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Why should South Africa invest in the development of renewable energy resources?

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Director: Centre for Renewable and Sustainable Energy Studies

Stellenbosch University

SANEA Lecture, Cape Town, 19 October 2011

Outline of Presentation

- Introduction to Renewable Energy in South Africa
- Current Policy and Financial Landscape for Renewable Energy
- Renewable Energy Resources and Projects in South Africa
  - Wind Energy
  - Ocean Energy
  - Solar Energy
  - Hydro Energy
- What can the contribution from Renewable Energy be?
- Why should South Africa invest in the development of these resources?
- Conclusion

Introduction

White Paper on Renewable Energy 2003

- Set target of 10 000 GWh by 2013.
- Based on 4% of total energy consumption in SA, electricity and liquid fuels.
- Primarily from biomass, solar, wind and small-scale hydro.
- Predicted role for SMMEs, IPPs and competition in energy markets.

- Drivers:
  - Environmental issues, such as pollution and exploitation of natural resources.
  - Climate Change due to CO_2 emissions from fossil fuels.
  - Energy security through diversification of supply.
  - Sustainable development.

Renewable Energy Feed-In Tariff (REFIT)

- First set of tariffs announced March 2009, wind, solar (CSP), small-scale hydro and landfill gas.
- Second set of tariffs announced November 2009, solid biomass, biogas, CSP (central receivers) and PV included.
- Attracted large number of project developers in different stages of their project development.

REFIT, Now History

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Technology	REFIT	Size Constraint
REFIT Phase 1		
CSP trough with storage (6 hours)	R 2.10/kWh	
Wind	R 1.25/kWh	
Hydro	R 0.94/kWh	1 – 10 MW range only
Landfill gas	R 0.90/kWh	
REFIT Phase 2		
CSP trough without storage	R 3.14/kWh	
CSP tower with storage (6 hours)	R 2.31/kWh	
Solid biomass	R 1.18/kWh	
Biogas	R 0.96/kWh	
Large grid connected PV	R 3.94/kWh	1 MW and larger
Concentrated PV	No tariff	
Roof top PV below 1 MW	No tariff	

REFIT Status?

- ***RFP Documentation*** **was due to be released end of March 2011.**
- ***PPAs*** **were due to be signed before December's COP 17 meeting.**
- ***THEN, NERSA*** **published a discussion document with revised (lower) REFITs!!!**
- **THEN DoE/NT announced that the REFITs were unconstitutional!**
- **REBid RFP Documentation released early August, due date 4 Nov**

IRP2010, Setting the Scene

RENEWABLE & SUSTAINABLE ENERGY STUDIES

	New build options							
	Coal (PF, FBC, Imports, own build)	Nuclear	Import hydro	Gas – CCGT	Peak – OCGT	Wind	CSP	Solar PV
	MW	MW	MW	MW	MW	MW	MW	MW
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	300
2013	0	0	0	0	0	0	0	300
2014	500[1]	0	0	0	0	400	0	300
2015	500[1]	0	0	0	0	400	0	300
2016	0	0	0	0	0	400	100	300
2017	0	0	0	0	0	400	100	300
2018	0	0	0	0	0	400[4]	100[4]	300[4]
2019	250	0	0	237[3]	0	400[4]	100[4]	300[4]
2020	250	0	0	237[3]	0	400	100	300
2021	250	0	0	237[3]	0	400	100	300
2022	250	0	1 143[2]	0	805	400	100	300
2023	250	1 600	1 183[2]	0	805	400	100	300
2024	250	1 600	283[2]	0	0	800	100	300

- **Wind:** 800 MW (2010-2013) 2 400 MW (2014 – 2019)
- **CSP:** 200 MW (2014-2015) 400 MW (2016 – 2019)
- **Solar PV:** 2 400 MW (2012 – 2019)

Latest News (Bid Documentation)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

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 seen as an upper bound of the tariffs that will be paid for the electricity from renewable energy technologies

What is the cost of electricity in SA?

RENEWABLE & SUSTAINABLE ENERGY STUDIES

c/kWh	Domestic Block 1	Domestic Block 2	Domestic Block 3	Domestic Block 4	Commercial Prepaid	Commercial	Industrial
RED 1	57- 64	63 - 68	83 - 88	99 - 104	106 - 111	106 - 111	106 - 111
RED 2	57- 64	63 - 68	83 - 88	100 -105	105 - 110	105 - 110	108 - 113
RED 3	57 – 64	63 - 68	83 - 88	99 - 104	106 - 111	106 - 111	108 - 113
RED 4	57 – 64	62 - 67	82 - 87	98 - 103	105 - 110	105 - 110	108 - 113
RED 5	57 – 64	63 - 68	83 - 88	99 - 104	106 - 111	105 - 110	106 - 111
RED 6	57 – 64	62 - 67	82 - 87	98 - 103	106 - 111	106 - 111	108 - 113

Table 5: Benchmarks: 2011/12 at 16.03 % guideline increase

Source: NERSA MYPD Announcement 2010

Eskom 2011/2012 Tarrifs:

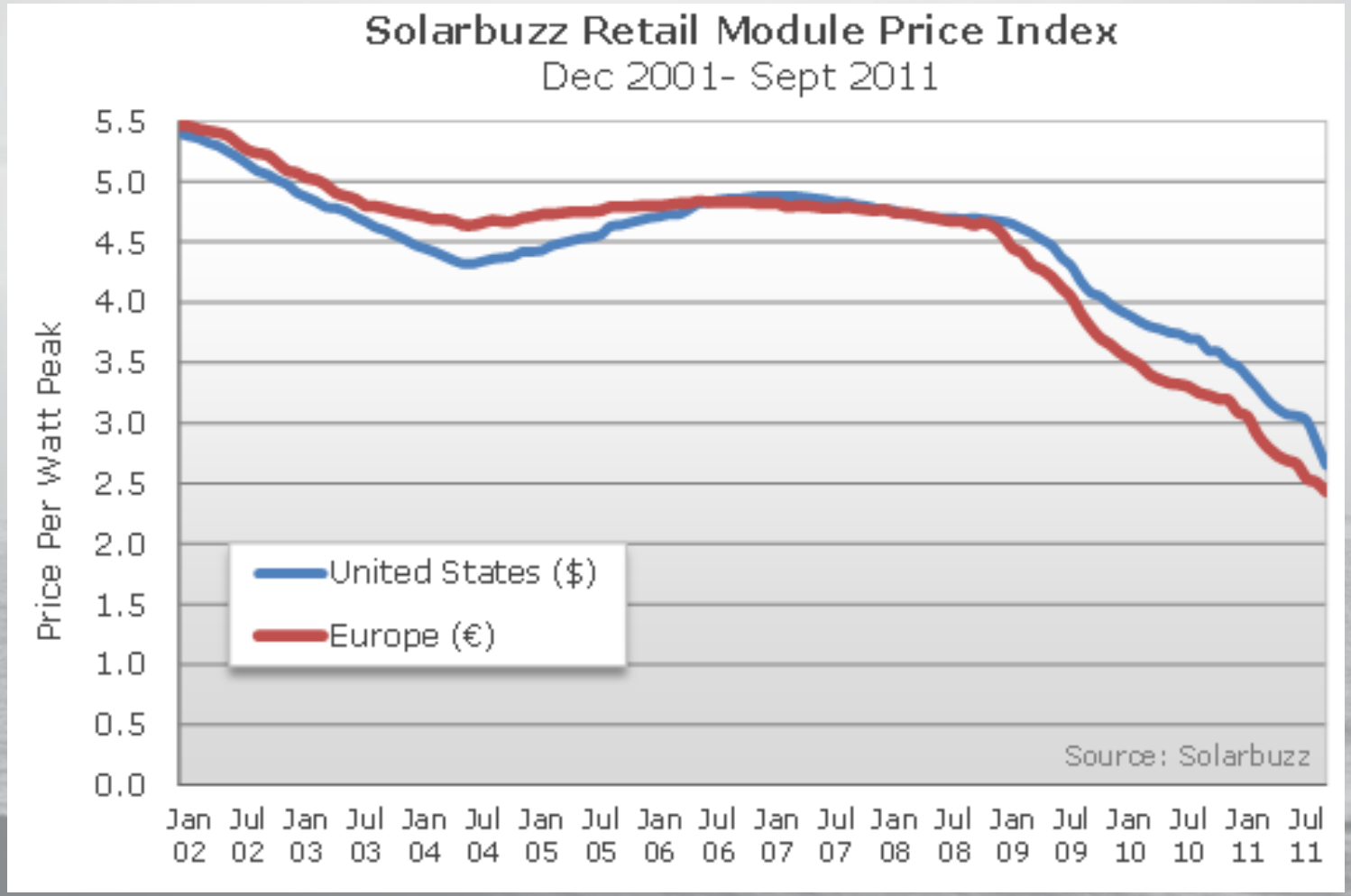
- **Eskom Homelight: R 1.13 – R 1.46/kWh (Excl VAT)**
- **Eskom Megaflex: R 0.21 – R 2.01/kWh (plus other charges)**
- **Eskom Businessrate: R 0.68/kWh (plus other charges)**

