



UNIVERSITEIT • STELLENBOSCH • UNIVERSITY
jou kennisvenoot • your knowledge partner

The Renewable Energy Resource and Research Base in South Africa

Prof Wikus van Niekerk

Director: Centre for Renewable and Sustainable Energy Studies

Stellenbosch University



6 November 2008

Renewable Energy Conference



CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Outline of Presentation



- Background
- Solar Energy
 - Solar Thermal Power Plants
 - Photovoltaic Systems
- Wind Energy
- Wave Energy
 - Stellenbosch Wave Energy Converter
- Bio-Energy and Biofuels
- Challenges & Opportunities
- Future Research Highlights





Background



- White Paper on Renewable Energy 2003
 - Set target of 10 000 GWh by 2012.
 - 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 CO₂ emissions from fossil fuels.
 - Energy security through diversification of supply.
- Sustainable development.

Centre for Renewable and Sustainable Energy

Formed in 2006 to execute the contract with SANERI for:

National Postgraduate Programme in Renewable and Sustainable Energy Studies



3

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



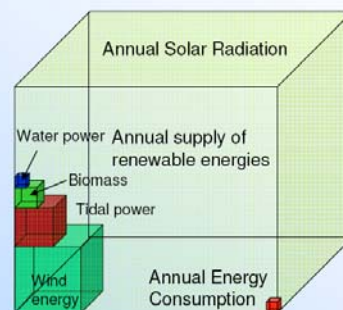
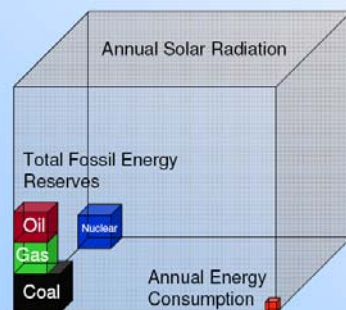
Background



Renewable Energy is energy that does not disturb the natural energy balance of the earth.

Traditional energy sources

Renewable energy sources



Source: SolMic

4

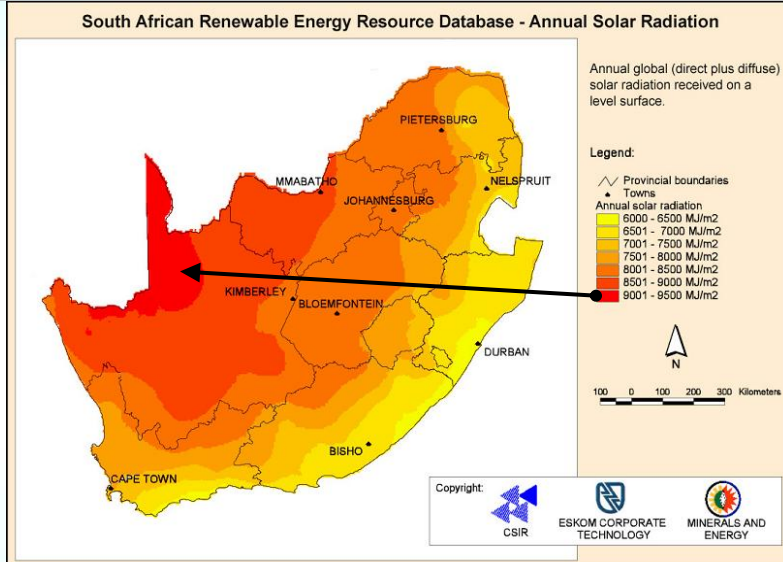
CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Solar Resource



RENEWABLE & SUSTAINABLE ENERGY STUDIES



5

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



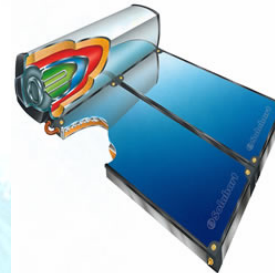
Solar Water Heaters



RENEWABLE & SUSTAINABLE ENERGY STUDIES



- Well proven and established technology.
- Technology
 - Flat plate collectors
 - Evacuated tubes
 - Thermo-siphon
- Subsidies:
 - Solar 500 project in 2007 rolled out by the CEF
 - Eskom DSM subsidy (www.eskom.co.za/dsm)
- Most obvious, cost effective system to use solar energy, we should each have one or two on our roofs.



