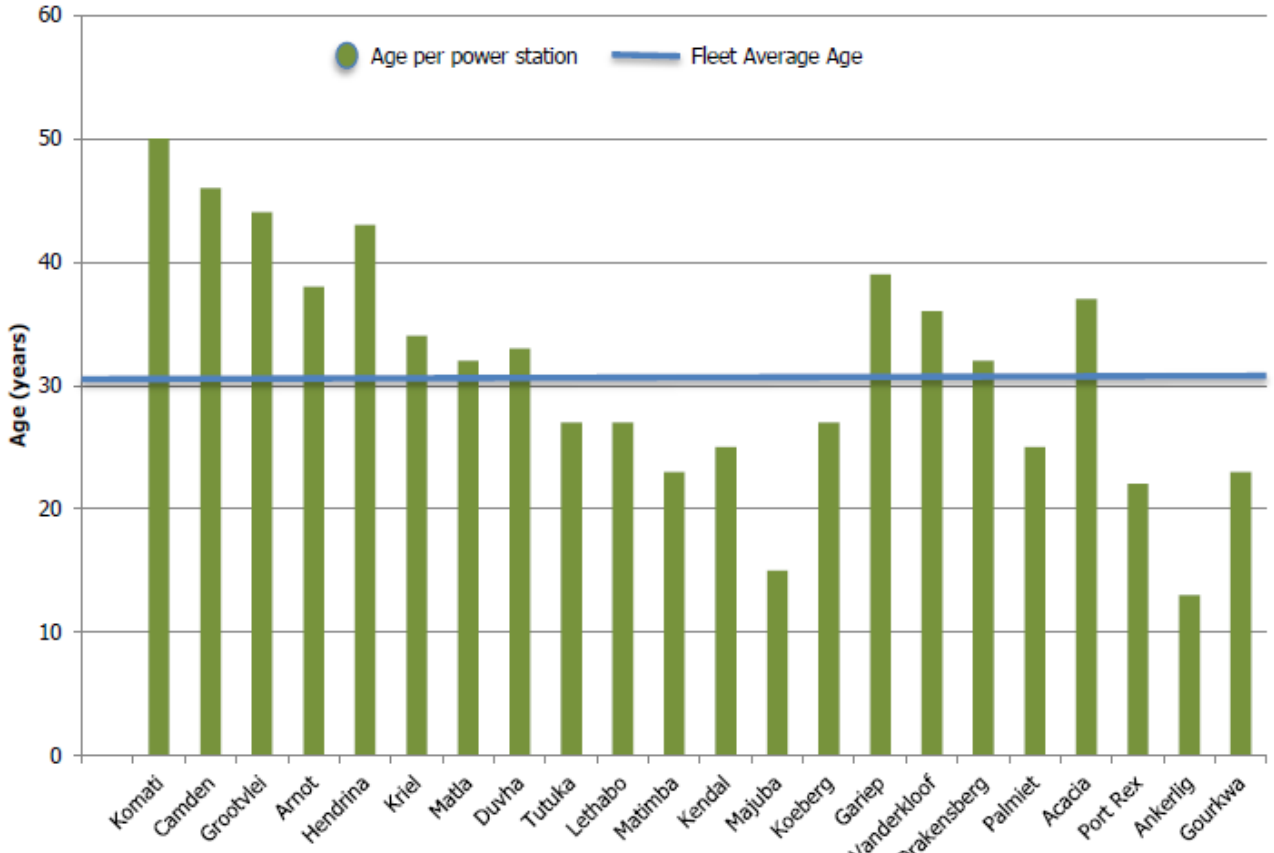
Factors Affecting Electricity Supply

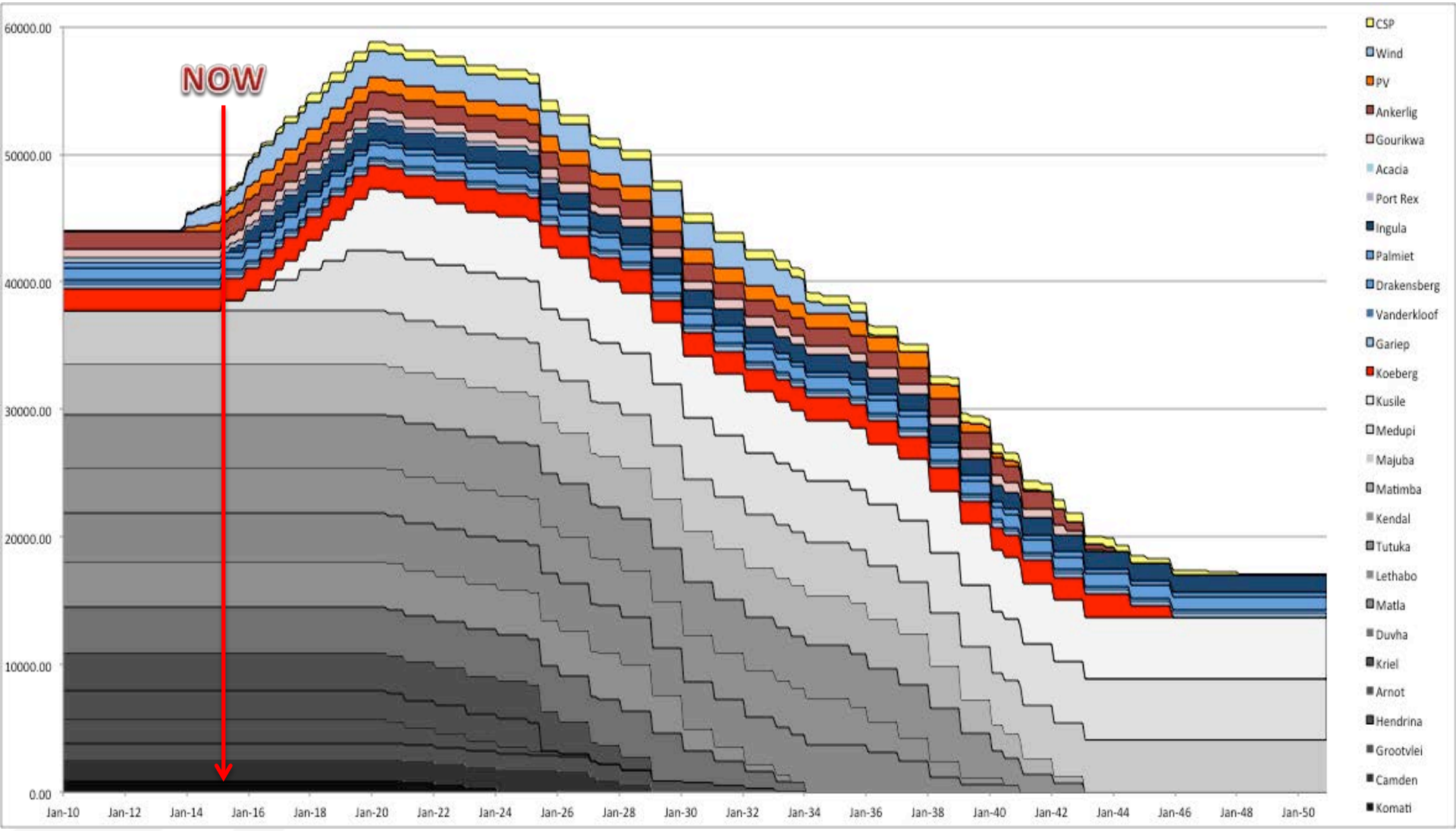
The useful life of the Eskom's generation fleet is at 60% on average.