(Another 25% on its way in 2012)

REBid:

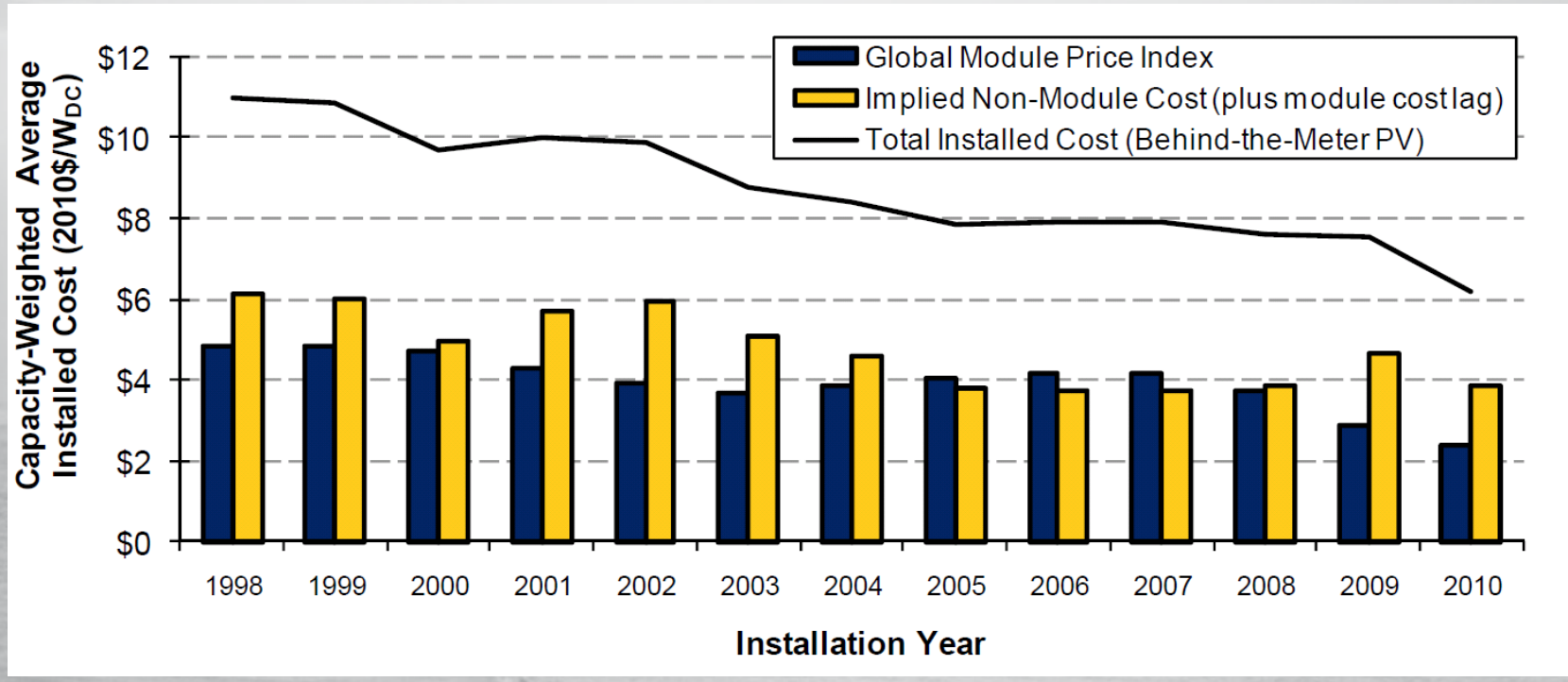
Wind < R 1.15/kWh; Solar < R 2.85/kWh; Small-Hydro < R 1.03/kWh

What is the cost of electricity from PV?



Source: http://www.solarbuzz.com

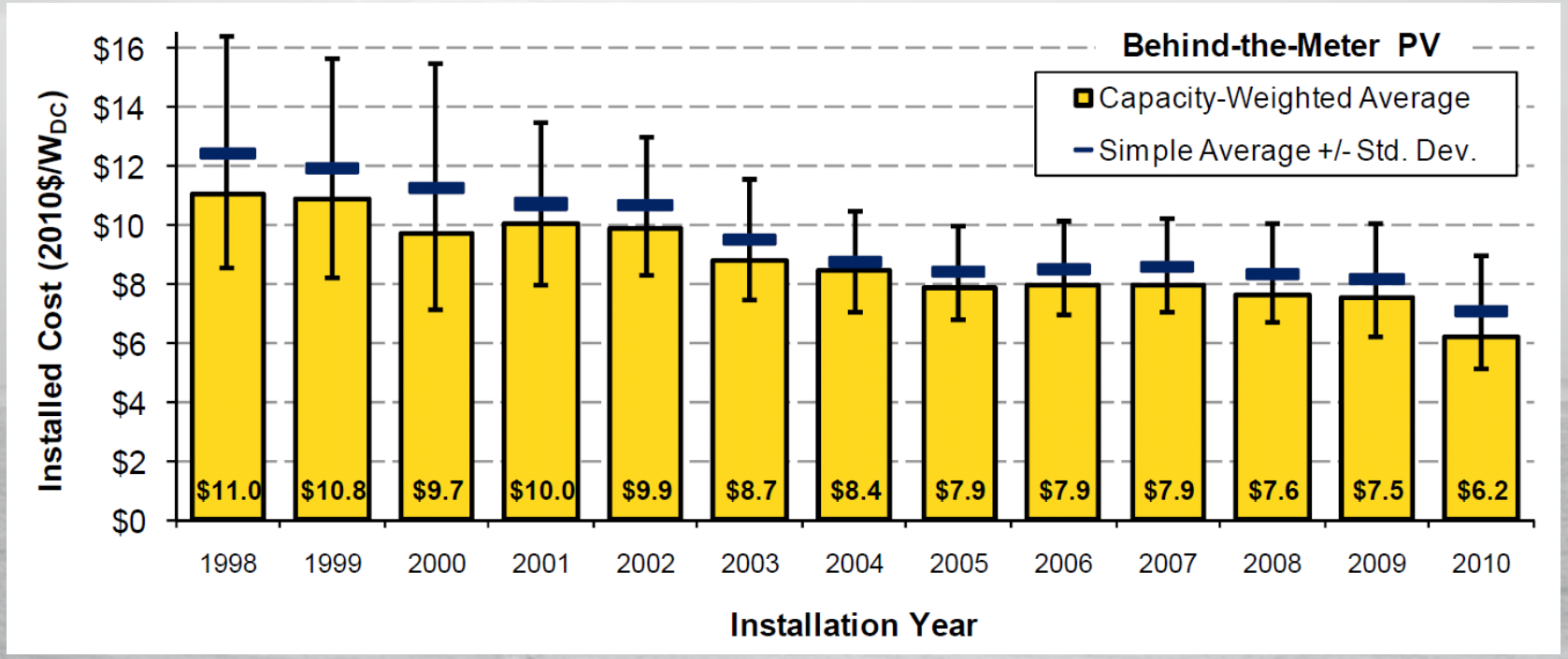
What is the cost of electricity from PV?



Source: NREL Report, Tracking the Sun IV 2011

What is the cost of electricity from PV?