6

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Bulk Solar Thermal Power Plants



- Solar dishes

- Solar troughs



- Solar towers

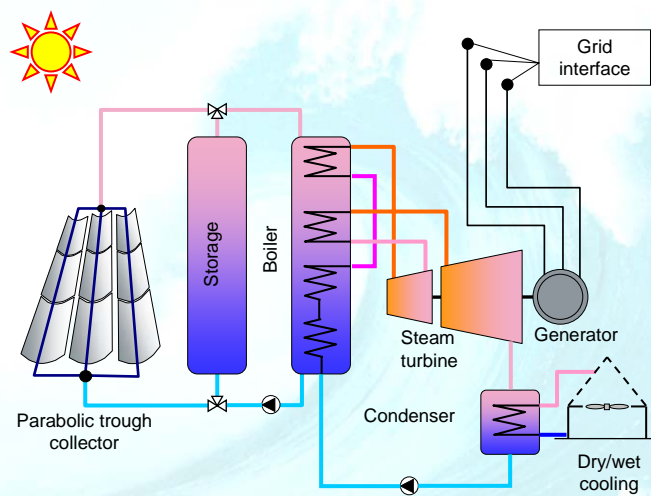
7



Concentrating Solar Power



How does it work?



8



Concentrating Solar Power



Parabolic trough

- Proven technology
 - Oldest plant in operation since 1984
 - Recent commercial plants built in Nevada (64 MW) and Spain (2x50 MW)
- Capacity per module: 30-80 MW
- Globally installed capacity: 418 MW
- Storage: 7.5 hours
- Hybridisation: Natural Gas



Nevada SolarOne - commissioned in 2007



9



Concentrating Solar Power



Fresnel reflectors

- Several prototypes have been built
- First commercial installation due in 2010
- Advantages:
 1. Direct steam generation
 2. Less wear and tear
 3. Lower cost



Source: DLR

10



Concentrating Solar Power



Solar Dish & Stirling Engine

- Capacity per module: 25 kW
- Few installations
- 500 MW installation is planned (20 000 dishes!)
- Eskom: Solar Dish at the DBSA in Midrand



Source: StirlingEnergySystems

11

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Concentrating Solar Power



Solar Tower

- Proven technology
 - First demonstration plants in the 80's.
 - Commercial plants are operating in the US and Spain.
- Capacity per module:
10-100 MW



Source: Wikipedia

12

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Concentrating Solar Power



Eskom, 100 MWe, CSP northwest of Upington

- Receiver – 540MW(t)
- Energy storage – 14 hours, Salt volume of 45,000 ton
- Plant capacity – 100MW(e), generating 24 hours over summer solstice
- Load factor – 70%
- Construction will take 3 years. Plant can be operational by 1st quarter 2012.
- Detailed technical risk assessment and mitigation studies have been conducted.

Research Focus

- Heliostat design
- Field layout & optimisation
- Receiver improvements
- Salt circuit re-design
- Resource characterisation



Source: Dr Louis van Heerden, Eskom Research and Innovation Department (Nov 2007)

13

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Solar Chimney Power Plant

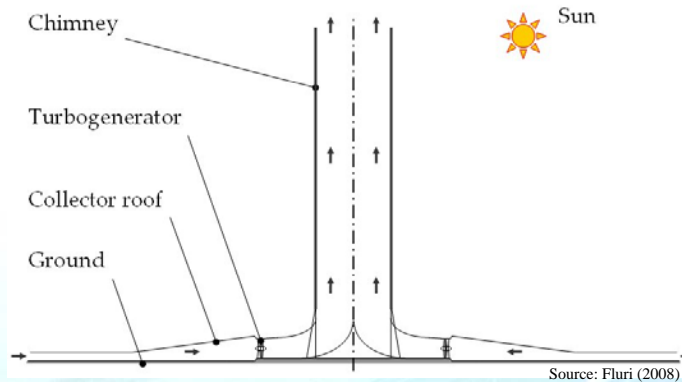
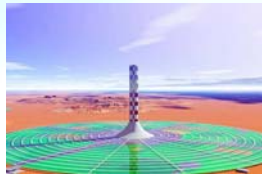