The required **maintenance** duration (corrective or preventive) of the power plants is growing, availability now below 80%



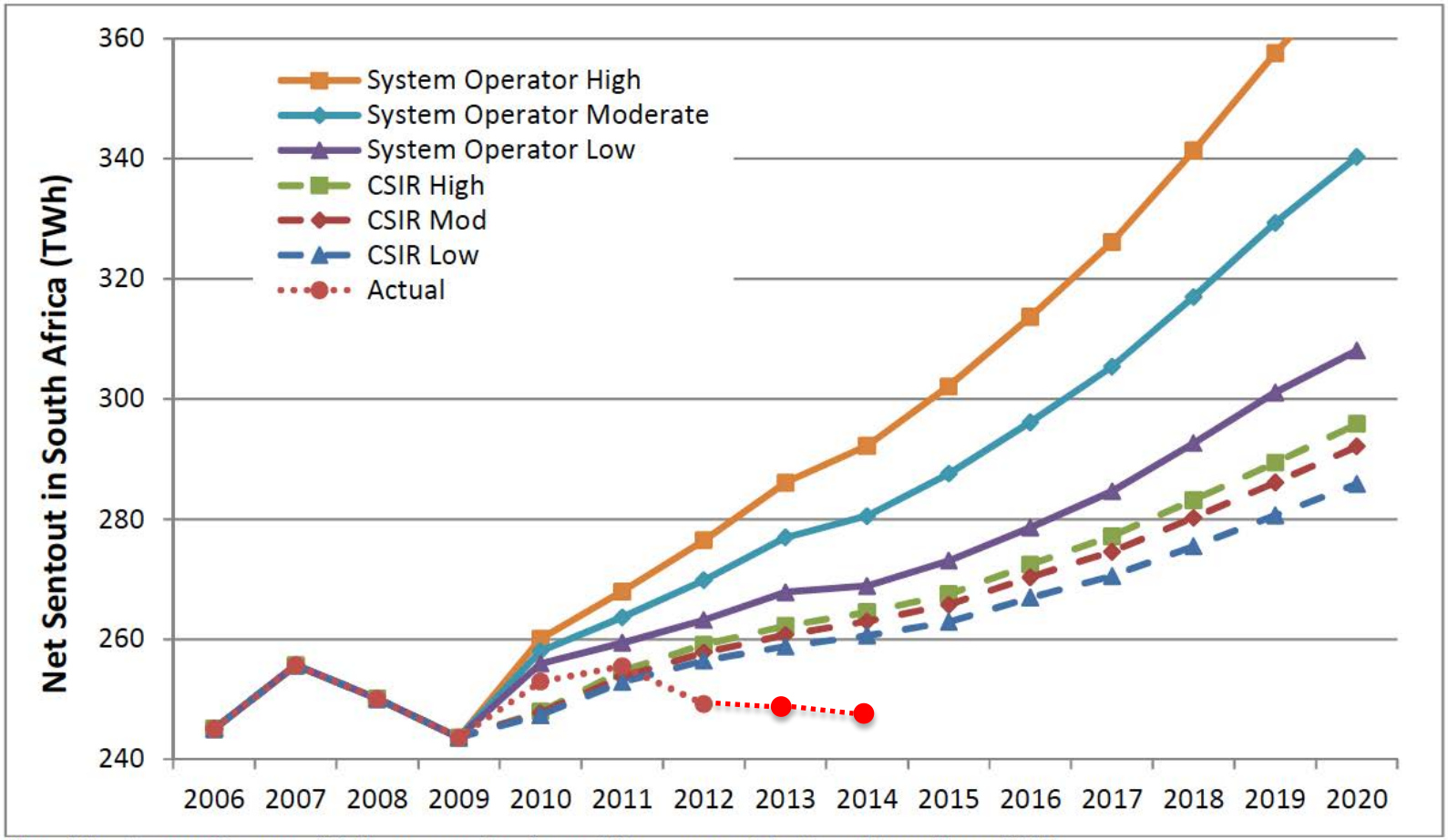
Age of Eskom generation fleet (source: RE Policy mapping Study of RSA)

Phasing Out of Older Coal Stations



Electrical Energy Demand (≈250 TWh)

Figure 5 – Expected RSA sent-out from IRP 2010 vs actual



Note: The System Operator Moderate was the demand forecast used in the policy-adjusted IRP
Sources: StatsSA (for actual), IRP 2010 (forecasts)

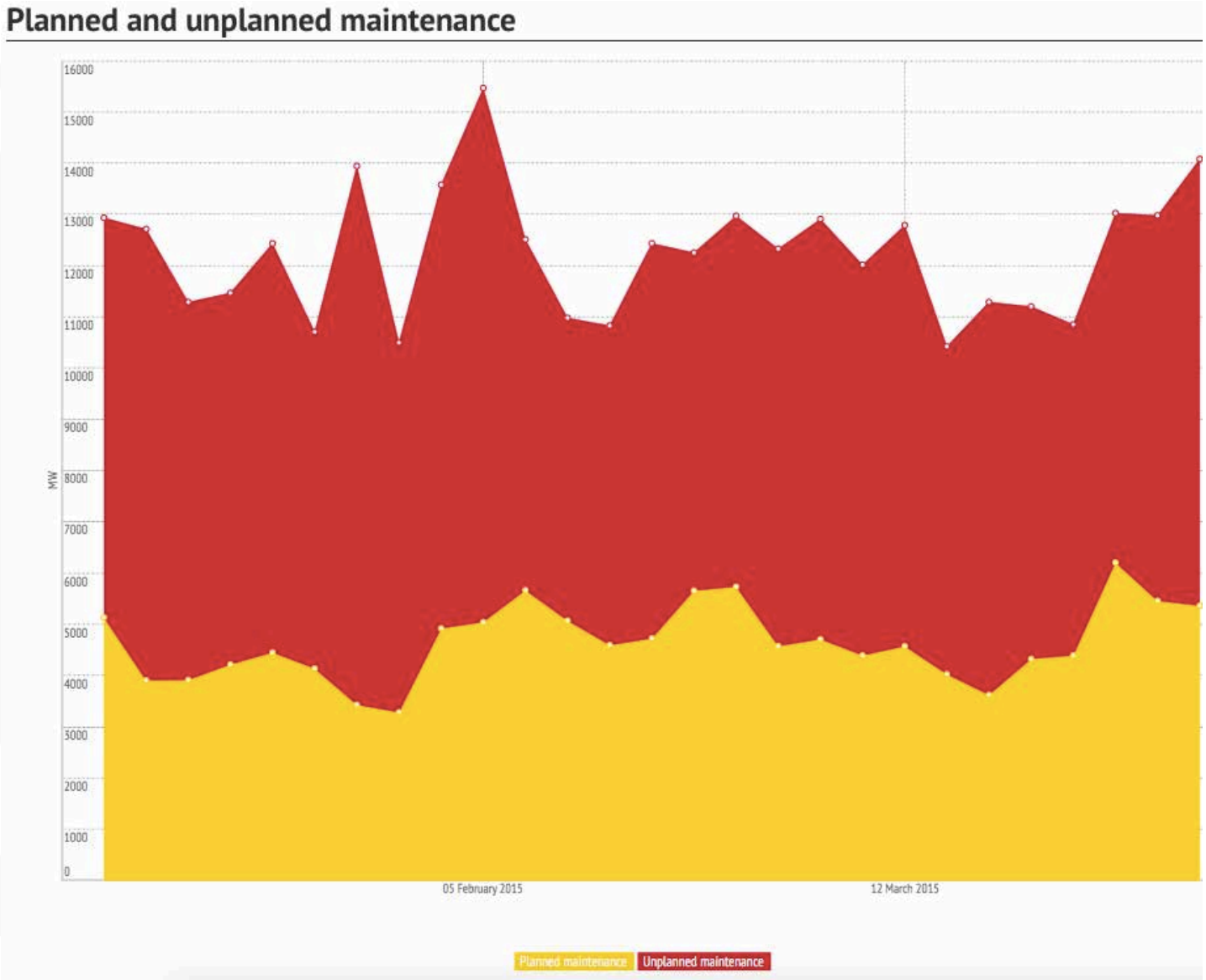
Eskom "Technical Disasters 1"