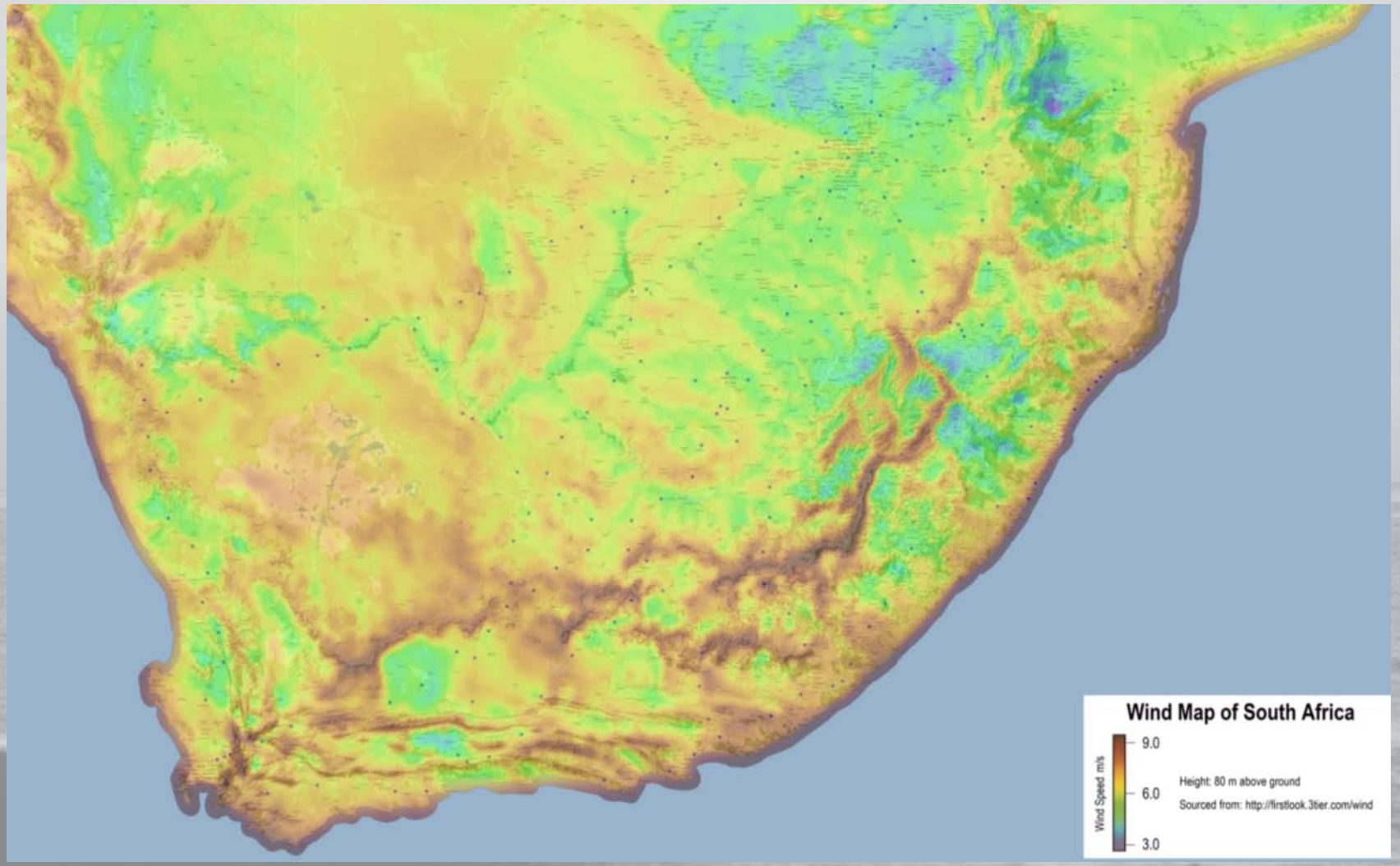
RENEWABLE & SUSTAINABLE ENERGY STUDIES



Source: NREL Report, Tracking the Sun IV 2011

Wind Energy Resource

RENEWABLE & SUSTAINABLE ENERGY STUDIES



Source: firstlook.3tier.com/wind

Wind Energy Projects

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Klipheuwel, Eskom Demonstration

- Wind turbines
  - Vesta V47 660 kW
  - Vestas V66 1 750 kW
  - Jeumont J48 750 kW

Darling Wind Farm, Darlipp

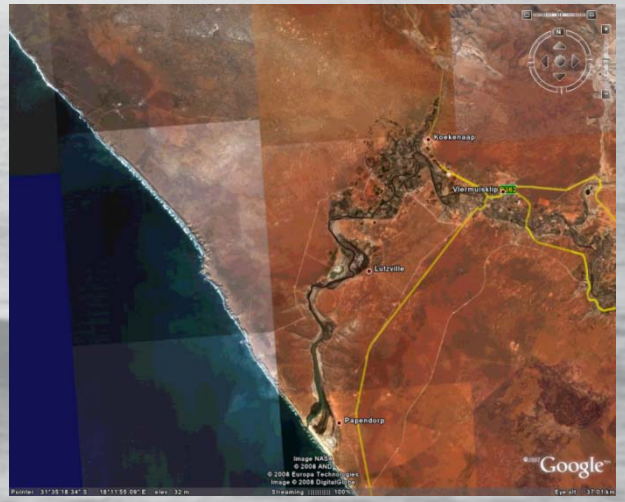
- Four 1,3 MW Führlander wind turbines
- Installed February-March 2008
- Commissioned May 2008
- Official “Switch-On”, 23 May 2008
- Expected capacity factor > 30% (23-24%)

Sere, Eskom Wind Energy Facility, near Lutzville on West Coast

- Up to 100 wind turbines, first phase 100 MW, second phase 100 MW
- Funded by French Development Bank, African Development Bank and World Bank loans
- Funding secured, soon out on tender, again

