Research on Wind Energy

4th Biennial Conference

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CSIR's low wind speed turbine

- Based on its aerospace capabilities, CSIR demonstrated in 1986 on its Pretoria campus that a worthwhile amount of energy can be extracted from the wind in regions with very low average wind speeds.
- Generated a maximum output of 2kW at approx 8m/s
- Research recommended that three basic models be developed for the moderate to poor wind flow regimes in SA

CSIR's autogyro

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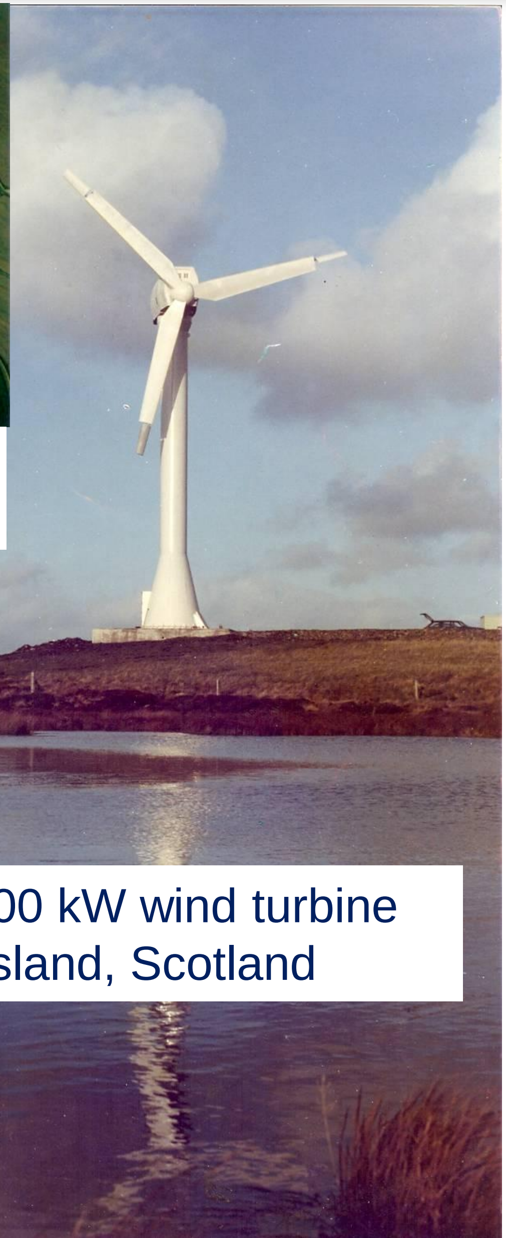
Large wind turbines

Ovid: composite man-rated trainer airplane



Howden's 300 kW wind turbine on Orkney Island, Scotland

- Further CSIR's aerospace technology demonstrators formed basis to investigate wind turbines
- CSIR was offered Howdens 300 & 750 kW turbines on Orkney & Shetland Islands.
- Undertook wind energy study tour to UK
- Too expensive to transfer to SA
- Howdens offered CSIR blade IP based on wood laminate technology. Offer not taken up.
- IP & further developments now owned by Vestas
- CSIR: exposure to large wind turbines & underlying technologies

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Eskom's wind farm, Klipheuwel, Cape Town

- CSIR, then DME & City of Cape Town undertook study on large grid connected wind turbines – included a study tour to Europe.
- Recommended that a demonstration scheme be established near Cape Town
- CSIR developed concept to the point where next step was implementation
- Eskom implemented scheme as a research project to gain understanding in developing & operating wind farms.
- CSIR did EIA for Klipheuwel wind energy scheme