Duvha turbine (2011) and boiler (2014) accidents:

Eskom "Technical Disasters 2"

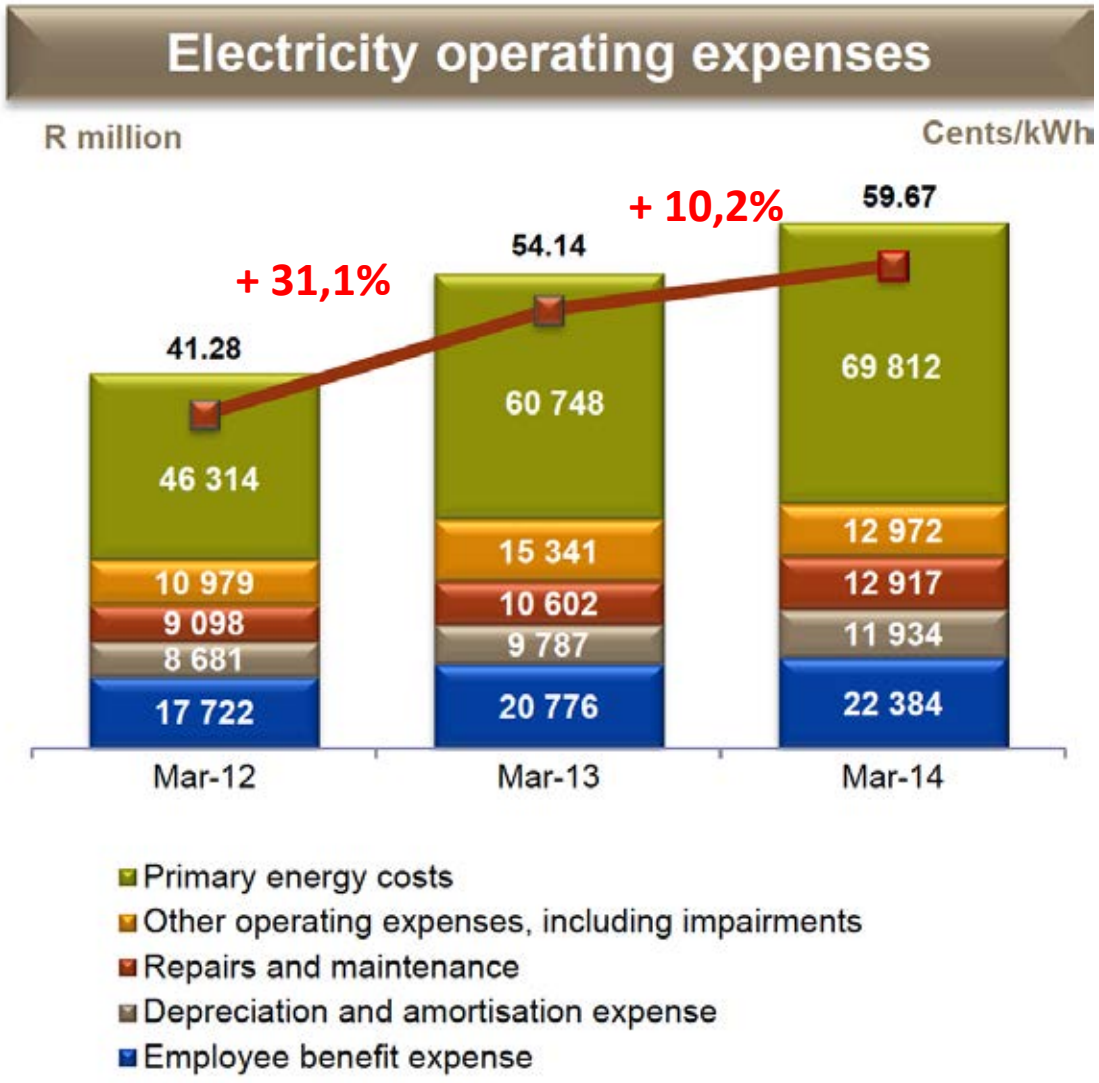
Majuba Coal Silo Collapse, 1 November 2014:

Eskom "Technical Disasters 3"



Source: Fin24

Eskom's "Financial Challenge"



Eskom's Final Straw?

EDITORIAL: Outrageous move at crisis-hit Eskom

ONE of Eskom's former CEs used to say that Eskom was not a spaza shop. **But you wouldn't even run a spaza shop the way the Eskom board, and its shareholder the government, is running the utility right now**.

Thursday's announcement by Eskom chairman Zola Tsotsi that the board had **suspended CE Tshediso Matona and three of his executives while it tried to find out what was wrong with Eskom was nothing short of outrageous.**

If Mr Tsotsi doesn't know by now, he should not be in the chair. It has been on his watch — and under the government's stewardship — that Eskom's operational performance and finances deteriorated to the . . .




Business Day Editorial Friday 13 March 2015

Eskom's Rescuer?

Brian Molefe appointed Eskom acting CE

BY AGENCY STAFF, 2015-04-18 09:11:25.0

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Brian Molefe. Picture: PUXLEY MAKGATHO

TRANSNET CEO Brian Molefe has been appointed Eskom acting CE.

Interesting National Debates

- Nuclear vs Renewable Energy & Gas
  - National Planning Commission stated in the National Development Plan that a RE/Gas future is preferable to a large Nuclear build programme
  - Department of Energy and the President are very eager to build 9,6 GW of nuclear power stations
- Nuclear Debate
  - Cost of nuclear is always unclear, latest cost in the UK approximately R 1,80/kWh
  - Liability issue, only the SA Government can take on the liability if there is a nuclear accident and this will negatively influence our credit rating and hence increase the cost of national debt
  - Procurement seems to be shrouded in secrecy, not a good sign

Updated IRP for Comment (Nov 2013)

Table 2 – Technology options arising from IRP 2010 and the Update Base Case in 2030

Technology option	IRP 2010 (MW)	Base Case (MW)
Existing Coal	34746	36230
New Coal	6250	2450
CCGT	2370	3550
OCGT / Gas Engines	7330	7680
Hydro Imports	4109	3000
Hydro Domestic	700	690
PS (incl Imports)	2912	2900
Nuclear	11400	6660
PV	8400	9770
CSP	1200	3300
Wind[3]	9200	4360
Other	915	640
TOTAL	**89532**	**81350**

Notes:

(1) Demand Response options added to IRP 2010 to ensure comparability (previously not considered in IRP)

(2) "Existing" coal includes Medupi and Kusile

Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)

Technology	Allocation* [MW]	Size Limits [MW]	Commercial Energy Rate*
Onshore Wind	1 850	1 - 140	R 1 150/MWh
Concentrated solar power	200	1 - 100	R 2 850/MWh
Solar photovoltaic	1 450	1 - 75	R 2 850/MWh
Biomass	12.5	1 - 10	R 1 070/MWh
Biogas	12.5	1 - 10	R 800/MWh
Landfill gas	25	1 - 10	R 600/MWh
Small hydro (≤10MW)	75	1 - 10	R1 030/MWh
Small projects utilising any of onshore wind, solar photovoltaic, biomass or biogas technologies which have a maximum installed capacity of 5 MW	100	< 5	Not specified