Latest Development

- Coega 1,8 MW Vestas turbine

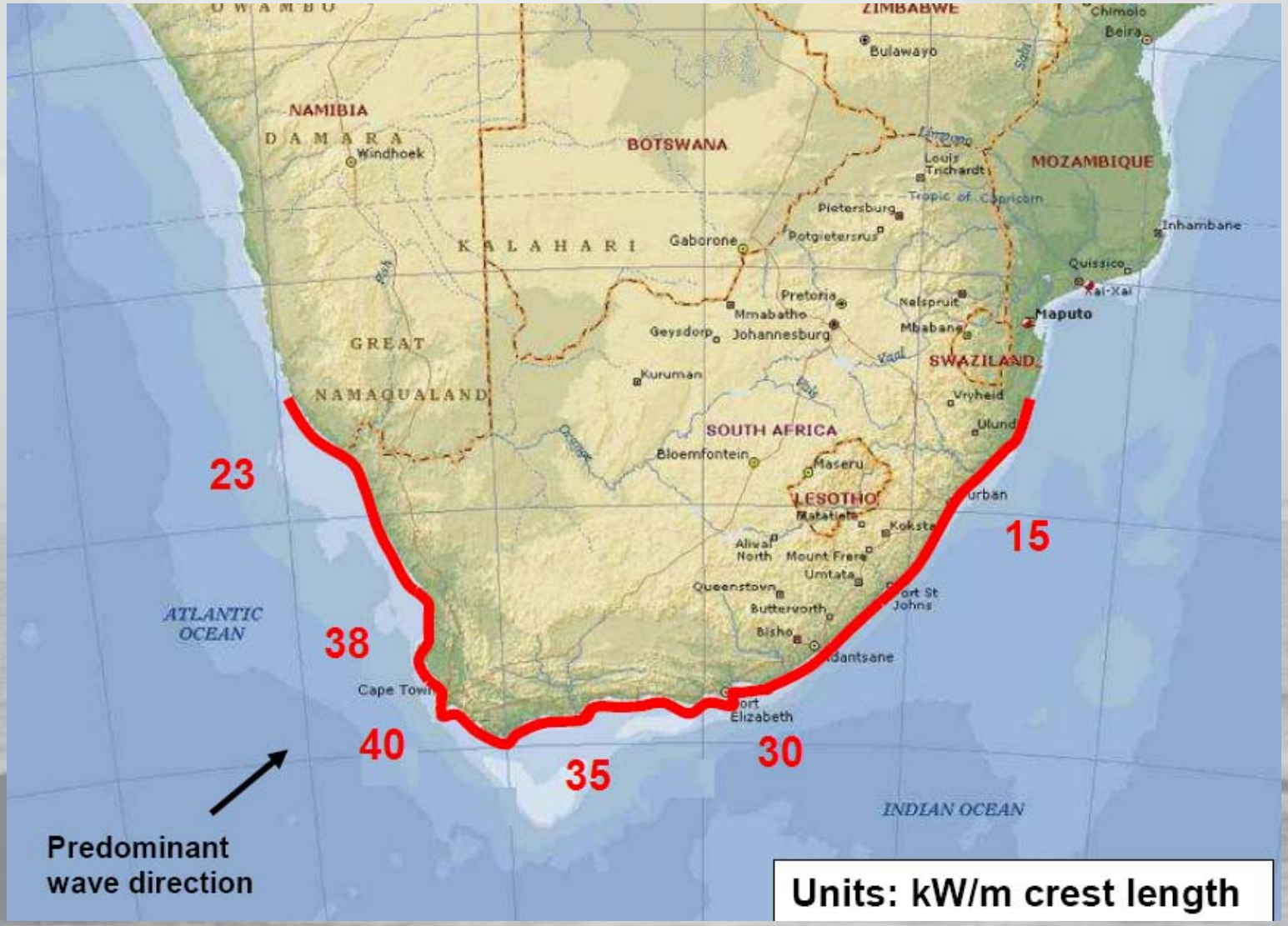


IPP Projects Under Development

- More than ***4 GW*** currently under development by various project developers

Wave Energy Resource

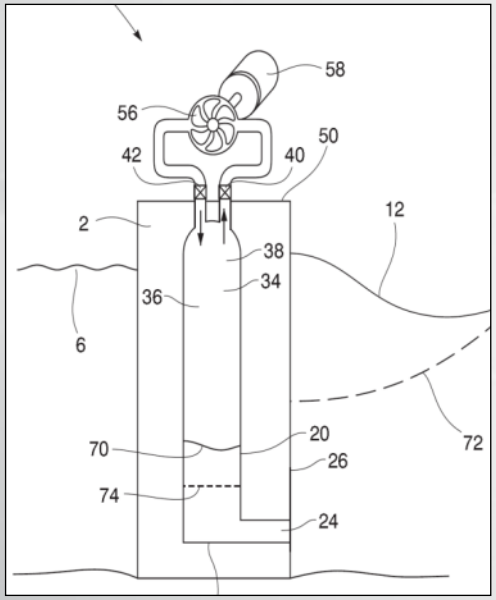
RENEWABLE & SUSTAINABLE ENERGY STUDIES

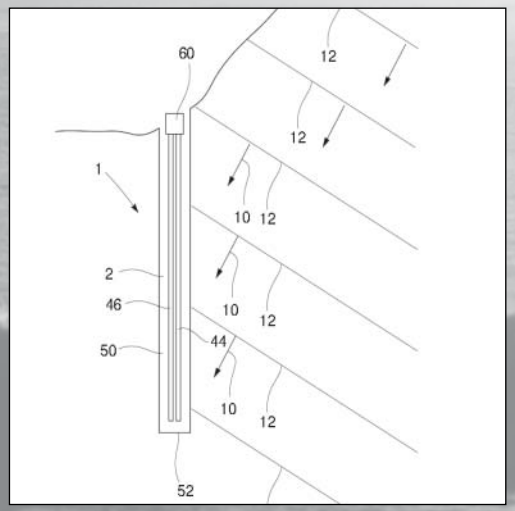


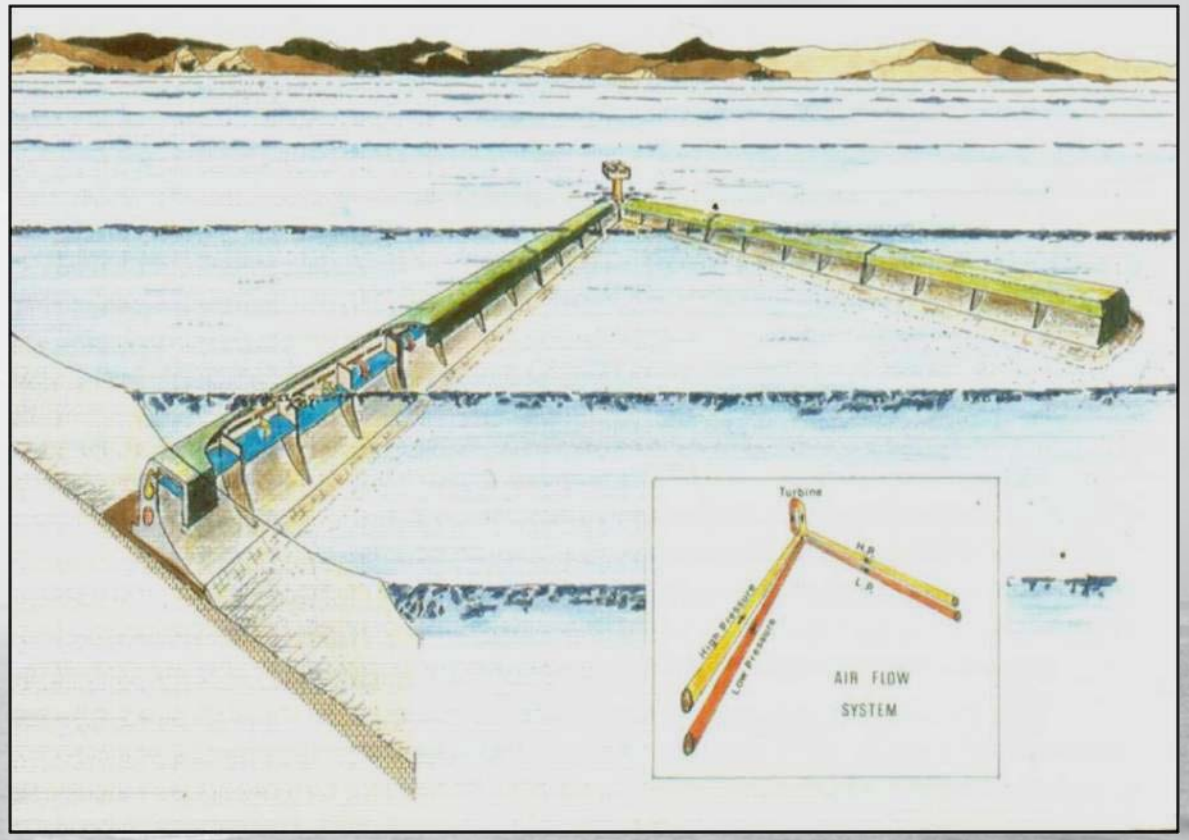
Source: Joubert (2008)

Wave Energy Projects

RENEWABLE & SUSTAINABLE ENERGY STUDIES





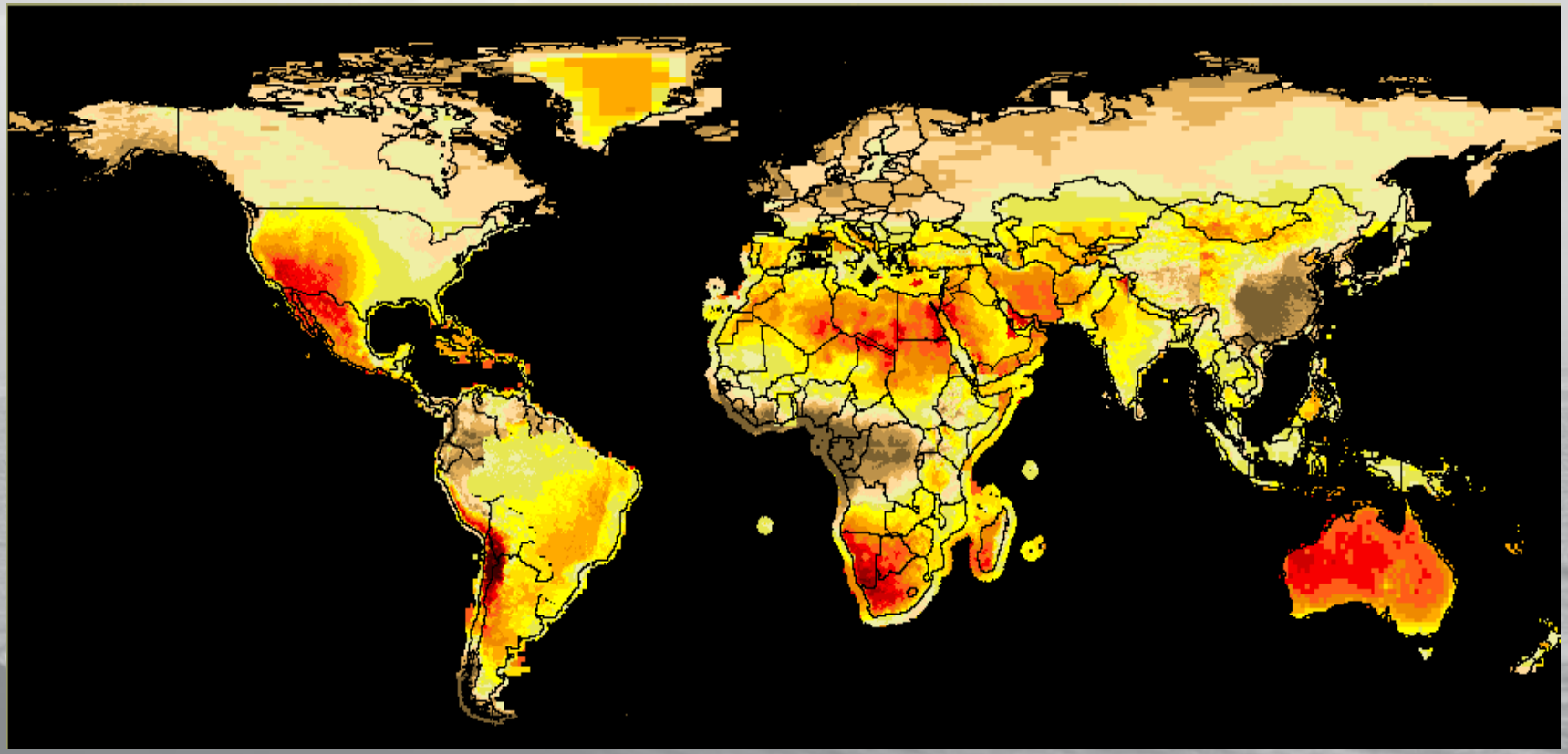


Stellenbosch Wave Energy Convertor (SWEC), ongoing research project. ShoreSWEC is a SWEC build into a breakwater.