14

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Solar Chimney Power Plant



15

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Solar Chimney Power Plant



Stellenbosch Research Questions – some examples

- Impact of various parameters on plant performance
 - Double glazing and anti-reflective coating
 - Various soil properties
 - Ambient wind
 - Vegetation under the collector roof
- Heat storage
- Peak or base load operation
- Optimum plant dimensions
- Optimum number/size of turbines

Cost Predictions for 200 MWe

- 0.105 - 0.268 €/kWh
- 3200 - 10 000 €/kW

16

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Spoke on Solar Thermal Energy

- *Profs Theo von Backström and Detlev Kröger*, Stellenbosch University
- *Prof Josua Meyer*, University of Pretoria
- Comparing various solar thermal power plants in the South African context.
- Dry cooling for solar thermal power plants.
- Fundamental heat transfer relationships for heat exchangers.
- Hybrid systems, combined cycle gas turbines augmented with solar thermal and storage.
- Solar (thermal) energy storage.

National Solar Energy Research Station

17

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES




- Direct conversion of sunlight into electricity by semiconductors
- **Major challenges are cost and storage!**
- Major roll-out of PV in Europe, Germany, France and now Spain, followed by some US states, e.g. California.
- Mostly subsidised by governments using as feed-in tariff.
- Very useful in rural applications with no access to the national grid.







18




CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES




Photovoltaic Systems













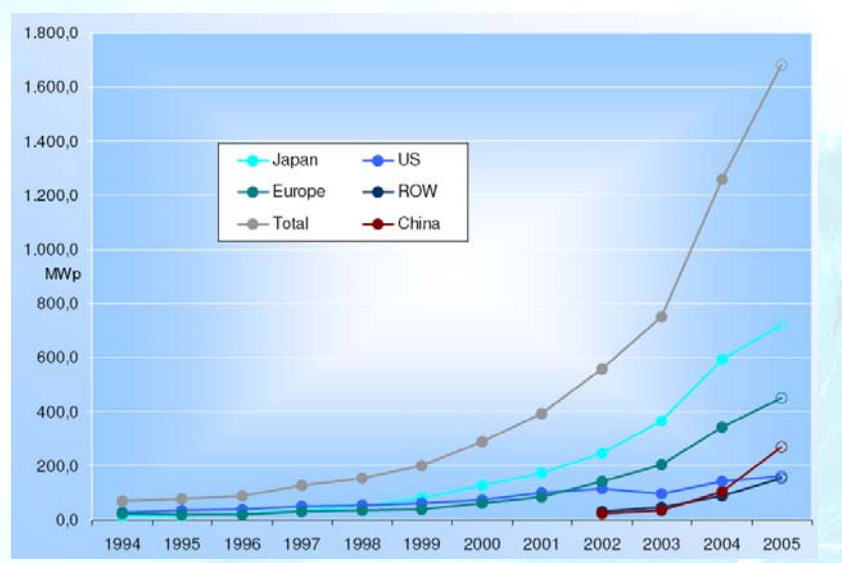
19
CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Photovoltaic Production







Year	Japan	US	Europe	ROW	China	Total
1994	~20	~10	~10	~5	~0	~45
1995	~25	~15	~15	~10	~0	~65
1996	~30	~20	~20	~15	~0	~85
1997	~40	~25	~25	~20	~0	~110
1998	~50	~30	~30	~25	~0	~135
1999	~70	~40	~40	~30	~0	~180
2000	~100	~50	~50	~40	~0	~240
2001	~150	~60	~60	~50	~0	~320
2002	~200	~70	~70	~60	~0	~400
2003	~300	~80	~80	~70	~0	~530
2004	~450	~90	~90	~80	~0	~710
2005	~600	~100	~100	~90	~0	~890