*Commercial Energy Rate is the maximum that will be paid for electricity from each particular technology. Solar PV ~20 Eurocents/kWh

Price: 70% **Other Factors: 30%**

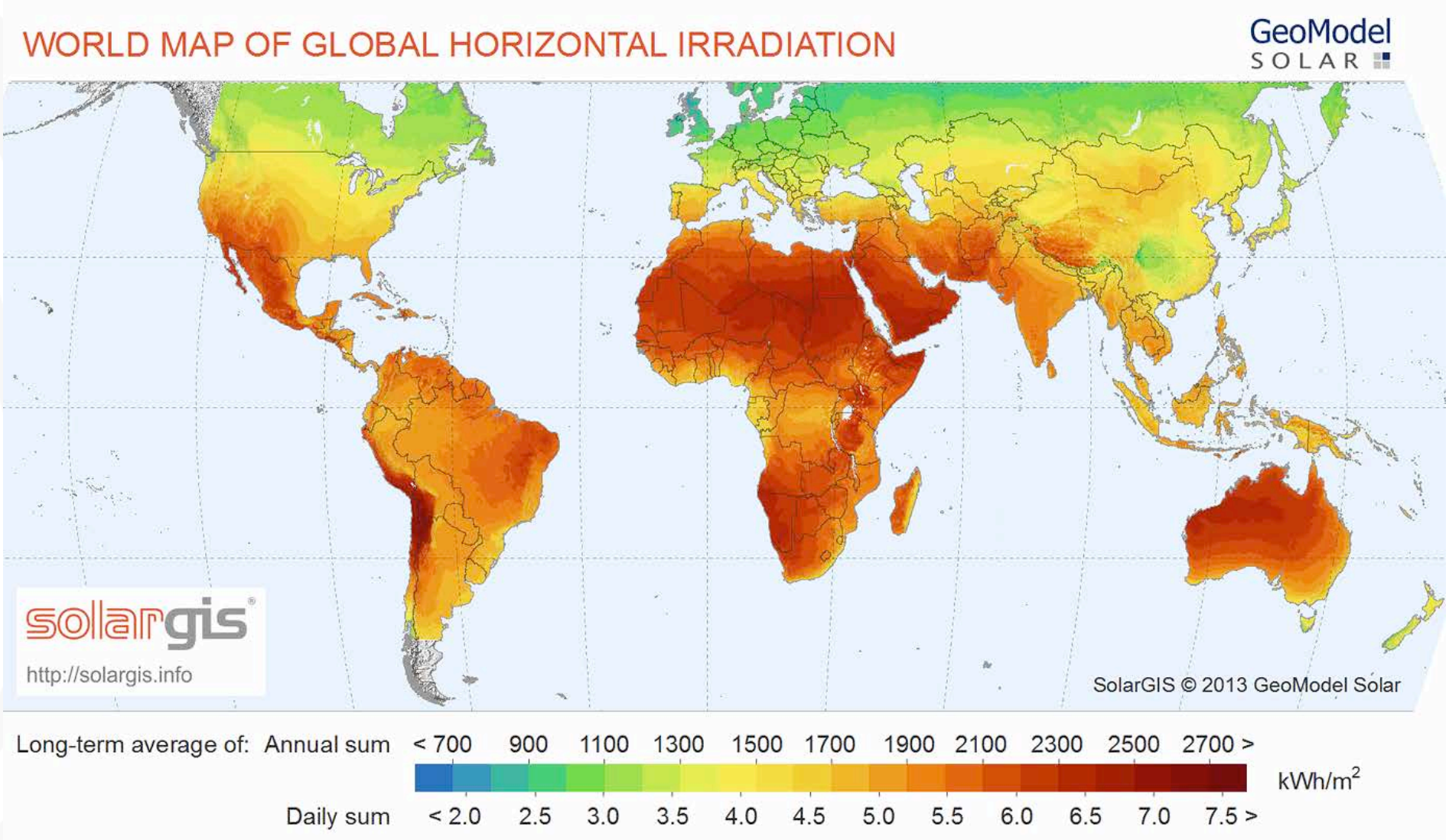
RE IPP PP Update

- Three Bid Windows:
  - BW 1 (Dec 2011): Wind - 634MW; PV – 632MW: CSP – 150MW
  - BW 2: (May 2012) Wind – 563MW; PV – 417MW: CSP – 50MW
  - BW 3 (Nov 2013): Wind – 787MW; PV – 435MW: CSP – 200MW; Other – 34MW
  - BW 3b (Jan 2015: CSP – 200 MW) (Total now **600 MW**)
- **BW 1** projects all reached financial close, most are under already generating electricity
- **BW 2** reached financial close, most already under construction with some generating electricity
- **BW 3** reached financial close only in Nov 2014 due to Eskom
- grid connections issues
- **BW 4** results announced 16 April 2015:
  - Wind 536 MW (Total now**: 2 520 MW**)
  - Solar PV 415 MW (Total now: **1 900 MW**)
  - Biomass 25MW Small hydro (<40MW) 4,7 MW

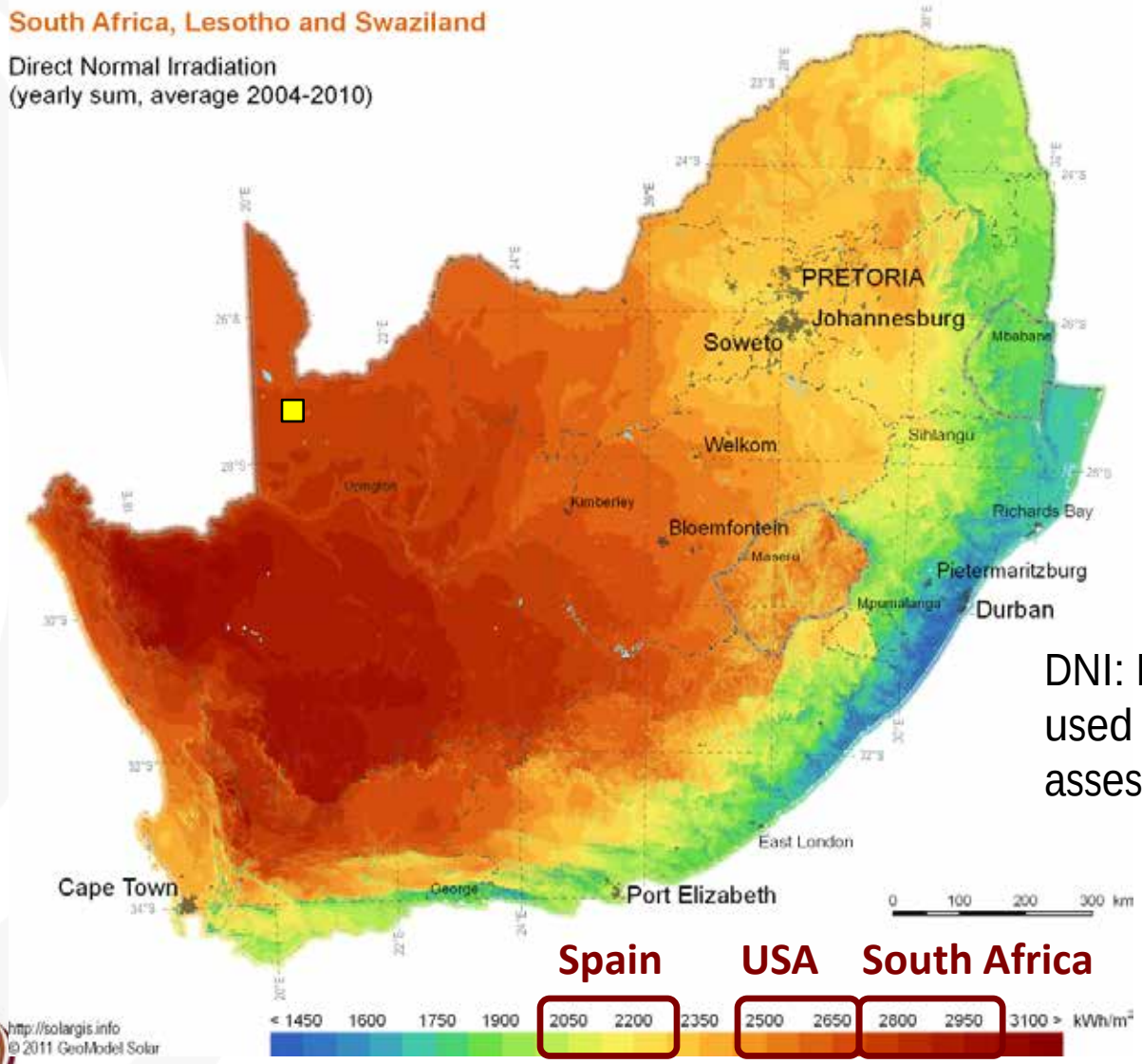
RE IPP PP Update (16 April 2015)

