The Journey in Developing a Low Carbon Economy for South Africa

Presenter: Rebecca Maserumule (PhD)
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Policy Context

National Development Plan

- Industrial Policy Action Plan

- White Paper on Science and Technology
- National Research and Development Strategy
- Ten Year Innovation Plan
- Energy Grand Challenge

- Enabling Environment

- Innovation Policy

- Energy Policy

- National Energy Act
- Household Electrification Strategy
- Integrated Resource Plan

- Climate Change Policy

- National Climate Change Response White Paper
- Paris Agreement
Guiding Frameworks

- National Development Plan
  - Investments in *energy infrastructure*
  - Affordable *tariffs* for needy households
  - *Diversify* energy resources and supply options
- National Climate Change Response Strategy
  - Long Term Mitigation Scenarios (Peak, Plateau and Decline)
- Industrial Policy Action Plan
  - Re-industrialisation
  - Support for local beneficiation of SA resource base
  - Local manufacturing.
- National Energy Act (IEP and IRP)
  - Universal access to *modern forms* of energy services
  - Energy security through guaranteed supply
  - Optimal usage of economically *viable energy resources*
  - Addressing constraints on the development of the renewable industry.
SA has ratified the Paris (COP21) Agreement

National Climate Change Response White Paper (2011) identified Near Term Climate Change Flagship Programmes:

- The Climate Change Response Public Works Flagship Programme
- The Water Conservation and Demand Management (WCWDM) Flagship Programme
- The Renewable Energy (RE) Flagship Programme (Solar, Biofuels, Wind etc.)
- The Energy Efficiency and Energy Demand Management (EEEDM) Flagship Programme
- The Transport Flagship Programme (EV Roadmap)
- The Waste Management Flagship Programme
- The Carbon Capture and Sequestration (CCS) Flagship Programme
- The Adaptation Research Flagship Programme
- National Hydrogen and Fuel Cells Research, Development and Innovation (HySA) Flagship Programme
Decarbonisation of the Energy and Transport Sectors is critical for SA’s transition to a low carbon economy. In this regard:

- Renewable Energy is now an integral part of SA’s Energy mix
- Hydrogen and fuel cell technology is recognised as a technology with the potential to decarbonise the energy and transport sectors
- Battery electric vehicles are being introduced into the SA transport system
- A green transport strategy is under development.
Department of Science and Technology (DST)

- Vision
  - Increased well-being and prosperity through science, technology and innovation.

- Mission
  - To provide leadership, an enabling environment, and resources for science, technology and innovation in support of South Africa’s development.

In support of Government Policy, the DST supports a number of Research, Development and Innovation (RDI) Initiatives implemented through Universities and Science Councils.
Global consensus on the contribution of R&D to cost reduction

Source: SunShot Vision Study, February 2012. US DOE
The race is on for safe, clean, affordable and reliable energy supply and South Africa must meet its medium – term energy supply requirements while innovating for the long term in clean coal technologies, nuclear energy, renewable energy and the promise of a hydrogen economy.

Progress towards a knowledge – based economy will be driven by four elements:
- Increased knowledge generation and exploitation
- Human capital development
- Knowledge infrastructure
- Enablers to address the “innovation chasm” between research results and socioeconomic outcomes

Flagship Programmes
- Hydrogen South Africa
- Renewable Energy Hub and Spokes
- Energy Storage Research Development and Innovation Initiative
- Advanced Biofuels Programme
- Centre for Energy Systems Analysis and Research
- Energy Efficiency and Demand Side Management Hub
SA Solar Technologies Overview

- **IRP’s 42% / 17.8 GW RE Goal by 2030** - Since 2011, when the government of South Africa promulgated the “Integrated Resource Plan” (IRP 2010) with the goal of achieving 42% of newly added electricity generation from renewable energy source by 2030 (17.8GW), an intense development and deployment pipeline has been set in motion within the country.

- **IRP’s 8400 MW PV and 1200 MW CSP Goal** - Under the IRP 2010, the Department of Energy (DOE) committed to installing 8400MW of PV and 1200 MW of CSP, of which 17.7% and 33% has already been allocated respectively through 2013.