20
CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Photovoltaic Systems Research



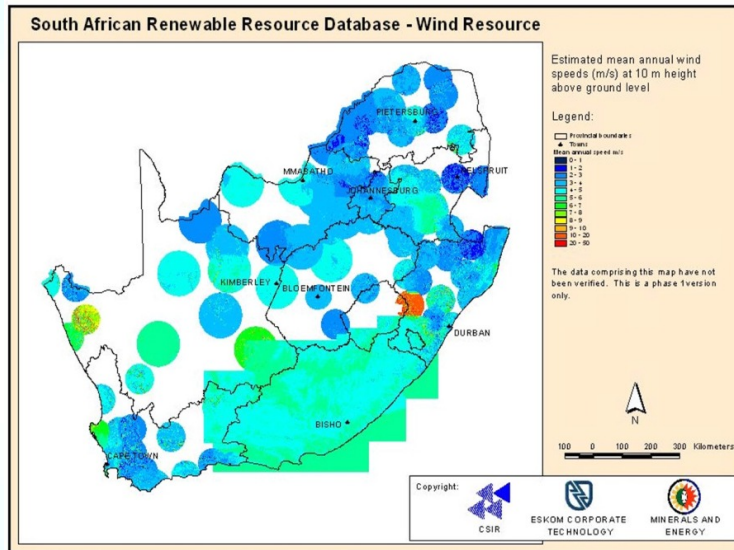
- Activities in South Africa:
 - Nelson Mandela Metropolitan University, *Dr Ernest van Dyk*, and University of Fort Hare, *Prof Edson Meyer*, working on characterisation and testing of PV cells and panels, also **Spoke on Photovoltaic Systems**. Starting work on concentrated photovoltaic systems.
 - University of Johannesburg (RAU), *Prof Vivian Alberts*, developed a new manufacturing process for CIGSS thin-film PV cells. Currently ramping up production at Johanna Solar in Germany, possible next factory in Paarl. Cost advantage 20%-50% (Current status ?)
 - University of Cape Town (UCT). *Profs David Britton* and *Margit Härting* working on thin-film poly-crystalline silicon PV cells.
 - University of Western Cape (UWC). *Prof Dirk Knoesen* researching hot-wire deposition of amorphous silicone.
 - Other activities are small and scattered, usually looking at integrating PV panels into RE systems.
 - Tenesol in Ottery manufacturing solar panels from imported Q-Cells, now also SetSolar in Epping and at least two other groups interested to establish PV manufacturing plants in SA, driver may be CDMs.

21

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Wind Energy Resource



22

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Wind Energy Resource

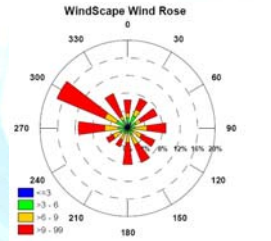
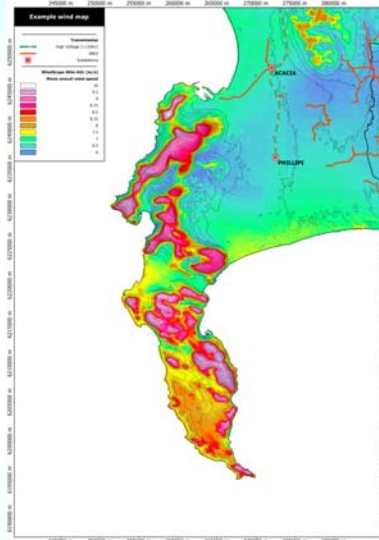


Figure 4-3. WindScape wind rose for the year 2003.

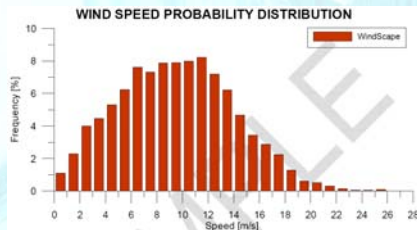


Figure 4-1. Speed probability distribution for the year 2003
Source: Windlab Systems Australia



Wind Energy in South Africa



Klipheuwel, Eskom Demonstration

- Wind turbines
 - Vesta V47 660 kW
 - Vestas V66 1 750 kW
 - Jeumont J48 750 kW
- Technical challenges
 - Eskom grid instability 2006 and again 2008
 - Cracked blade, failed bearing and motor
- Installation cost R 30m
- Capacity factor < 20%