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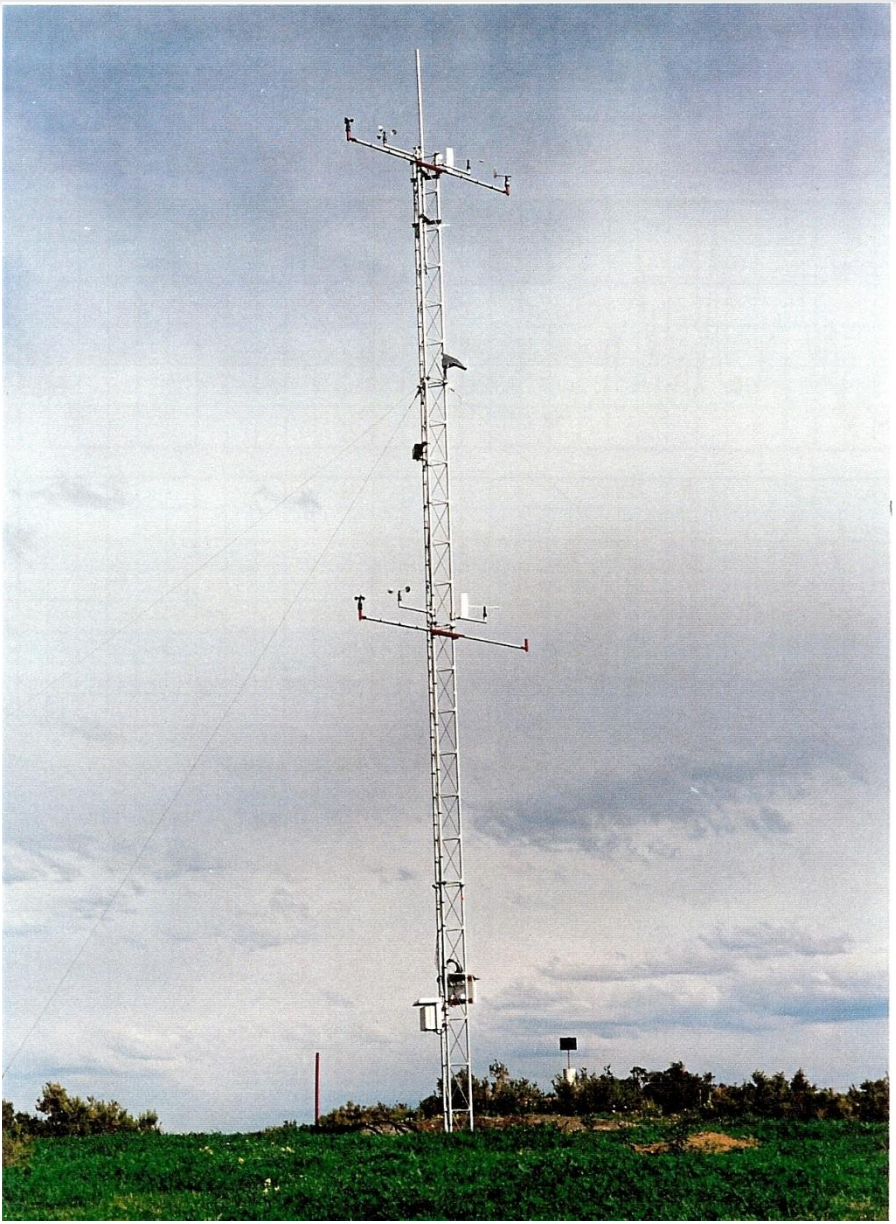
Darling wind farm



- CSIR invested funding for initial wind measurements on 10 metre mast.
- Good quality data resulted in Danida funding CSIR to do comprehensive wind measurements
- Initial investment resulted in CSIR participating in current Wind Atlas for South Africa (WASA) project