**Table 1: PV and CSP Targets and Current Project Allocation**

<table>
<thead>
<tr>
<th>IRP Target (MW)</th>
<th>Already Allocated (MW)</th>
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<tbody>
<tr>
<td>PV 8400</td>
<td>1483.9 (17.7%)</td>
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<tr>
<td>CSP 1000</td>
<td>400 (33.0%)</td>
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Solar energy research - RDI clusters

Policy and Strategic Planning
- Impact Assessment
- Techno-Economic Assessment
- Geo-Spatial Assessment

Systems Integration
- Distributed Generation
- Solar Resource Assessment
- Systems Modelling

Solar thermal
- Optical
- Thermal
- Cooling
- Electrical
- Storage

Solar PV
- Materials / Cells
- Module & system performance
- Electronics
- Storage

Local Manufacturing
- Value Chain Assessment
- Test facilities
- Localization
- Demo/Pilot
- Applications
Research Institutions

- SANEDI
- University of Fort Hare (PV spoke)
- Nelson Mandela Metropolitan University (PV spoke)
- University of Stellenbosch (CSP spoke)
- University of Pretoria (CSP spoke)
- University of North West (HTA)
- University of Johannesburg (PV)
- Council for Scientific and Industrial Research (PV, HTA)
- South African Weather Services (Resource assessment/atlas)
### DST in support of broader government objectives

<table>
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<tr>
<th>Government Objectives on solar energy</th>
<th>Solar RDI Thematic Areas</th>
<th>Proposed Interventions</th>
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<tbody>
<tr>
<td><strong>Objective 1: Ensure the Security of Supply</strong></td>
<td>Strategic planning</td>
<td>Impact and sustainability assessment</td>
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<tr>
<td></td>
<td>System integration</td>
<td>Techno-economic assessment</td>
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<td></td>
<td></td>
<td>Distributed generation</td>
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<tr>
<td><strong>Objective 2: Minimize the Cost of Energy</strong></td>
<td>Solar thermal</td>
<td>Solar thermal (system analysis, optical, thermal, cooling, electrical)</td>
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<tr>
<td></td>
<td>Solar PV</td>
<td>Solar PV (PV materials &amp; cells, PV module &amp; system performance, inverters, balance of system)</td>
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<tr>
<td><strong>Objective 3: Increase Access to Energy</strong></td>
<td>System integration</td>
<td>Distributed generation</td>
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<td></td>
<td></td>
<td>Solar resource assessment</td>
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<td></td>
<td></td>
<td>Modelling</td>
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<tr>
<td><strong>Objective 4: Diversify Supply Sources and Primary Sources of Energy</strong></td>
<td>System integration</td>
<td>Solar resource assessment</td>
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<tr>
<td></td>
<td>Strategic planning</td>
<td>Integrated energy systems</td>
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<td></td>
<td></td>
<td>Techno-economic assessment</td>
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<tr>
<td><strong>Objective 5: Minimize Emissions from the Energy Sector</strong></td>
<td>Industry stimulation</td>
<td>Market application</td>
</tr>
<tr>
<td></td>
<td>Strategic planning</td>
<td>Impact and sustainability assessment</td>
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<tr>
<td><strong>Objective 6: Promote Localisation, Technology Transfer and Job Creation</strong></td>
<td>Industry stimulation</td>
<td>Value chain assessment</td>
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<tr>
<td></td>
<td></td>
<td>Commercialization/Localization</td>
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<td></td>
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<td>Market application</td>
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# Solar Thermal: CSP Systems Design and Optimisation

### Solar thermal

| ST | Systems Analysis (Plant level) | Build and operate a world-class test facility for CSP technologies  
Optimisation of conventional CSP systems  
Investigate efficient hybridisation (retrofitting, boosting, new build) |
| ST2 | Optical Reflector | Strengthen simulation capability (numerical and optimisation ...)  
Design and develop the next generation reflectors in collaboration with selected world leaders |
| ST3 | Thermal Receiver - HTF - TES | Simulation capability investment  
Develop selective coatings for receiver surfaces  
Explore the use of locally available materials for HTF and TES that are appropriate for South Africa |
| ST4 | Cooling | Test facilities for pilots and prototypes for dry and hybrid cooling  
Designs, methods, techniques and technologies for management of water consumption through reduction, remediation, elimination and creation |
| ST5 | Electrical Power Block | Investigate non-Rankine (gas) power systems for improved efficiency and lower water consumption (no intent to do power plant development) |
Technology Status and prospects

Existing 1\textsuperscript{st} and 2\textsuperscript{nd} PV generation $\rightarrow$ 3\textsuperscript{rd} PV generation and advance concepts

- I - Crystalline silicon technologies: single crystalline, multi-crystalline, ribbon
- II - Thin-film technologies: cadmium-telluride, copper-iodium/gallium-, diselenide/disulphide and related II-VI compounds, thin-film silicon
- III - Emerging technologies and novel concepts
- IV - Concentrating photovoltaics

Quantum wells, up-down converters, intermediate band gaps, plasmonics, thermo-photovoltaics, etc