Technology	MW available to be allocated in the Fourth Bid Submission Phase	Number of recommended preferred bidders for the Fourth Bid Submission Phase	Total Contracted Capacity for all the recommended Preferred Bidders for the Fourth Bid Submission Phase	Average fully indexed Price (April 2014 terms)
Onshore wind	590MW	5	676.4MW	R619/MWh
Concentrated solar power	n/a	n/a	-	-
Solar photovoltaic	400MW	6	415.0MW	R786/MWh
Biomass	40MW	1	25.0MW	R1450/MWh
Biogas	n/a	n/a	-	-
Landfill gas	15MW	-	-	-
Small hydro (≤40 MW)[1]	60MW	1	4.7MW	R1 117/MWh
TOTAL	**1 105MW**	**13**	**1 121.1MW[2]**	

World Solar Resource (GHI)

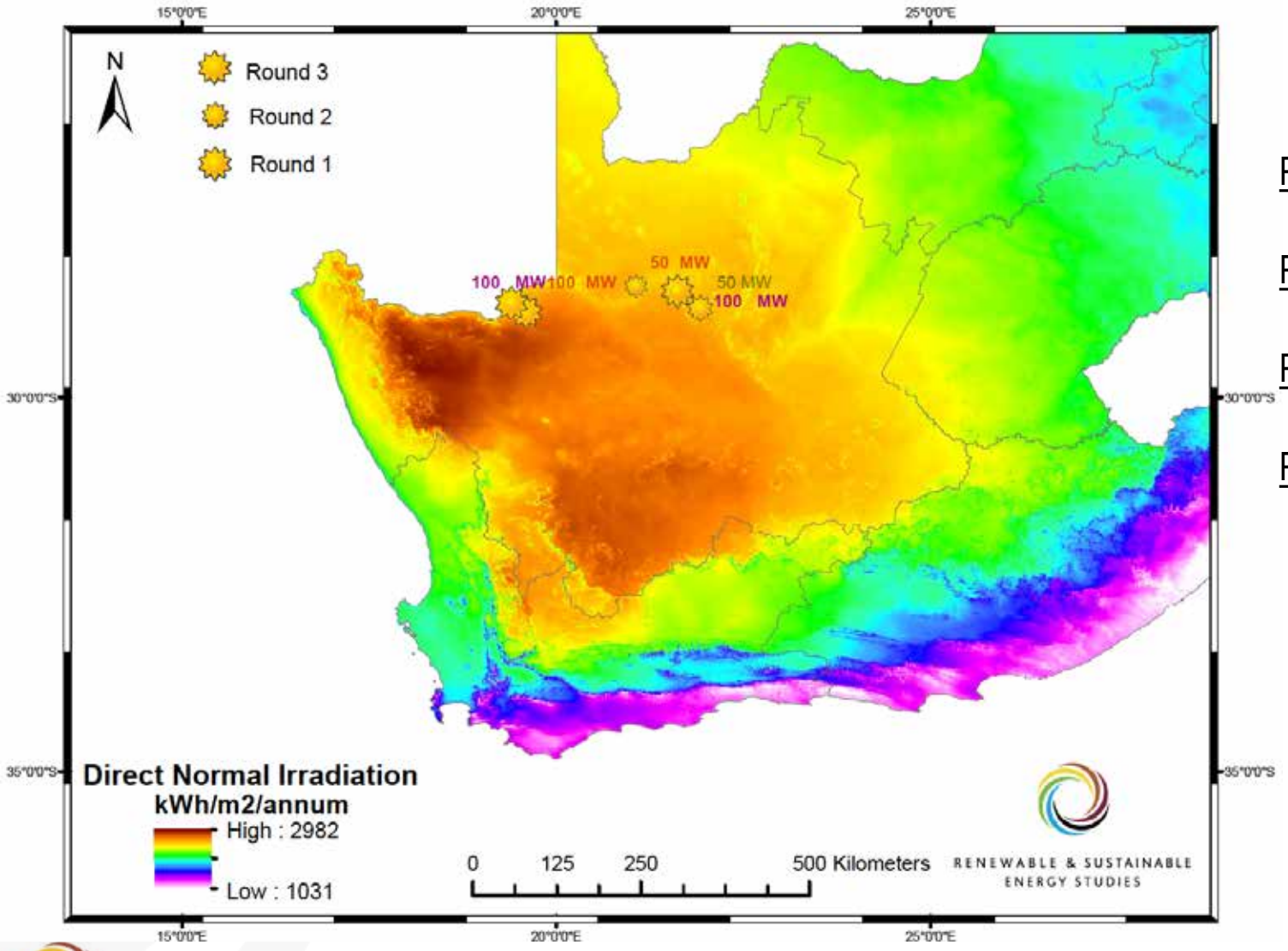


South Africa Direct Normal Irradiance



DNI: Direct Normal Irradiance used for CSP and CPV resource assessments

CSP Projects Rounds 1, 2 & 3



Round 1
150 MW

Round 2
50 MW

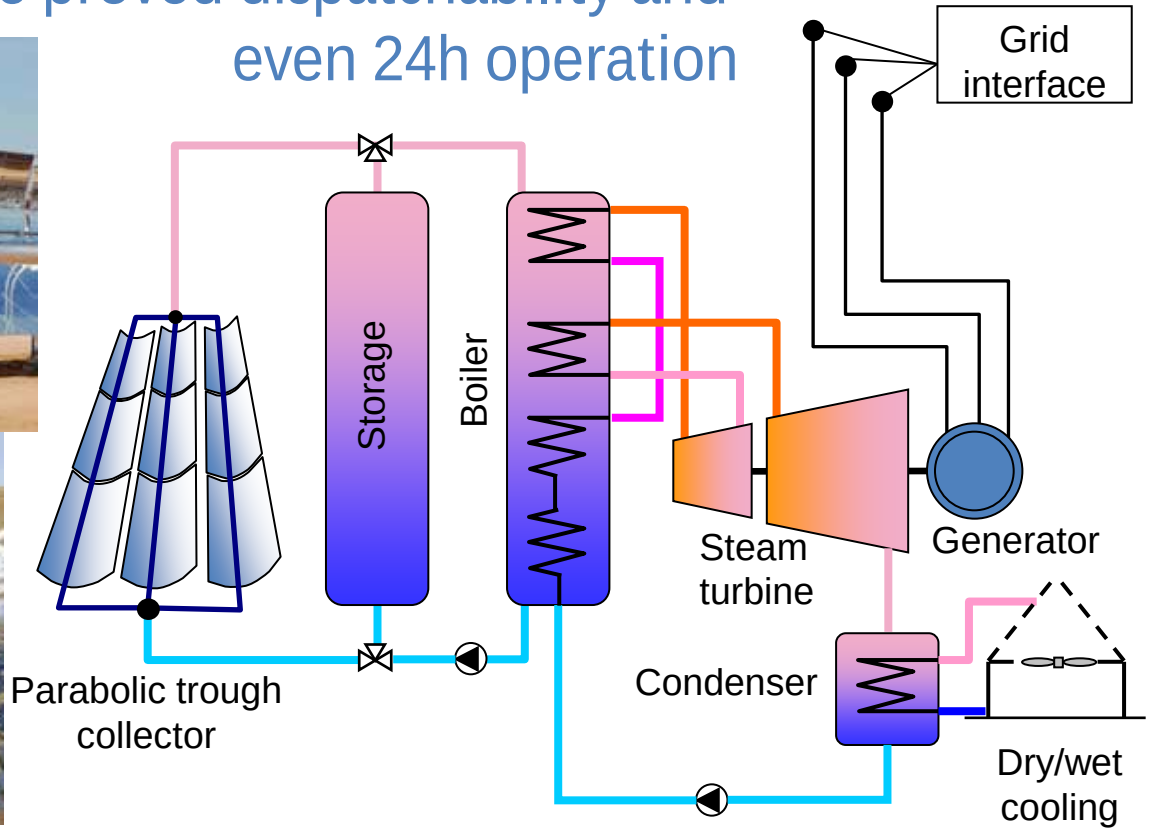
Round 3
200 MW

Round 3b
200 MW

600 MW

CSP – Basic Technology

- "Old" technology that is still developing
- SEGS plants more than 30 years old, still operating
- CSP plants with storage proved dispatchability and even 24h operation



Oldest CSP Plants in the USA

Latest CSP Plants in the USA