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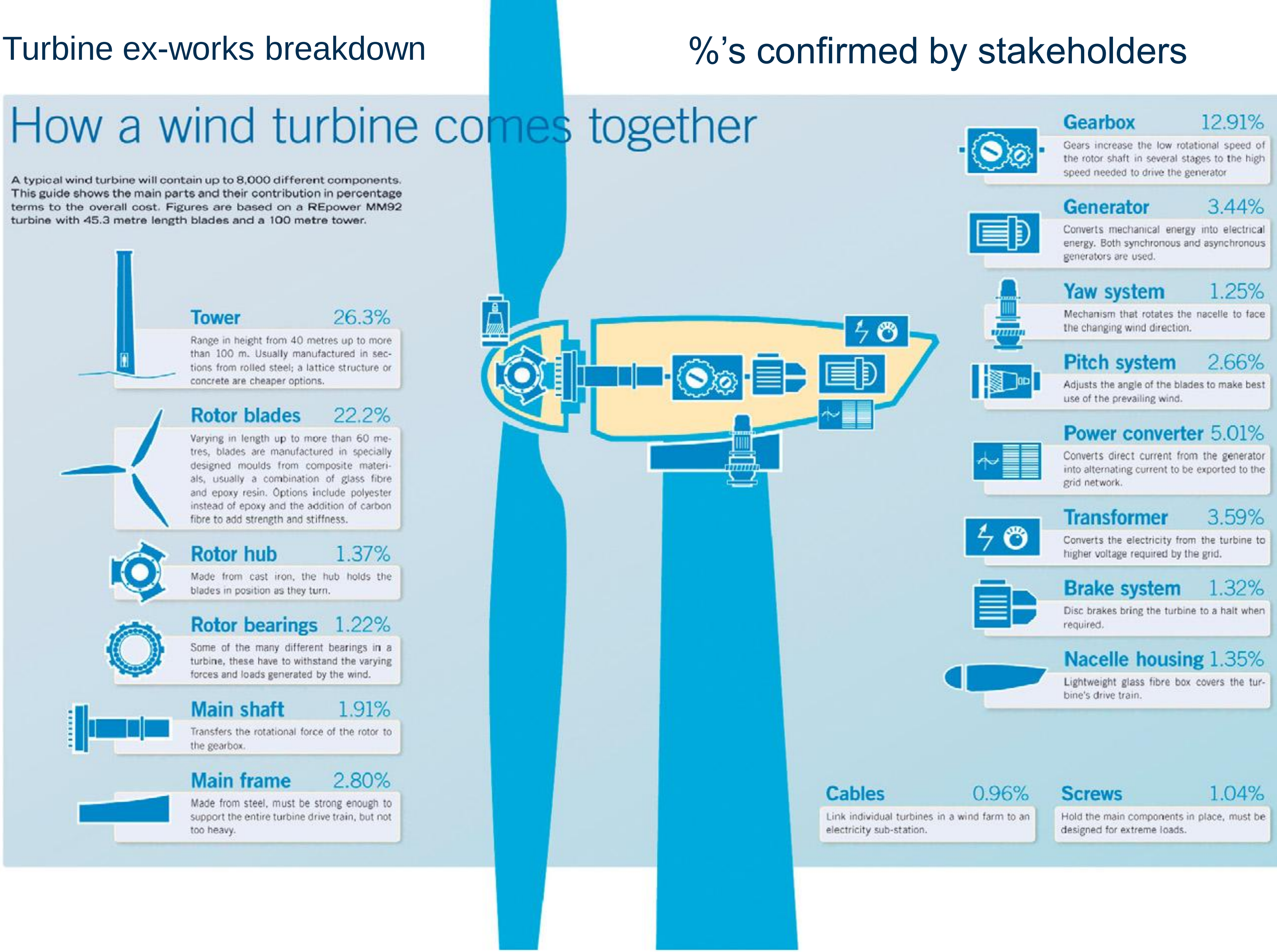
Wind energy industrial strategy for South Africa

South African Wind Energy Programme (SAWEP) - two key strategic outputs aimed at guiding wind energy development in SA:

- Wind Atlas for South Africa (WASA) – First verified wind atlas launched by Deputy Minister of Energy on 13 March 2012
- Investigation into a Wind Energy Industrial Strategy for SA - outputs of which will help determine the possibility of establishing a wind industry in South Africa.
- CSIR & Risø DTU (now DTU Wind Energy) undertook this investigation:
  - Final report has 3 parts
    - Part 1: Global Wind-energy Market and Industry;
    - Part 2: South African Wind-energy Market and Industry; and
    - Part 3: Strategic analysis
- This presentation is based on Part 3: Strategic analysis with emphasis on RD&D portion of strategy

Turbine ex-works breakdown

%’s confirmed by stakeholders



Source: Wind Directions, January/February 2007.