## Solar PV: Late generation PV & optimisation of device structures

<table>
<thead>
<tr>
<th>SPV1</th>
<th>PV materials &amp; cell</th>
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<tbody>
<tr>
<td></td>
<td>▶ Use of nano-crystalline materials to improve the spectral absorption and stability</td>
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<tr>
<td></td>
<td>▶ Material performance and substitution</td>
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<tr>
<td></td>
<td>▶ Incorporation of nano-structured materials into AR coatings, prepared by cheaper deposition alternatives</td>
</tr>
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<td></td>
<td>▶ Cell performance and device engineering</td>
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<tr>
<th>SPV2</th>
<th>Module &amp; system performance</th>
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<tbody>
<tr>
<td></td>
<td>▶ Investigate reliability and long-term degradation mechanism</td>
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<tr>
<td></td>
<td>▶ Improved and alternative cell and module production methods, techniques and technologies</td>
</tr>
<tr>
<td></td>
<td>▶ Validate the technology</td>
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<tr>
<td></td>
<td>▶ Establish reliability of prototypes</td>
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<tr>
<td></td>
<td>▶ Develop industry product and rating standards</td>
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<tr>
<th>SPV3</th>
<th>Inverters</th>
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<tr>
<td></td>
<td>▶ Develop optimized inverter for CPV systems</td>
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<tr>
<th>SPV4</th>
<th>PV systems integration</th>
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<tbody>
<tr>
<td></td>
<td>▶ Develop reliable, long-term, stable and low cost optical component</td>
</tr>
<tr>
<td></td>
<td>▶ Improve tracker design and tracking accuracy</td>
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PTIP HISTORY

- Established Research Laboratories
- Fabricated > 10% Devices (1cm²)
- 1993

- Filed International Patents
- Incorporated PTIP
- 1995

- Constructed Pilot Facility at UJ
- Fabricated > 10% Modules (1500cm²) and 16% Devices
- 2002

- International License Awarded to Bosch for local manufacturing in Germany
- 2003

- Transfered R&D Labs to TechnoPark
- Singulus Partnership
- 2004

- Commissioned Production Line TechnoPark (7200cm²)
- 2005

- IDC Shareholding
- TIA Funding
- 2007

- 2010

- 2012

- 2013
• About 30 measuring stations operational and operated by SAWS & Universities

• DST funded 13 stations through SAWS in support of national capability development.
Hydrogen South Africa (HySA) Strategic Goals

Background
• Advanced Battery Programme supported by DST since 2011
• Broader Energy Storage RDI Roadmap presented to EXCO in 2015.

Strategic Goals
• Develop high quality precursor materials for lithium ion batteries based on SA manganese resources
• Develop local skills to beneficiate manganese for the energy storage and electric vehicle markets
• Promote equity and inclusion in the economic benefits of South Africa’s resources
• Human Capital Development in line with DST’s broader HCD Strategy.
Mn Precursor Value Proposition

ES RDI Strategy
• Develop high quality precursor materials for lithium ion batteries based on SA manganese resources
• Develop local skills to beneficiate manganese for the energy storage and electric vehicle markets
• Promote equity and inclusion in the economic benefits of South Africa’s resources
• Human Capital Development in line with DST’s broader HCD Strategy

Global Mn Resource Distribution

- Australia: 25%
- Brazil: 17%
- China: 9%
- Gabon: 8%
- India: 4%
- Kazakhstan: 1%
- Mexico: 1%
- South Africa: 26%
- Ukraine: 1%
- Other: 9%

South Africa possesses significant amounts of high grade Mn reserves

Export

- $100/tonne
- $2000/tonne
- $10 000/tonne

Beneficiation Value Chain

- Mn ore
- LMO
- NMC
  - 622 - several
  - 352 - ANL
  - 271 - BASF
Existing and Potential Collaboration in ES RDI

- **Battery Applications**
  - Renewable/solar wind grid
  - Niche mobile

- **Precursor Development**
  - From Mineral Ores

- **Materials Synthesis**
  - Cathodes, Anodes, Electrolytes

- **Materials Characterisation**
  - Microscopy, Spectroscopy, Diffraction, Modelling

- **Electrode Fabrication**
  - Electrode Engineering

- **Electrode Electrochemistry**
  - Capacity, Voltage Impedance

- **Diagnostics and Modelling**
  - Cell Disassembly and Examination

- **Cell and Pack Engineering**
  - Battery Design and Analysis

- **Life and Safety Testing**
  - Long Term Cycling/Aging, Thermal Abuse

Collaborators:
- UL, CSIR, UWC, UL
- NMMU, CSIR, UL
- Mintek
- CSIR, UL
- UWC, UL
- NMMU, Collaborators
Battery Electric Vehicles: uYilo Facilities
Advanced Biofuels

• Support the Biofuels Industrial Strategy 2007 by developing the national technical capability (bio-fuel technology development), capacity (HCD) and facilitate commercialization through demonstrations.