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%





Wind Energy in South Africa

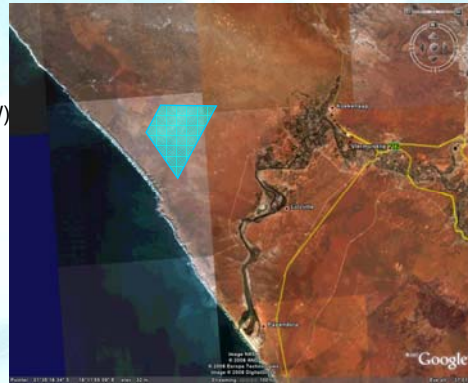


Eskom Wind Farm, Skaapvlei near Lutzville

- Up to 100 wind turbines, first phase 100 MW, second phase 100 MW
- Funded by French Development Bank
- Out on tender, again

Private Developers

- Windlab System (800 MW)
- Genesis Energy (Seeland, PE)
- Darlip (7,8 MW, 13 MW, 200 MW)
- Typical areas:
 - West Coast
 - Port Elizabeth
 - Karoo?
 - Escarpment?



25

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Wind Energy Research



Spoke on Wind Energy

- *Prof Maarten Kamper*, Stellenbosch University
- *Prof Prag Pillay and Dr Azeem Kahn*, University of Cape Town
- Working on new generation generators for wind turbines, energy storage using flywheels, integrating wind energy into local/rural grids, fault detection and condition monitoring, etc.
- Wind energy in very cold environments, Antarctica, also identified by the IEA as an area of current research.
- University of North West, composite blade technology for wind turbines.
- Smaller activities at NMMU, DUT, UL.

26

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



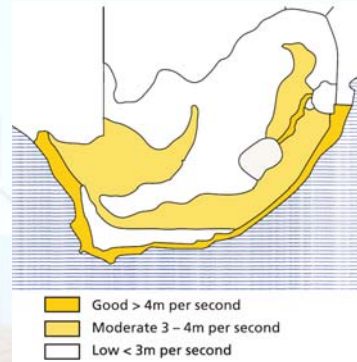
Wind Energy Research



Wind Map of South Africa

- Consortium consisting of:
 - SAWEP, South African Wind Energy Project
 - SANERI
 - Riso, National Laboratory for Sustainable Energy, Denmark
 - CSIR
 - South African Weather Services
 - University of Cape Town

Planning to use meso scale modelling and wind monitoring to develop an accurate wind atlas of South Africa.

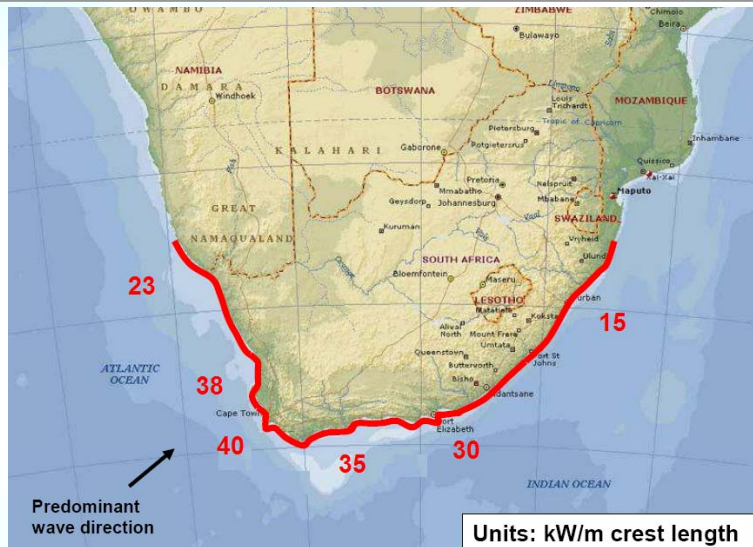


27

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Wave Energy Resource



Source: Joubert (2008)

28

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

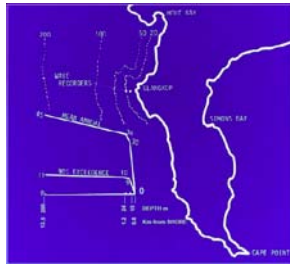


Wave Energy Resource



(Geustyn, 1983)