Solana (Abengoa) now in operation
250 MWe, 6 hours storage (molten salt), Solar field 2.2 km^2, Area 1 200 ha, Annual energy production of 980 GWh
.

Abengoa Kaxu and Khi Plants in South Africa

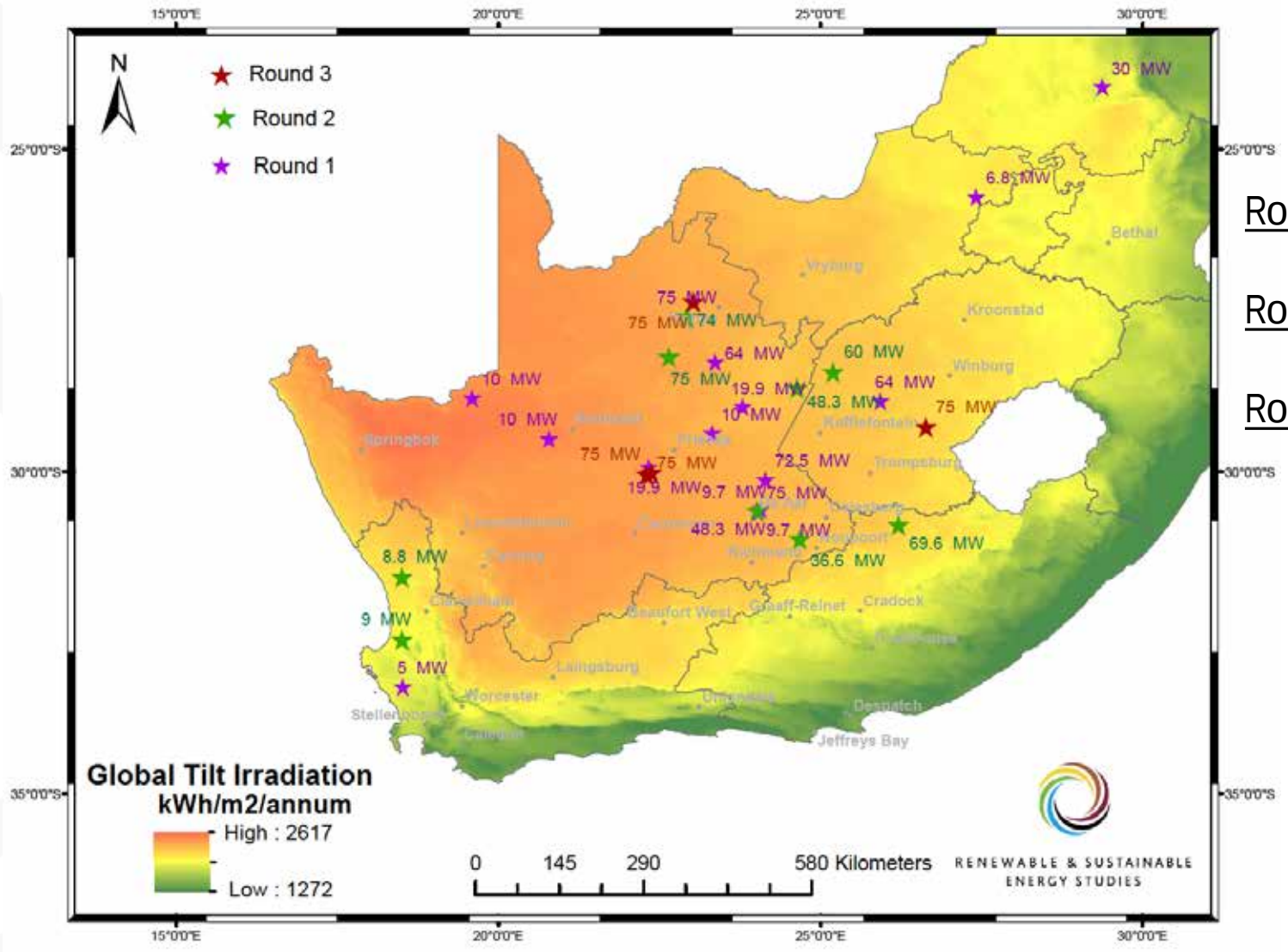
CSP – Cost

- RE IPP PP has recognised the value of storage that CSP plant can offer and hence allowed 2.7 times the tariff in the evening, 5-10pm, in rounds 3 and 3b.

For Round 3 the max tariff is R 3.94/kWh

	Bid Window 3	Bid Window 2	Bid Window 1
Price: Fully Indexed (Ave Rand per MWh) (Base Apr '11)	R 1 460*	R 2 512	R 2 686
Price: Fully Indexed (Ave Rand per MWh) (Base Apr '13)	R 1 640*	R 2 822	R 3 017
MW allocation	200 MW	50 MW	150 MW
Total Project Cost (R'million)	R 17 949	R 4 483	R 11 365

PV Projects Rounds 1, 2 & 3



Round 1

631.5 MW

Round 2

417.1 MW

Round 3

435.0 MW

1 483.6 MW

Photovoltaic Systems

- Well established and proven technology
- Performance guarantees up to 20 years
- Declining prices

Soitec Plant in South Africa – 44MW CPV Plant

Tracker developed (in Stellenbosch!) and manufactured locally. Was earmarked to supply trackers for 300 MW CPV project in California, now cancelled

Rooftop PV (Short Term Win for SA?)

