ENERGY TRANSITION IN SOUTH AFRICA
10th October 2019

Oil and Gas Conference 2019

Stanley Semelane
CSIR Energy Centre
## Presentation outline

- About the CSIR
- The CSIR Energy Centre
- CSIR Just Energy Transition Research Work
Our mandate

CSIR MANDATE

“The objects of the CSIR are, through directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act.”

(Scientific Research Council Act 46 of 1988, amended by Act 71 of 1990)
Vision and mission

VISION
We are accelerators of socio-economic prosperity in South Africa through leading innovation

MISSION
Collaboratively innovating and localising technologies while providing knowledge solutions for the inclusive and sustainable advancement of industry and society
### Strategic objectives

- **Conduct research, development and innovation, localise transformative technologies and accelerate their diffusion**
- **Collaboratively improve the competitiveness of high impact industries to support South Africa’s re-industrialisation**
- **Drive the socioeconomic transformation through RD&I which supports the development of a capable state**
- **Build and leverage human capital and infrastructure**
- **Diversify income, maintain financial sustainability and good governance**
The CSIR in numbers

The CSIR is a science council, classified as a national government business enterprise.

IN NUMBERS:

<table>
<thead>
<tr>
<th>Pretoria</th>
<th>Johannesburg</th>
<th>Durban</th>
<th>Cape Town</th>
<th>Stellenbosch</th>
</tr>
</thead>
<tbody>
<tr>
<td>320</td>
<td>586</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff with PhDs</td>
<td>Staff with M-qualifications</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 344 Total staff base

1 608 *SET base

62% Black South Africans

36% Female South Africans

319 Journal articles

19 New patents

50 New technology demonstrators

R2 534 m Total income

+R126 m Total investment in HCD

R5.42 m Royalty and licence income

+R126 m Total income in HCD

*Science, engineering and technology figures as at 31 March 2019
The CSIR Energy Centre
CSIR Energy Centre
Positioned to assist with the regional energy transition

Technology-focussed Research Groups
- Energy Efficiency and demand shaping
- Energy Meteorology
- Renewable Energy tech
- Thermal energy

Electro-Chemical Energy Technologies
- Batteries
- Fuel cells

HySA
- Hydrogen Technologies
- Synthetic fuels

System-focussed Research Group
- Energy System Design
- Energy System Operation

End user-focussed Research Groups
- Industrialisation support
- Socio-economic analysis
- Techno-economics
- SMME development
- Just transition

Energy Industry

Energy-Autonomous Campus
Real-world implementation of research programme
<table>
<thead>
<tr>
<th>Image</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image 1" /></td>
<td>- Industrialisation support (local component manufacturing)</td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Image 2" /></td>
<td>- Financial &amp; Economic modelling (Techno-economics)</td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Image 3" /></td>
<td>- Financial &amp; economic modelling (Techno-economics)</td>
</tr>
<tr>
<td><img src="image4.jpg" alt="Image 4" /></td>
<td>- SMME Support in the energy sector</td>
</tr>
<tr>
<td><img src="image5.jpg" alt="Image 5" /></td>
<td>- Socio-economic analysis (Energy Transition)</td>
</tr>
<tr>
<td><img src="image6.jpg" alt="Image 6" /></td>
<td>- Energy Diversification pathways</td>
</tr>
</tbody>
</table>

**Energy Industry Capabilities**
CSIR Energy Transition Research Work
Possible future: RSA’s energy system based on electricity
transitioning to decarbonisation based on predominantly renewables

Hypothetical energy-flow diagram (Sankey diagram) for South Africa’s future energy system

Sources: CSIR analysis
Two drivers require a global energy transition: Natural resources are finite and CO₂ emissions need to be capped

**Resources are finite**

- **Coal**
  - (140 to 300 yrs)
- **Gas**
  - (60-100 yrs)
- **Oil**
  - (40 – 60 yrs)

**CO₂ emissions need to be reduced**

- **Price pressure**
- **Regulatory/policy pressure**

**NDP Vision 2030**

- Reliable and efficient energy service at competitive rates, while supporting economic growth through job creation
- Social Equity through expanded access to energy at affordable tariffs and through targeted, sustainable subsidies for needy households
- Environmental sustainability through efforts to reduce pollution and mitigate the effects of climate change