Solar Energy Resources

RENEWABLE & SUSTAINABLE ENERGY STUDIES

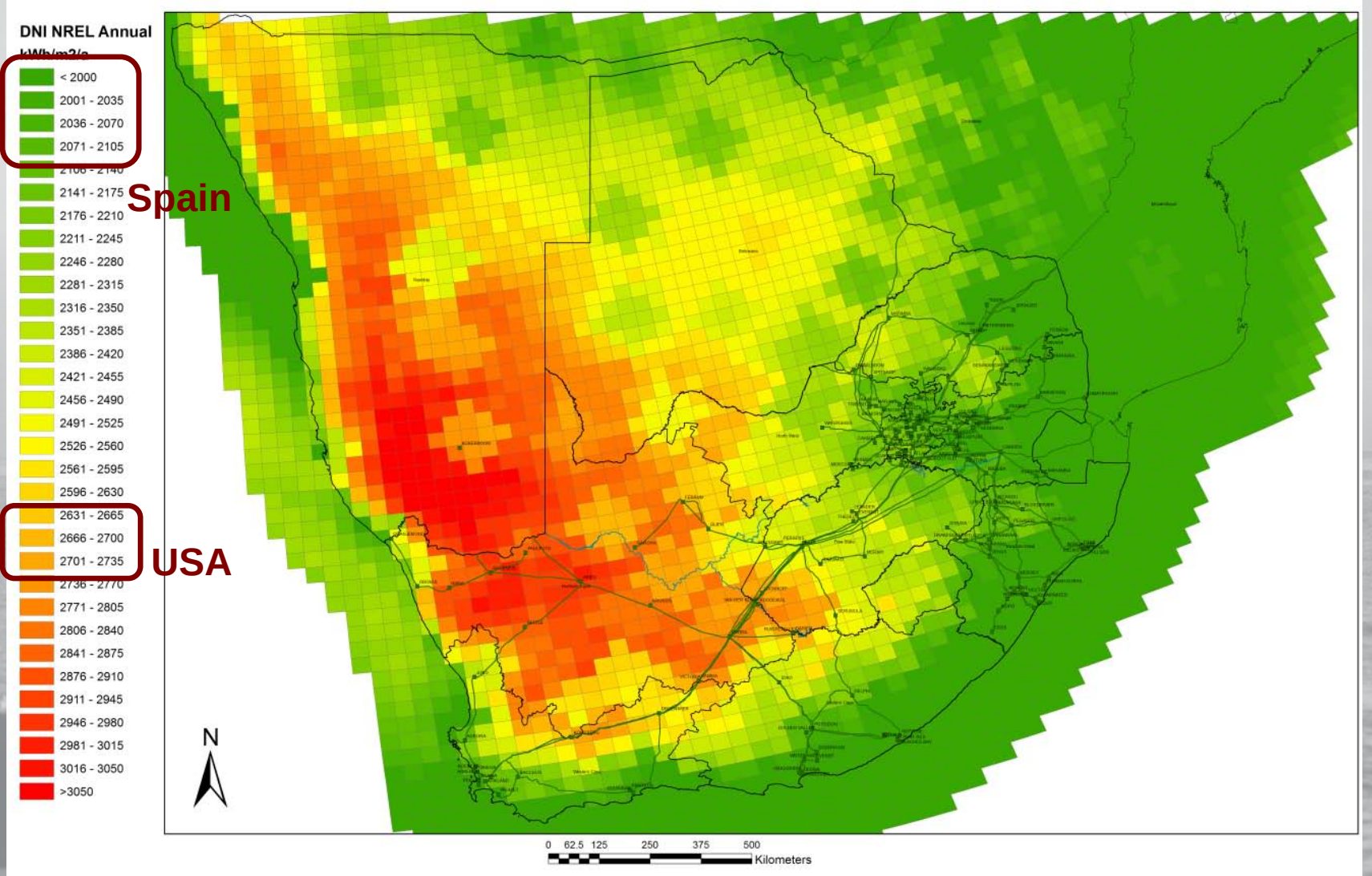
Direct Normal Irradiance (DNI) solar resource worldwide



Solar Energy Resources (2)

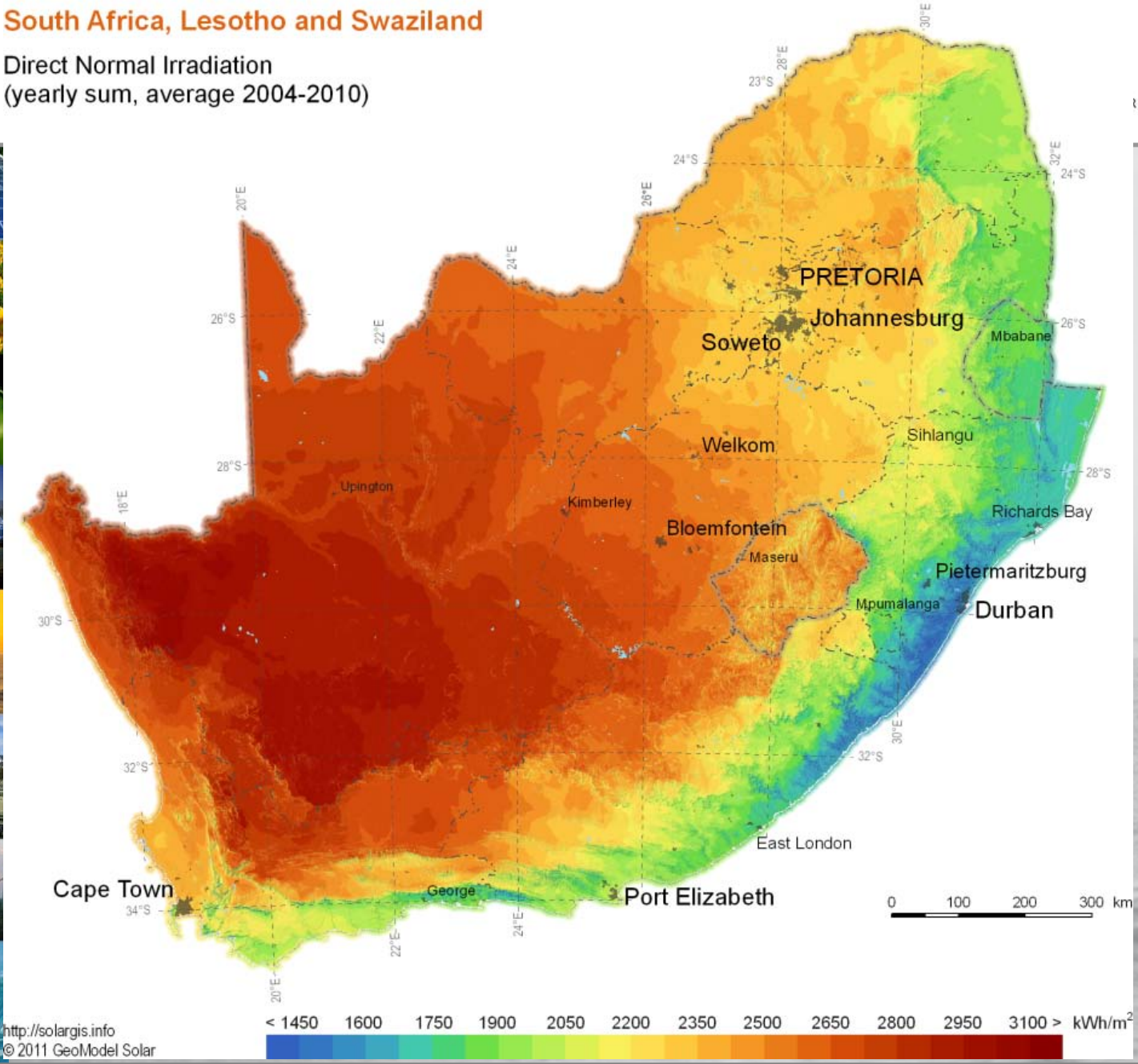
RENEWABLE & SUSTAINABLE ENERGY STUDIES

- South Africa DNI solar resource and Eskom transmission lines



South Africa, Lesotho and Swaziland

Direct Normal Irradiation
(yearly sum, average 2004-2010)