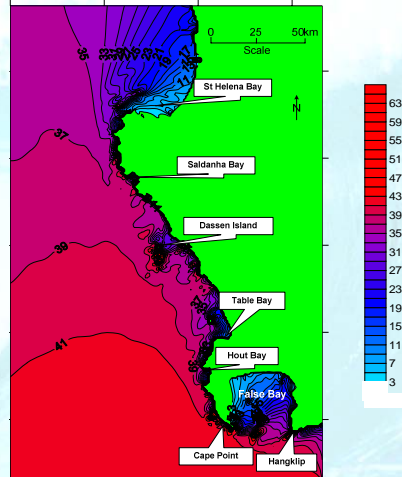
The Cape southwest coast has the best documented wave energy resource along the SA coastline.



(Joubert 2007)

Modelled the annual average wave power using hindcast wave data

Mean annual average wave power (kW/m)

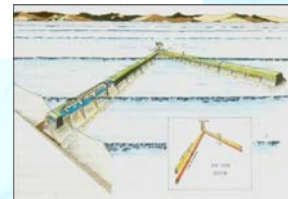
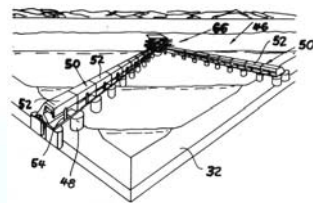


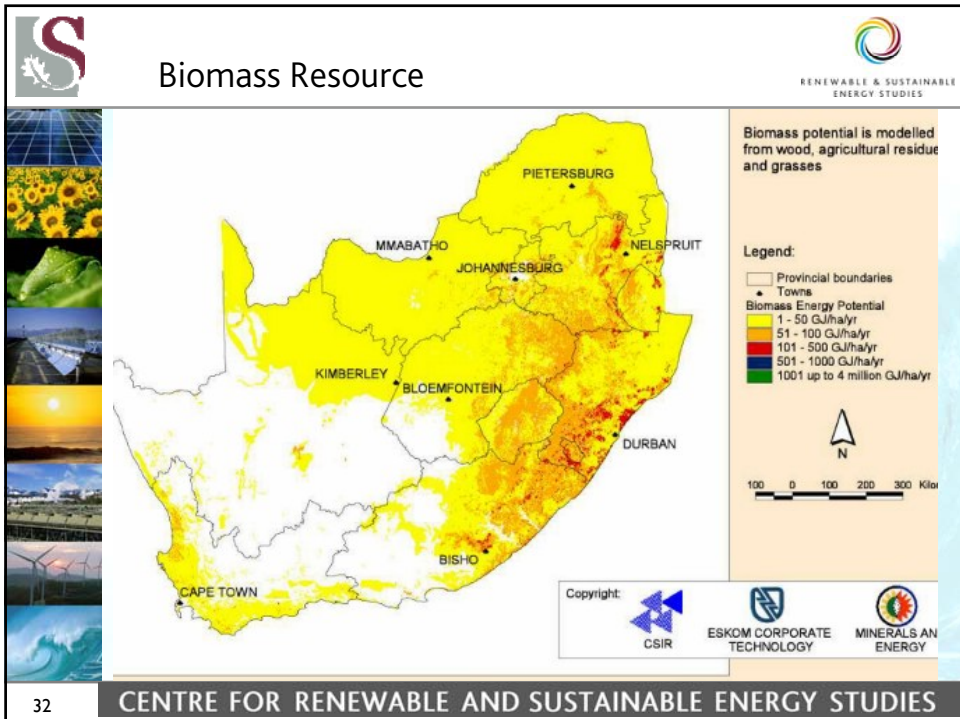
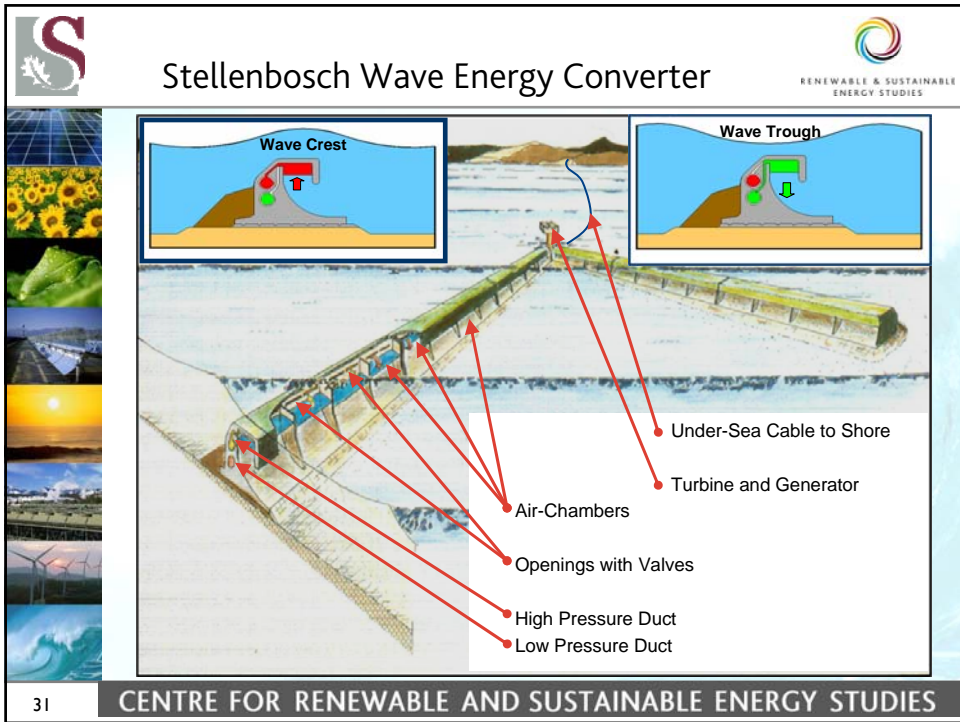
Stellenbosch Ocean Energy Research Group