- Installation of Rooftop PV "behind the meter" is financial viable in many sunny areas of SA (Does depend on the tariff structure)
- Rooftop PV is a "fuel-saver" and can make a significant contribution to Eskom's current generation shortage, backed up by the pump storage and open-cycle gas turbines

PV – Value Proposition

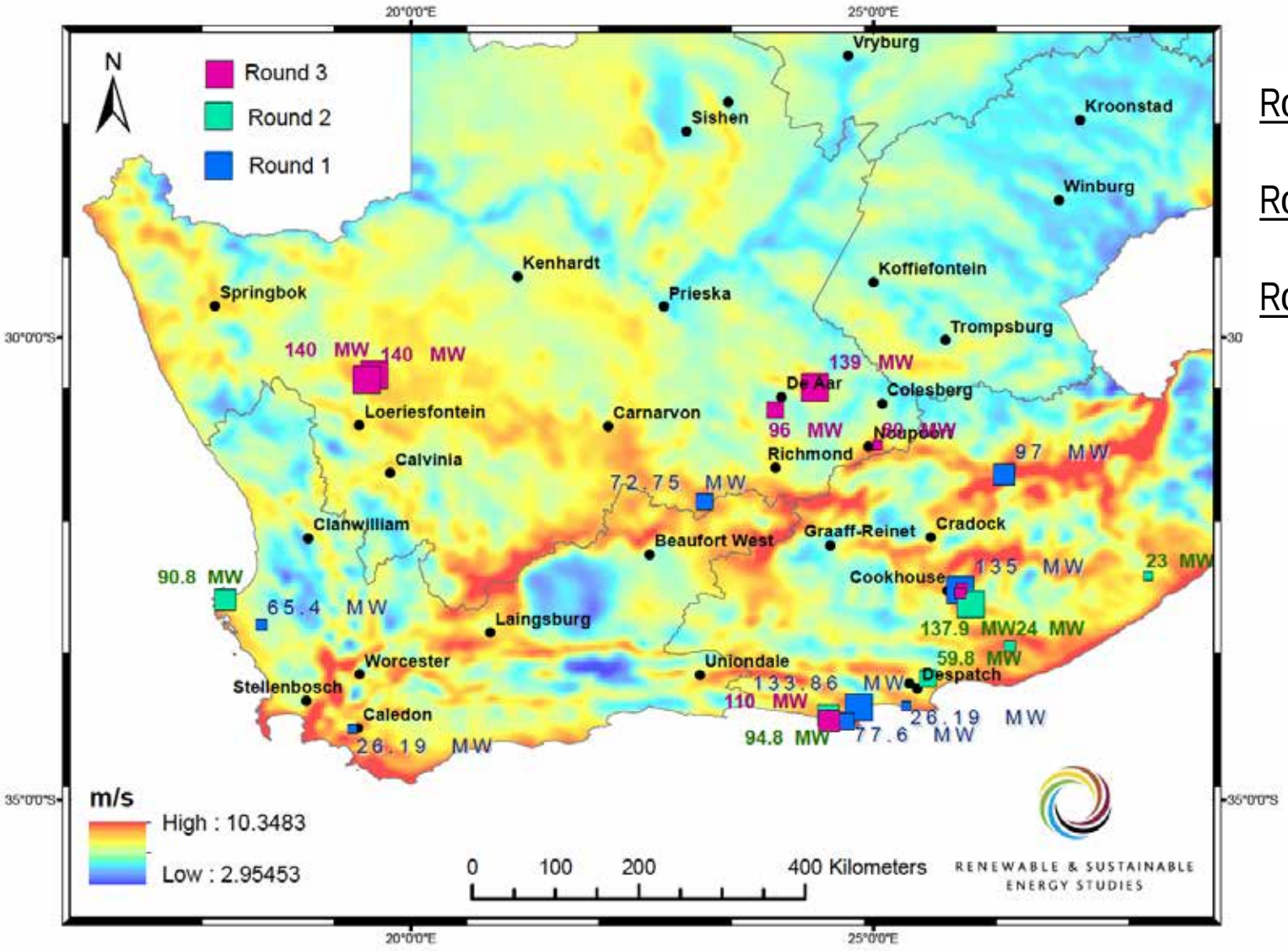
	Bid Window 3	Bid Window 2	Bid Window 1
Price: Fully Indexed (Ave Rand per MWh) (Base Apr '11)	R 881	R 1 645	R 2 758
Price: Fully Indexed (Ave Rand per MWh) (Base Apr '13)	R 990	R 1 848	R 3 098
MW allocation	435 MW	417 MW	632 MW
Total Project Cost (R'million)	R 8 145	R 12 048	R 21 937

- Note, utility scale PV is now at 99c/kWh, that is probably less than what electricity from Medupi and Kusile will cost Eskom
- Rooftop PV could be even larger market that utility scale PV plants
- Major issue is still STORAGE as electricity from PV is not available at night, or on cloudy days

Wind Energy Technology

- Well established and proven technology (most IPP projects on time and within budget)
- Significant installations world-wide
- Low price/kWh; prices have stabilised
- No water consumption
- Intermittency requires careful planning

Wind Projects Rounds 1, 2 & 3



Round 1

634 MW

Round 2

562 MW

Round 3

787 MW

1 983 MW

Jeffreys Bay Wind Farm

Eastern Cape 138 MW (60x 2,3 MW) SIEMENS SWT 2.3

Start of construction: December 2012

Fully operational: May 2014, exactly on the contracted day

Very high capacity factors, some months higher than 40%

First Failure of a Wind Turbine in SA

Dorper Wind Farm near Molteno had a turbine tower failure, week of 18 August, 2014

Wind Energy – Value Proposition

- Lowest cost "utility-scale" renewable electricity available in South Africa at 74c/kWh
- Needs large scale, sustained deployment to increase local content
- Capacity credit of up to 25% possible in South Africa

	Bid Window 3	Bid Window 2	Bid Window 1
Price: Fully Indexed (Ave Rand per MWh) (Base Apr '11)	R 656	R 897	R 1 143
Price: Fully Indexed (Ave Rand per MWh) (Base Apr '13)	R 737	R 1 008	R 1 284
MW allocation	787 MW	562 MW	634 MW
Total Project Cost (R'million)	R 16 969	R 10 897	R 12 724

A “Symphony of Renewables”