Brief overview of international R&D strategies

- **The International Energy Agency (IEA) published a global technology roadmap for wind energy - primary tasks are:**
  - Wind technology development
  - Delivery and systems integration
  - Policy frameworks
  - International collaboration

- **European wind energy sector launched the European Wind Energy Technology Platform (TPWind). The Strategic Research Agenda (SRA) of TPWind is divided into five thematic priorities for research:**
  - Wind resources, design wind conditions and forecasting
  - Wind turbine technology
  - Wind energy integration
  - Offshore deployment and operation
  - European research infrastructures

Global Research & Development trends

- **Mainly *incremental* technology advances to improve cost effectiveness (except offshore floating)**

- **Key research areas**
  - **Large turbine development:** improved reliability; better understanding of aerodynamics; innovative concepts and integrated design; improved design codes; improved gearbox design; gearless design; improved blade design; mechanical structures and new materials
  - **Offshore** wind in shallow (bottom mounted) and in deep waters (floating structures)
  - **Power system operation and grid integration**: wind power plant capabilities (providing ancillary services, wind farm control); grid planning and operation; energy and power management.
  - **Wind farm optimisation**
  - **Wind conditions**: complex terrain; offshore meteorology; wakes; extreme wind speeds; wind profiles at high heights; short-term predictions

Innovation & preliminary wind energy technology tree

- South African Industry's propensity to innovate is in the same league as their counterparts in Europe. To state this differently, South African Industry has a can-do attitude and mind-set
- Industry has experience in manufacturing components to exacting specifications, integrating complex systems and this being done with efficient use of resources.
- Industry is very much aware of the need to be globally competitive by reducing costs and maintaining, if not increasing, on quality.
- A preliminary macro-environment (big picture) analysis was done of the South African innovation community
- A preliminary technology tree was developed and recommended that a South African Wind Energy Technology Platform be established in support of a wind energy industrial strategy

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Preliminary technology tree

Needs	**Innovative wind turbine system designs**	**Local manufacture of components**		**Job creation**		**Energy security**
Key Solutions	•Wind resource assessment and maps •Advanced designs for next generation wind turbines •Advanced materials selection and development •Advanced and cost effective manufacturing techniques			•High quality manufactured components •Certification and testing procedures •Advanced techniques for wind turbine/grid integration •Human capacity development		
Platform	**South African Wind Energy Technology Platform**					
Applied technology	Life cycle evaluation and prediction	Component design and manufacturing	Wind farm design optimisation	Condition monitoring & fault prediction	Policy development & decision support	
Base technology	•Constitutive equations •Materials characterisation •Aero-elasticity methodologies •Numerical failure identification methods •Non-destructive evaluation	•Database of new materials •New design standards •Power electronics •Manufacturing processes •Quality assurance	•Increased accuracy of wind resource database •Wind turbine emulation system •Extreme wind condition evaluation techniques •Complex terrain & offshore evaluation techniques	•Monitoring & evaluation •Supervisory Control & Data Acquisition (SCADA) systems •Smart grid technologies	•Data and information evaluation techniques	
Infrastructure	•Wind measurement equipment •Computational fluid dynamics •Finite element methods •Dedicated wind tunnels •Blade test facilities •Generator test facilities •Drive train test facilities			•Natural resource databases •Geographic Information Systems •Quantitative methods •Science and Engineering know-how •Supply chain linkages •Indigenous knowledge		

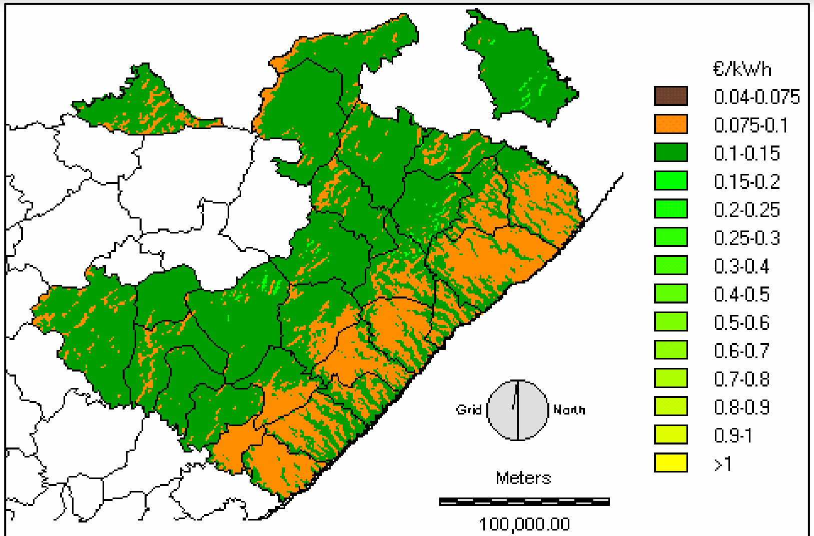
Further details & table available on poster: "South Africa – a new innovator and manufacturer of wind turbines?"