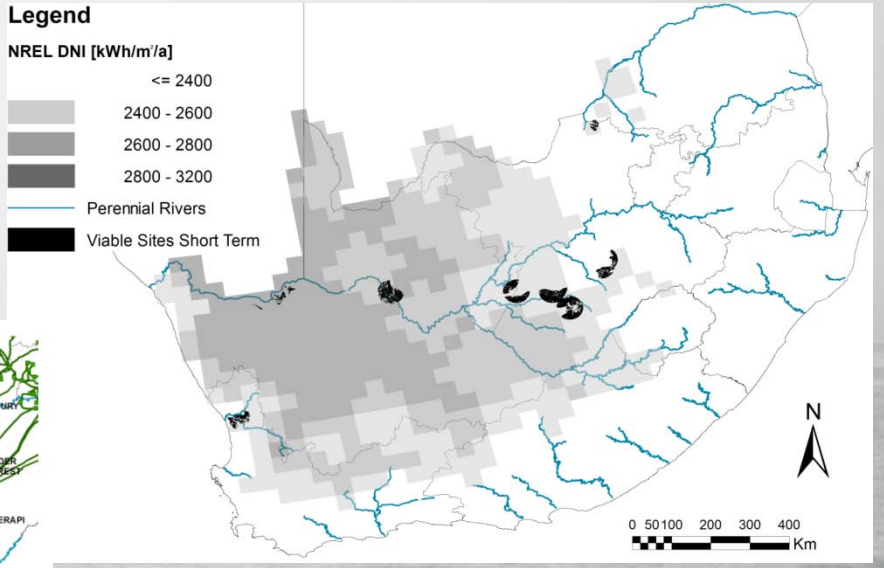


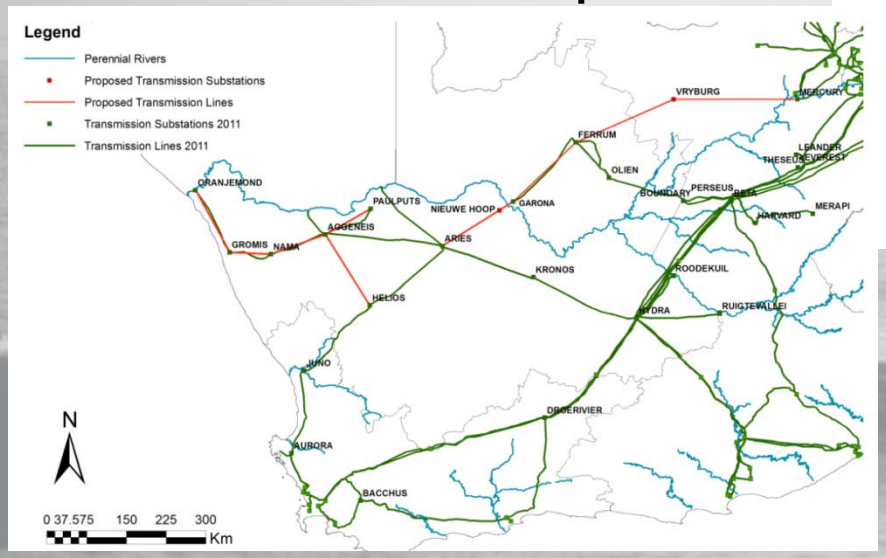
Solar Energy Resources (4)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- Projects currently being developed, **890 MW**
- Criteria:
  - DNI > 2 400 kWh/m^2/annum
  - Distance to from transmission substation on the tx grid < 30 km
  - Flat area, slope < 2%
  - Non-sensitive land-use areas
- With current grid **1 129 MW**
- With planned expansion **3 000 MW**

Total available 262 GW in South Africa, 183 GW in the Northern Cape



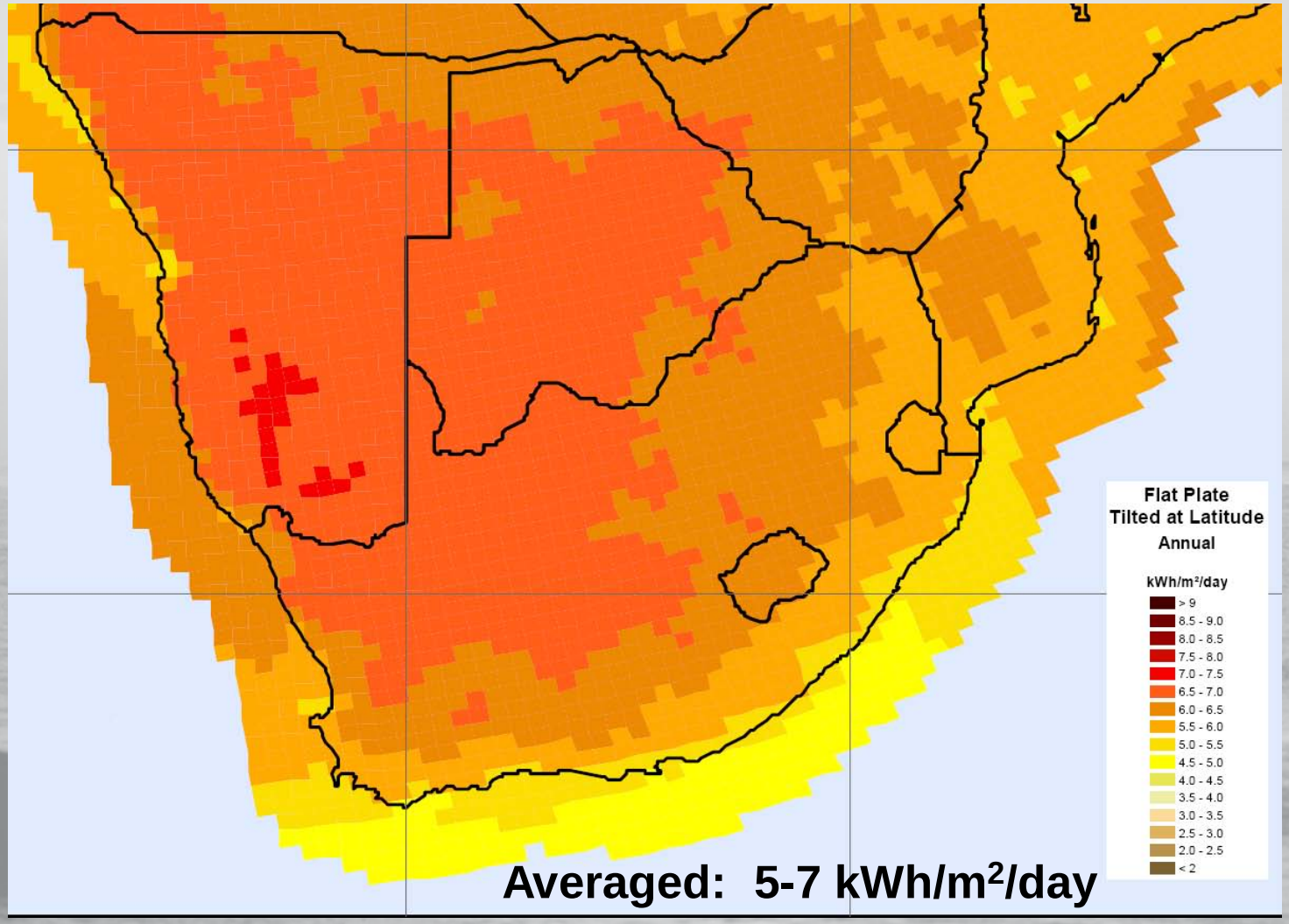


Meyer & Van Niekerk, Solar PACES 2011

Solar Energy Resources (5)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Latitude Tilt Irradiance (LTI), used for stationary PV

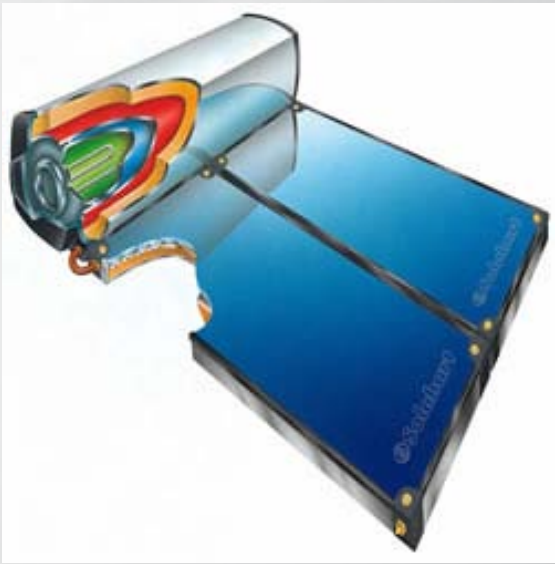


Averaged: 5-7 kWh/m²/day

Conversion Technologies (1)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- **Solar Thermal**
  - Solar Water Heaters
  - Commercial Solar Water Heating & Cooling
  - Easy implementable technology with guaranteed returns

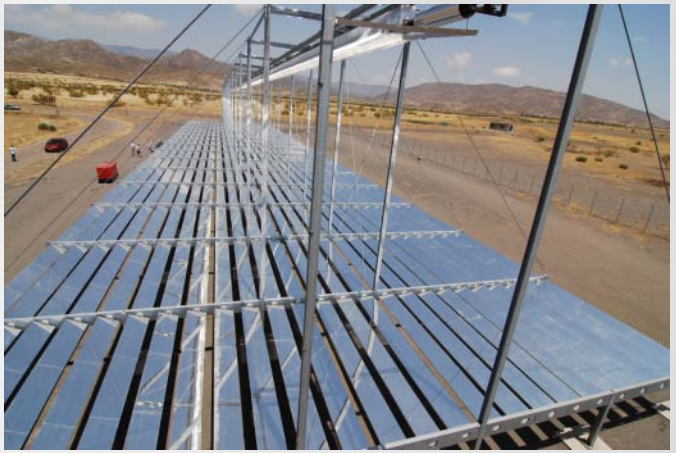


- **Solar Electricity**
  - Photovoltaic modules
  - Concentrated Solar Power (CSP) plants
  - Necessary for large scale solution to energy crises