• Research Chairs Programme
  • University of Stellenbosch: Lignocellulose bio-fuels
    • Development of micro-organisms (enzymes and yeast) that breakdown lignin in order to unlock convertible sugars to bio-fuels
  • North-West University: Conventional bio-fuels
    • Efficiency improvements of conventional technologies and
    • Localization and customization of bio-fuels technologies
Advanced Biofuels

• Bio-fuels Technology Demonstration Programme
  • Funding support for development and demonstration of late generation bio-fuels (non food crops)

<table>
<thead>
<tr>
<th>Focal Area</th>
<th>Objective</th>
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<tr>
<td>Coalgae</td>
<td><strong>Eliminate blending infrastructure</strong> - combining of coal discards with algae to form bio-blended fuel sources (currently @ 15% algae).</td>
</tr>
<tr>
<td>Bio-crude oil</td>
<td><strong>Produce crude oil from renewable sources</strong> - through pyrolysis producing bio-crude oil from algae at laboratory scale.</td>
</tr>
<tr>
<td>Coalgae gasification</td>
<td><strong>Leveraging existing refineries</strong> – use of cleaner coal in the existing coal/gas to liquid process</td>
</tr>
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Advanced Biofuels – Coalgae Facilities

Photo bioreactors – growing micro algae

Coalgae product – mix of coal fines with algae
Cabinet approval of the HySA Strategy in 2007 with the goal of achieving outcome in 2020

Establishment of 3 Centres of Competence (CoCs) with relevant infrastructure and technical capacity

Catalysts and other PGM based components have been developed that will contribute towards the 25% target

Development of technology and a local supply chain in hydrogen and fuel cells through strategic partnerships is ongoing

South Africa sees the potential of using hydrogen and fuel cells in both stationary and transport sectors, in line with global developments.
HySA VALUE PROPOSITION

**BENEFICIATION VALUE CHAIN**

- **STACK**
- **MEA**
- **CATALYST**
- **PGM**

**HySA Strategy**

- Wealth creation through value added manufacturing of PGM catalysis with a goal of supplying 25% of PGM catalysts demand by 2020
- Promote equity and inclusion in the economic benefits of South Africa’s resources
- Develop local cost competitive hydrogen generation solutions based on renewable resources

**World Platinum Reserves**

- Zimbabwe
- Finland
- Russia
- North America
- South Africa

- South Africa possesses 75% of global Pt reserves

**Export**

- $1090/ounce
- $2170/ounce
- $9500/ounce
- $14400/ounce

**Zimbabwe**

**Finland**

**Russia**

**North America**

**South Africa**
HySA Implementation Phases

2008 - 2013
- Recruit mission-critical staff
- Identify initial markets
- Develop first-pre commercial technologies

2014 - 2018
- Establish critical supply chain capability
- Deliver first products to market
- Demonstrate capabilities in pilot markets

2019 - 2023
- Contribute to international innovation
- Compete successfully on world market
- Capture 25% of global catalysis value chain in hydrogen and fuel cells
• Renewable hydrogen production, storage and distribution
• Electrolysers and hydrogen compression systems

• Hydrogen catalysis
• Portable power systems
• Fuel processors, catalysts and MEAs

• Systems integration and technology validation
• Combined heat and power
• Hydrogen fuelled niche vehicles
Public Private Partnerships (PPPs)

UWC Nature Reserve

- Fuel cells in office buildings
  - Fuel cell providing power for lighting
  - Reduction in use of grid electricity and carbon footprint

Cofimvaba Schools

- Fuel cells providing primary and back up power in schools
  - Fuel cell used to power ICT equipment
  - Improved quality of education

Windsor East Clinic

- Fuel cells for back up power in health facilities
  - Fuel cell provides back up power to vaccine fridges
  - Clinic serves 3000 patients a month
  - Fuel cell improves service delivery
Fuel Cell Demonstrations in the Transport Sector

Public Private Partnerships (PPPs)

Anglo American Platinum

- Fuel cells in underground Mining equipment
  - Fuel cell powered locomotives to replace diesel powered vehicles
  - Materials for cost effective hydrogen storage and refueling

Impala Platinum

- Fuel cells in material handling equipment
  - Fuel cell powered forklift
  - Hydrogen refueling infrastructure
  - Increase in productivity due to reduced refueling time
  - Improved air quality

South African Post Office

- Fuel cells as range extenders in electric mobility
  - Limited range of electric scooters impacting on productivity
  - Fuel cells will be used to extend the driving range
Conclusions

- South Africa is gearing towards a low carbon future
  - This will be done through a ‘Peak-Plateau-Decline’ (PPD) trajectory; and
  - The transport and energy sectors have an important role to play.
- Smart integration for seamless movement of commuters on public and private transport will alleviate congestion
- The use of alternative fuels and technologies will improve the efficiencies of all vehicles.
- South Africa through the DST is building high level capacity to support the country’s transition towards a low carbon future
- High level skills will unlock innovations and technologies that will allow South Africa to leap frog and catch up with the developed world.
Thank You