Ocean Energy Research Group at Stellenbosch University

- Prof Deon Retief & Johan Müller
- Established as a response to the oil crises in the seventies.
- Funded by DeBeers, Murray & Robberts, Boart and LTA.
- Resource assessment, including tidal, OETC and tidal flows.
- Identified wave energy as the most promising resource.
- Developed the SWEC, Stellenbosch Wave Energy Converter.
- **South African Patent No 82/3976**, Prof G de F Retief, Generation of power from water waves.







Biomass



- Agricultural waste:
 - Bagasse, used in sugarcane industry to fire boilers.
 - Woodchips and cuttings from forestry operations.
 - Corn and wheat husks and stalks.
 - Manure.
- Energy crops:
 - Bio-Ethanol: Maize, corn, sugarcane, etc.
 - Bio-Diesel: Soya beans, Jithropa, palm oil, algae, etc.
 - Others: Switch grass, Triticale, etc.

BIODIVERSITY RISK

Fuel vs Food debate,

Second generation conversion processes - lignocelluloses into ethanol.



33

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Biofuels Research



Activities in South Africa:

- Stellenbosch University, *Prof Emile van Zyl (SANERI Senior CoER : Biofuels) and his team members Profs Hansie Knoetze, Harro von Blottnitz (UCT) and Drs Johann Gorgens and Marinda Bloom* will focus on the 2nd generation lignocellulose conversion technologies, which include the following activities:
 - second generation technologies for the one-step fermentation of starch to ethanol,
 - the use of lignocellulose as feedstock for biofuels production by biochemical and thermo-chemical conversion,
 - process modelling for integrating biofuels and high-value chemicals production in biorefineries, and
 - costs and life-cycle analyses to evaluate the environmental and economic impacts of these technologies .
- University of North West (UNW), *Prof Sanette Marx (SANERI Assoc. CoER : Biofuels)*, primarily focuses on the improving of 1st generation technologies, including algal biodiesel, and the adaptation of these technologies for use by particularly rural communities.
- University of Cape Town (UCT). *Prof Sue Harrison* is working on algae production in bioreactors for biodiesel and biomass production.
- University of Western Cape (UWC). *Prof Don Cowan's* team will use metagenomics in search for cellulases working at extreme temperature for efficient conversion of lignocellulose to ethanol.
- BioSciences, CSIR. *Mr. Dheepak Maharajh* initiated a project on algal production in pond systems for biodiesel production.
- Various small and scattered activities over the country, primarily looking at biodiesel production.