Conversion Technologies (2)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

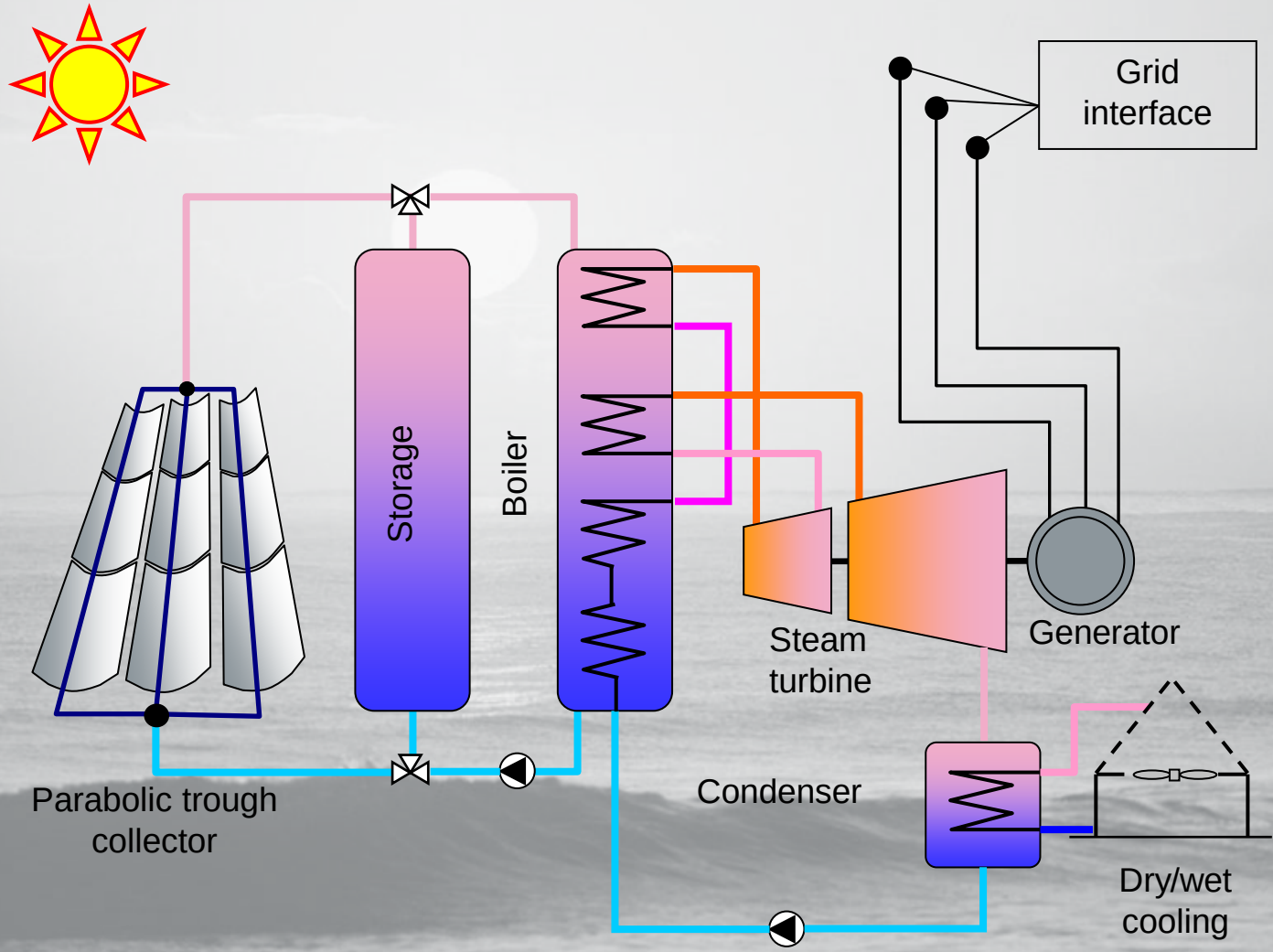
Parabolic Troughs



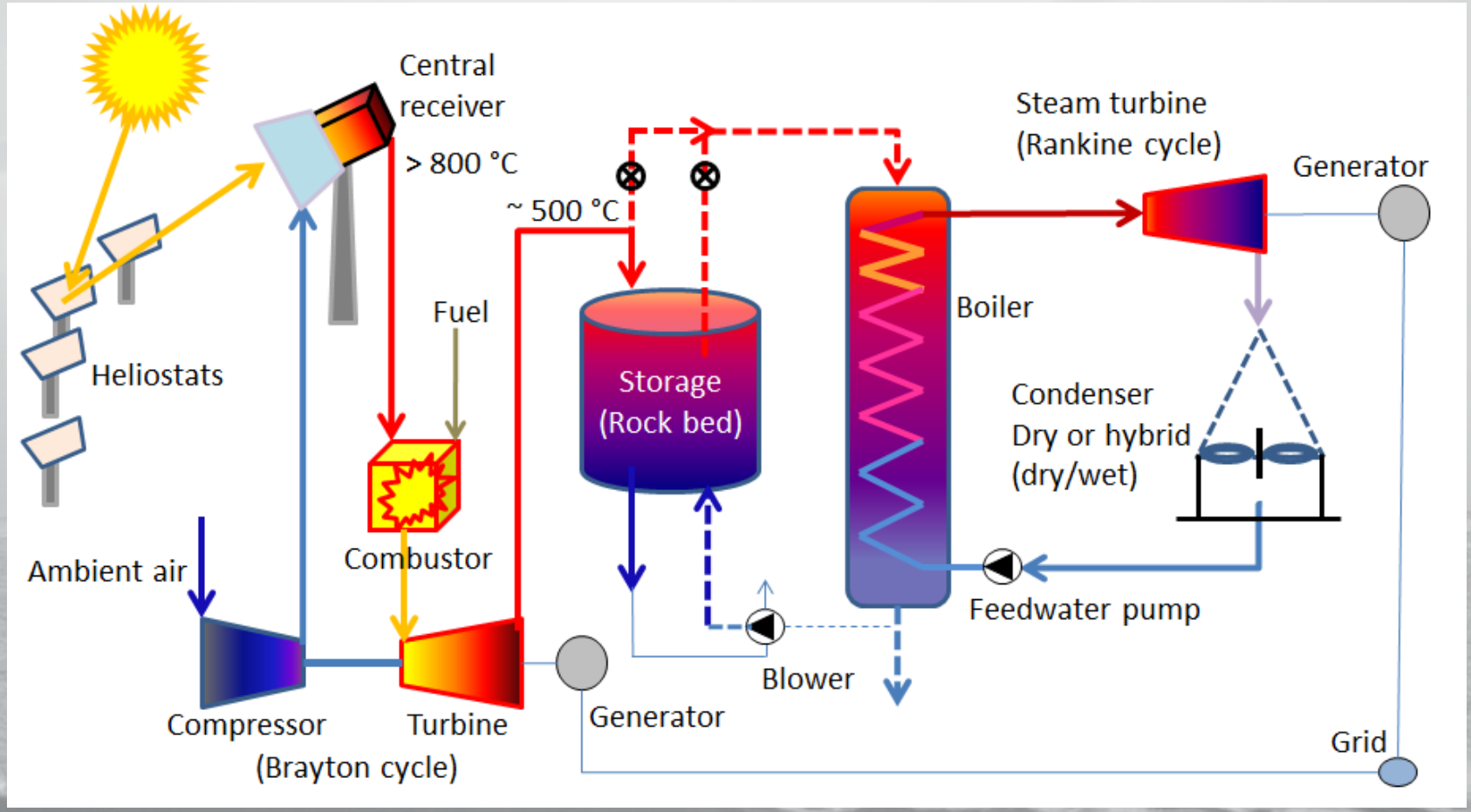
Linear Fresnel Reflectors

Central Receivers

Conversion Technologies (3)



Conversion Technologies (4)



SunSPOT Cycle that provides: Dispactchable or even Baseload electricity to the grid

Conversion Technologies (5)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Gemasolar: first, operational solar power station to generate electricity for 24 hours,

20 MWe, direct salt loop with storage

Conversion Technologies (6)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Ivanpah (BrightSource), Under construction, 370 MWe(Net), 3 Towers, Direct steam loop, Dry-air cooled

CSP Projects in South Africa

Eskom, 100 MWe, CSP northwest of Upington

- Receiver – 540MW(t)
- Energy storage – 14 (now 3?) hours, Salt volume of 25,000 ton
- Plant capacity – 100MW(e), generating 24 hours over summer solstice
- Load factor – 68%
- Construction will take 3 years. Plant can be operational by 2016.
- World Bank funding secured for the project.

IPP Projects

- 150 MW, near Pofadder in the Northern Cape by Kaxu CSP;
- 75 MW, near Groblershoop in the Northern Cape by Solafrica Thermal Energy;
- 100 MW, near Kathu in the Northern Cape by Renewable Energy Investments South Africa (REISA)
- 125 MW, near Upington in the Northern Cape by Ilangalethu Solar Power;
- 110 MW, near Upington in the Northern Cape by Khi CSP South Africa;
- 100 MW, near Kimberley in the Northern Cape by Afri-Devo;
- 30 MW, near Daniëlskuil in the Northern Cape by Afri-Devo; and
- 100 MW, near De Aar in the Northern Cape byAfrican Clean Energy Developments, (ACED).

Hydro Energy

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- Existing:
  - Hydroelectric power stations at Gariep (360 MW) and Vanderkloof (240 MW)
  - Caharo Bassa in Mozambique (2 000 MW)
  - Kunene river in Namibia/Angola
- Energy Storage:
  - Steenbras (180 MW), Palmiet (400 MW) and Drakensberg (1 000 MW)
  - New Ingula (1 333 MW) and Project Lima (on hold)
- Micro and Small Hydro:
  - Small installations, < 100 kW
  - Run-of-river systems
  - Small Hydro, e.g. Bethlehem Hydro, 7 MW
- Future:
  - Inga in the DRC, Grand Inga 40 GW (Eskom's current installed capacity)

What can Renewable Energy contribute? (1)

- Clean Energy
- Quick Implementation
- Energy Security
- Jobs, jobs, jobs
- New Manufacturing Industry
- Electricity at lower cost?