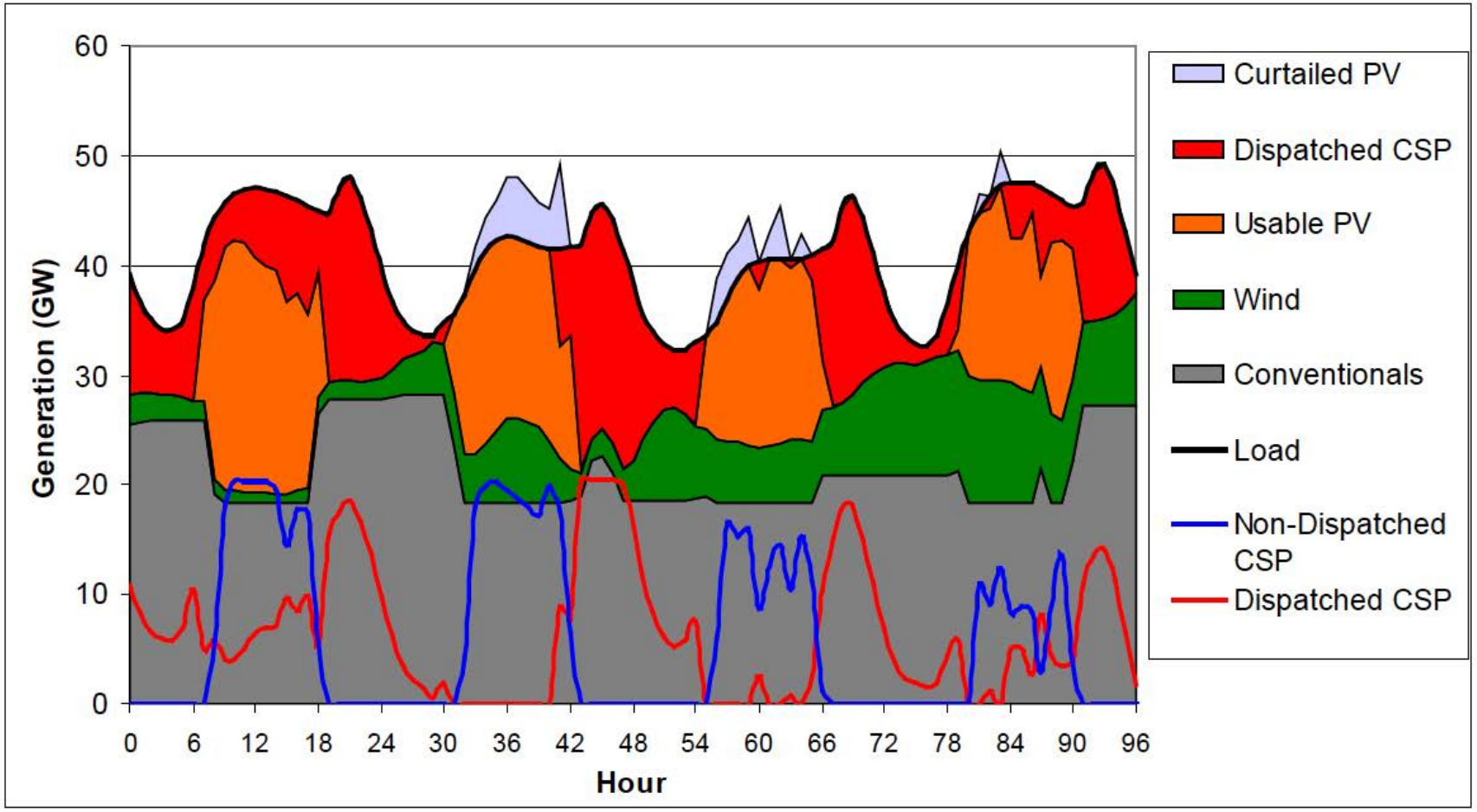
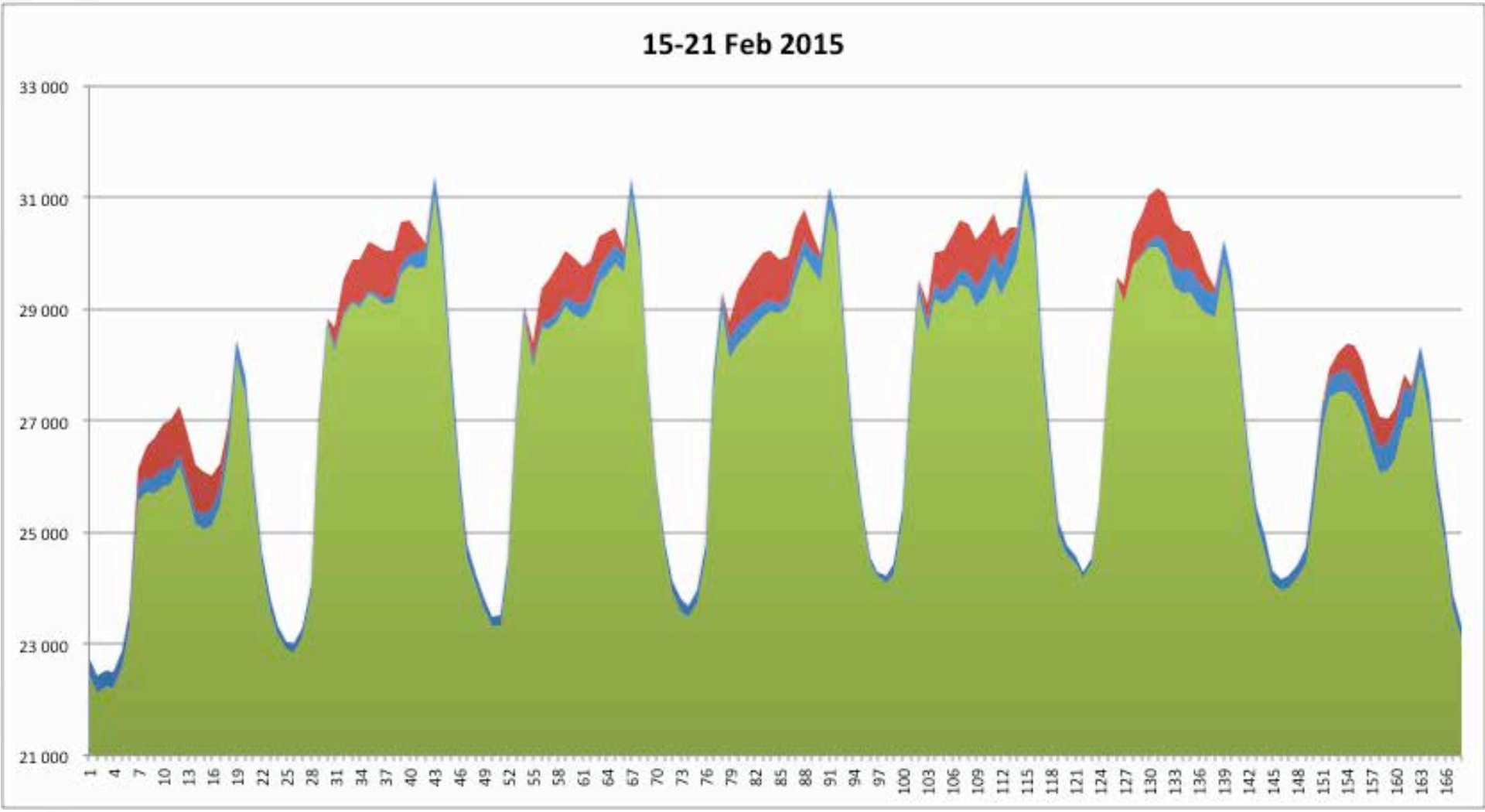


Figure 7. Simulated system dispatch on April 7-10 with 15% contribution from PV and 10% from dispatchable CSP

SA's "Symphony of Renewables"



Conclusions

- Eskom (and hence South Africa) is in a very precarious position, with significant technical and financial challenges that need to be resolved
- Nuclear vs Gas/RE debate will continue for a while (perhaps until it becomes irrelevant?)
- Wind and Solar PV electricity LCOE most likely already lower in SA than electricity from new coal-fired power stations and possibly also nuclear
- Solar electricity, PV and CSP, complement each other in areas of high solar irradiance
- Potential to localise the manufacture of PV and CSP components is much greater than for many other technologies (especially nuclear), but it will need a guaranteed future market in SA of sufficient size
- Distributed electricity generation has many advantages and Wind, CSP and PV lend themselves to this
- Current Eskom crisis will stimulate the RE (and gas) electricity market in SA

Acknowledgements

- Industry associations:
  - SAPVIA
  - SASTELA
  - SAWEA
- Reports by:
  - NREL
  - Frost & Sullivan
  - Black & Veatch
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  - Frank Dinter (Eskom Chair in CSP)
  - Kenny Alan (PhD & Postdoc)
  - Riaan Meyer (CEO GeoSUN Africa)
  - Karin Kritzinger (CRSES)

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