34

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Hydro Energy



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



35

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Others



- Bio Digesters
 - Large potential for domestic biogas production, cooking heating and electricity generation
- Ocean Energy
 - Agulhas ocean current, Eskom currently conducting measurements
 - Tidal energy is not feasible in SA
- Energy from waste
 - Incinerators, coupled to boilers
 - Landfill to gas, harvesting of methane from capped landfills and converted to electricity using a gas engine or turbine.
- Durban Landfill Projects
 - La Mercy & Marianhill landfills
 - 0,5 MW & 1,1 MW
 - CDM Projects
 - Bisasar Road 1 MW now online.



36

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Energy Challenges in SA



- **Energy security**, Eskom will not be able to supply sufficient electricity to the country in the short to medium term.
- **Carbon emissions**, with 90% of electricity generated from coal and Sasol converting coal to liquid fuel SA is one of the higher per capita emitters of CO₂ in the developing world. The key uncertainty is what will happen after the Kyoto Protocol expires in 2012.
- **Lack of direction and leadership**, the SA Government has not set out a clear path of how to achieve the renewable energy targets set in the White Paper, and those actions listed were not carried out.
- **Funding and incentives**, renewable energy receives a fraction of the energy research funding, there are no incentives for independent power producers to produce energy from renewable resources.

California Solar Initiative

- The program is funded at \$3.35 billion over 11 years.
- 10% of the program is set aside for low income homes.
- Expands the net metering cap to 2.5%, allowing approximately 500,000 new solar systems into the net metering program.
- Mandates that solar systems are a standard option for all new homeowners.
- Requires the states municipal utilities to create their own solar rebate program, totaling \$800 million in rebates.
- Directs the California State Licensing Board to review current licensing requirements for solar installers.

37

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Energy Opportunities in SA



- **RE resources**, South Africa has extensive, proven resources of renewable energy, in particular **solar energy**, wind energy, **wave energy** and biomass production.
- **Expertise**, in a number of areas South Africa has world-class research expertise and facilities to support local RE projects that, at the same time, can also make an international contribution.
- **Community awareness**, recent energy crises and blackouts made everyone aware of the risks of our current dependence on a single utility mainly generating electricity from coal. The opportunity exists to roll out RE in the current period of electricity shortage.
- **Funding**, the energy sector in SA has always been well funded, PBMR's R 5billion is an example of this. *Minister of Finance* announced a new tax on electricity generated from non-renewable sources of 2c/kWh to be implemented in 2009.



38

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Future Research Highlights



- Solar Thermal Energy
 - Conversion
 - Cooling
 - Storage
 - Demonstration plants (100 MW CSP) and,
 - National Solar Energy Research Centre
- Photovoltaic
 - Cost reduction
 - Concentrated photovoltaic systems
- Wind Energy
 - Wind map of South Africa
- Bio-Energy
 - Second generation conversion technologies of lignocelluloses
 - Reliable source for bio-diesel
- Wave Energy
 - Reliable wave energy converters
 - Environmental impacts and approval processes

39

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Acknowledgements



- Prof Emile van Zyl
- Prof Ryno Swanepoel
- Dr Louis van Heerden
- Dr Tom Fluri
- Saliem Fakir
- James Joubert

40

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES



Contact Details



S UNIVERSITEIT-STELLENBOSCH-UNIVERSITY
jou kennisennoot-jour knowledge partner

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

About Us	Studies	Projects	Links	News Flash
History	Postgraduate Programmes	Biofuels	Sponsors	Short Courses
People	Course Modules	Solar	Companies	Forums
Partners	Research Topics	Wave	Societies	Press Releases
Contact Us	Application Procedures	Wind	Public Sector	
	Bursaries	Other		

<http://www.sun.ac.za/crses/>

wikus@sun.ac.za