What can Renewable Energy contribute? (2)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- **Clean Energy**
  - SA energy sector is very carbon intensive
  - Electricity from coal - 90%
  - Large % (25?) of liquid fuel also from coal
  - While we have access to abundant renewable energy resources

- **Quick Implementation**
  - Wind farms can be built in 1-2 years
  - Feasible to get wind farm project from idea to generation in less than four years
  - PV probably faster
  - CSP will take longer

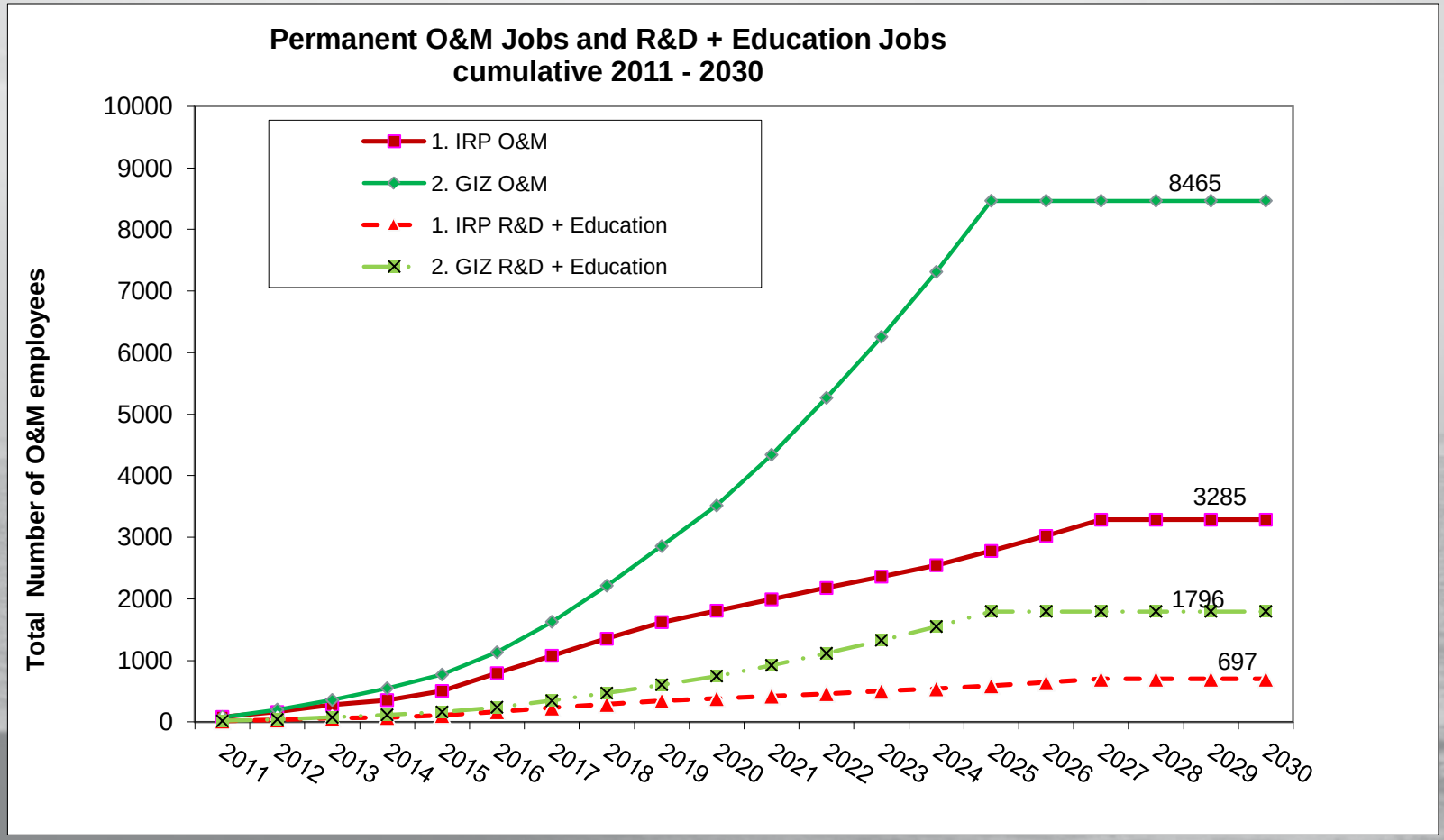
What can Renewable Energy contribute? (3)

- **Energy Security**
  - Diversity of resources assists with managing intermittency of renewable energy
  - Internationally (and nationally?) imposed carbon taxes may increase the price of electricity and influence the competitiveness of our industry
  - As renewable energy is distributed and also more prevalent in the southern and western parts of the country it should increase security of supply, at least here in the Western Cape

What can Renewable Energy contribute? (4)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- **Jobs, Jobs, Jobs (E.g. Wind Energy)**



SAWEC Study, GIZ, 2011

What can Renewable Energy contribute? (5)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- **Jobs, Jobs, Jobs (E.g. Wind Energy, IRP 2010)**

Year	O & M	R&D + Education	Installation	Manufacturing	Consulting
2011	82	17	209	56	10
2012	80	17	204	64	11
2013	117	25	298	160	28
2014	76	16	194	156	27
2015	148	31	378	421	73
2016	289	61	842	987	171
2017	283	60	822	1,124	195
2018	276	59	803	1,255	218
2019	270	57	785	1,472	255
2020	185	39	605	1,008	175
2021	185	39	605	1,260	218
2022	185	39	605	1,470	255
2023	185	39	605	1,764	306
2024	185	39	605	1,764	306
2025	231	49	756	2,573	446
2026	244	52	844	3,108	539
2027	264	56	912	3,360	582
2028	-	-	-	-	-
2029	-	-	-	-	-
2030	-	-	-	-	-
Total 2027	**3,285**	**697**	**912**	**3,360**	**582**

SAWEC Study, GIZ, 2011

What can Renewable Energy contribute? (6)

RENEWABLE & SUSTAINABLE ENERGY STUDIES

- **Jobs, Jobs, Jobs (E.g. Wind Energy, IRP 2010)**

Year	Engineers	Technicians	Skilled Worker	other	Total Staff Training
2011	52	102	112	97	364
2012	53	102	113	97	365
2013	94	169	192	156	611
2014	74	125	145	113	458
2015	173	280	331	248	1,031
2016	388	617	743	563	2,311
2017	418	651	790	586	2,445
2018	447	683	834	608	2,573
2019	497	742	914	650	2,803
2020	347	521	646	472	1,986
2021	409	598	746	529	2,282
2022	461	661	830	576	2,528
2023	533	750	948	643	2,873
2024	533	750	948	643	2,873
2025	756	1,048	1,332	886	4,023
2026	899	1,234	1,577	1,042	4,753
2027	972	1,334	1,705	1,127	5,138
2028	-	-	-	-	-
2029	-	-	-	-	-
2030	-	-	-	-	-
Average per year	**418**	**610**	**759**	**532**	

SAWEC Study, GIZ, 2011

What can Renewable Energy contribute? (7)

- **New Manufacturing Industry**
  - For Wind Energy: Towers, Blades, Power Electronics and perhaps Generators and Nacelles
  - For PV Industry: Modules, Frames, Power Electronics, and in future Cells and Thin-Film Panels
  - For CSP Industry: Heliostat Structures, Mirrors, some Receivers, Heat Exchangers, Pipes and Valves and perhaps Turbines and Generators
  - All construction and other support services will be local stimulating manufacture as well

Conclusions

- South Africa has abundant renewable energy resources that can be tapped for clean energy and increase security of supply.
- South Africa has one of the best solar regimes in the world, of all the renewable energy resources it is by far the most abundant available in the country.
- Stimulating significant growth in the renewable energy sector will not only results in o&m jobs but also establish a manufacturing industry that will create even more jobs
- The manner in which the Government implements the current IRP and REBid is very important to establish the credibility of SA's emerging renewable energy industry. Is it only lip-service to appease a critical world audience or is it a real commitment to clean energy?

Conclusions

- **What needs to be done?**
  - Current REBid process should be completed with limited “issues.”
  - Roll-out of the new RE IPPs should be efficient and according to plan (that is what private industry is good at.)
  - IRP should be updated with the new costing information and RE targets increased, especially for CSP, to establish a RE manufacturing industry in SA.
  - Technology transfer and development should be continued, especially in those areas where SA has a competitive edge.
  - Small scale RE should be allowed and encouraged.

Acknowledgements

- Riaan Meyer, CRSES
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- James Joubert, M&M
- Dr Tom Fluri, M&M (Now in Germany)
- Other colleagues and students

Contact Information

RENEWABLE & SUSTAINABLE ENERGY STUDIES

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