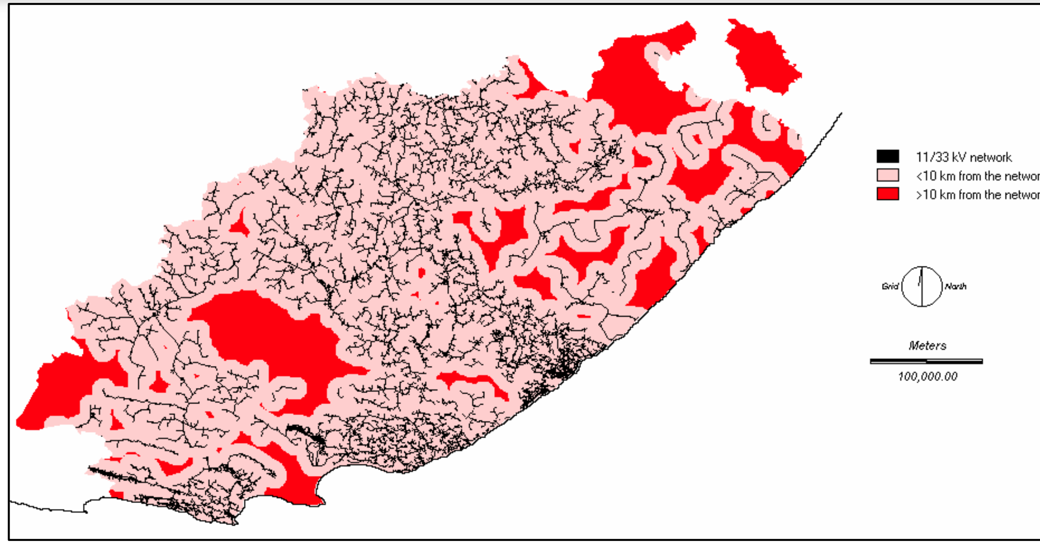
Smart sustainable wind energy based systems to complement South Africa's electrification programme

Renewable Energy for Rural Electrification in E Cape

- 3 year multinational EU (Garrad Hassan of UK, Netherlands Energy Research Foundation) - CSIR investigative project
- Objective: identify rural electrification opportunities using renewable energies linked to existing & new economic activities
- Renewable energy resources investigated: wind, mini-hydro & biomass
- Geographic Information Systems (GIS) to present & interpret results
- Large part of project was wind resource assessment of the E Cape Province
- WAsP numerical model was used for wind resource assessment
- **Output**: identified implementable projects – emphasis on objective technological evaluations

Modelling & Simulation Example using GIS



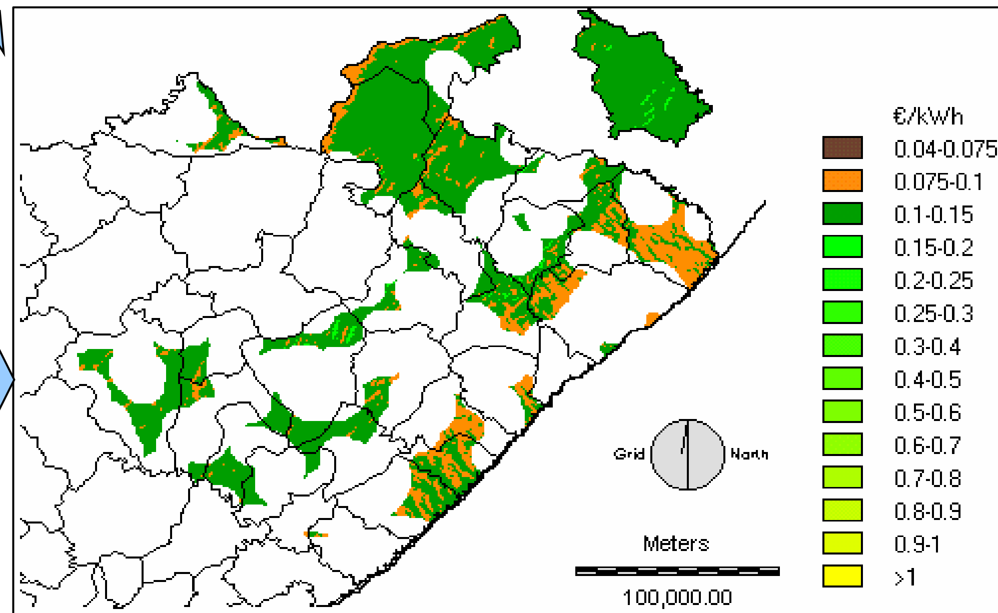


Cost of wind generated electricity

Distribution grid with, as an example, 10kms either side blanked off

Overlaying above two maps identify possible areas where wind generated electricity may be cheaper than grid extension

1st verified wind atlas – opportunity to develop an accurate model



Impact of Eastern Cape Project

- Obtained first hand understanding of complexity of poverty alleviation – technical & non-technical (water-energy-food-employment nexus)
- Developed Integrated Energy/Economic Framework – framework for sustainable socio-economic development for rural areas
- Identified renewable energy projects at Hluleka Nature Reserve & Lucingweni village on Wild Coast

Hybrid mini-grids: Hluleka & Lucingweni

- With Cabinet endorsement, then Minister of Minerals & Energy mandated the NER (now NERSA) to facilitate piloting hybrid mini-grids
- Experience & understanding gained to inform decision & policy makers
- NER contracted CSIR to develop implementation plan
- Implementation partner – Shell Renewables
- Integrated Energy/Economic Framework applied
- Mini-grids integrated with providing potable water
- Energy & water efficiency concepts applied
- CSIR: first-hand exposure to small wind turbines and integration of a range of related technologies – action research

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Hybrid mini-grid energy systems

Hluleka Nature Reserve

Lucingweni village

Impact of Eastern Cape project

Department of Science & Technology – mini-grids were used as a case study on "Technology Transfer for Poverty Alleviation"

CSIR lessons learnt applied to

- updating Integrated Energy/Economic Methodology
- identifying shortcomings in then wind data resource map
- understanding the non-technical issues in sustainable projects
- deeper understanding on smart sustainable energy resulting in:
  - investigations into conversion of organic waste into energy (anaerobic digestion)
  - project: "Modular form of Electrification in Rural Communities in South Africa"
  - Global Research Alliance (GRA) initiative on "Smart Sustainable Energy for the Rural Poor"

Modular form of electrification in rural communities

Project funded by the Royal Danish Embassy in Pretoria and carried out by:

- eThekwini (Durban) Municipality
- Risø DTU (Danish National Laboratory for Sustainable Energy)
- South African National Energy Research Institute (SANERI)
- CSIR
- University of the Witwatersrand
- North West University

Project aim:

Investigate the suitability of modular smart-grid approach for electrification of rural communities, with particular emphasis on the needs of the eThekwini Municipality

Brief review of modular form of electrification

Recommendations for a demonstration project:

- Potential of modular approach confirmed and should be refined through further modelling and simulation work.
- Establish a research facility so that technologies can be refined and evaluated in a controlled environment prior to implementation in the field.
- Human capacity development

Strategic recommendations:

1. Develop a Roadmap for SA on Smart Grid Technologies
2. Develop a Renewable Energy Technology Integration Platform
3. In DTI's Industrial Policy & Action Plan (IPAP), under green industries, localisation strategies be developed to include smart grid/modular forms of electrification
4. Align outcomes of projects to support the National Development Plan and other policies

GRA: Smart Sustainable Energy for the Rural Poor

Smart Sustainable Energy will deliver impact through three co-creative streams: **Social Innovation**, **Ecosystem Innovation**, **Technical Innovation**:

- leading to solutions that will seamlessly integrate with the electrical grid.

Successful inclusive innovations for the Base-of-the-Pyramid (BoP) have to be :

- **Affordable**, **Acceptable**, **Appropriate**, **Accessible**.

At a functional level, amongst others, the GRA team has aligned with the Eastern Cape Provincial Government and its Sustainable Energy Strategy, District Municipalities

A project design document has been developed for investors & stakeholders

Broad phases: modelling & simulation, real-world trialling of developed innovations, development of modular solutions suitable for commercialisation and deployment

Thank you

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