Sources: WEC; BCG; CSIR analysis, National Development Plan
Coal shut-down schedule and implications

- Unemployment rate is 30% in MP
- 42% not economically active
Affected power stations in the short-term

<table>
<thead>
<tr>
<th>Power station name</th>
<th>Date of commercial service</th>
<th>Total nominal capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnot</td>
<td>1971-1975</td>
<td>2232</td>
</tr>
<tr>
<td>Camden</td>
<td>1966-1969</td>
<td>1481</td>
</tr>
<tr>
<td>Duvha</td>
<td>1980-1984</td>
<td>3450</td>
</tr>
<tr>
<td>Grootvlei</td>
<td>1969-1977</td>
<td>1120</td>
</tr>
<tr>
<td>Hendrina</td>
<td>1970-1977</td>
<td>1793</td>
</tr>
<tr>
<td>Kendal</td>
<td>1988-1993</td>
<td>3840</td>
</tr>
<tr>
<td>Komati</td>
<td>1958-1966</td>
<td>904</td>
</tr>
<tr>
<td>Kriel</td>
<td>1976-1979</td>
<td>2850</td>
</tr>
<tr>
<td>Lethabo</td>
<td>1985-1990</td>
<td>3558</td>
</tr>
<tr>
<td>Majuba</td>
<td>1992-2001</td>
<td>3843</td>
</tr>
<tr>
<td>Matimba</td>
<td>1987-1991</td>
<td>3690</td>
</tr>
<tr>
<td>Matla</td>
<td>1979-1983</td>
<td>3450</td>
</tr>
<tr>
<td>Tutuka</td>
<td>1984-1990</td>
<td>3510</td>
</tr>
</tbody>
</table>

Power stations generally run for approximately 50 years.
Eskom power stations shut-down implications on coal mining

- SA produced 183 million tons of coal in 2018
- 80+ million was consumed by Eskom
- 60+ million tons was exported
- Sasol is produced 40 million tons
- How long can we continue exporting coal?
Planning for the transition

• 12 of SA Coal Power Station are located in Mpumalanga
Net job decrease in coal of ≈100k but net gain overall as gas grows to ≈55k jobs towards 2030, RE contributes up to ≈110k by 2030.
Local Content Requirements (LCRs)

Are the current LCRs enabling a just transition?
### Economic Development (30% of IPP BIDS)

<table>
<thead>
<tr>
<th>Job Creation</th>
<th>Ownership</th>
<th>Preferential Procurement</th>
<th>Enterprise Development</th>
<th>Socio-Economic Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Companies</td>
<td>Management Control</td>
<td>Local Content</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>25%</td>
<td>25%</td>
<td>15%</td>
<td>10%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Is the ED enabling a just energy transition?
Actual tariffs: Reductions in tariff for new wind, solar PV and CSP

Actual average tariffs in R/kWh (Apr-2017-R)

<table>
<thead>
<tr>
<th>Date</th>
<th>Solar PV</th>
<th>Wind</th>
<th>CSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 2011</td>
<td>3.84</td>
<td>3.74</td>
<td>3,84</td>
</tr>
<tr>
<td>Mar 2012</td>
<td>3.50</td>
<td>3.50</td>
<td>3,50</td>
</tr>
<tr>
<td>Aug 2013</td>
<td>3.28</td>
<td>3.28</td>
<td>3,28</td>
</tr>
<tr>
<td>Aug 2014</td>
<td>3.06</td>
<td>3.06</td>
<td>3,06</td>
</tr>
<tr>
<td>Nov 2015</td>
<td>2.13</td>
<td>2.13</td>
<td>2,13</td>
</tr>
</tbody>
</table>

Planning for the transition

Is the current energy policy enabling a just energy transition?

- No projects in this region (MP)
- Proposed REDZ cover Emalahleni only
- Solar radiation is 5.61 kWh/m²/d 10% less than Northern Cape
- Grid infrastructure available

Solar PV Installation to date
Economic outlook of Mpumalanga

National GDP
R4.65 trillion

- Agriculture, forestry and fishing: 3%
- Mining and quarrying: 25%
- Manufacturing: 13%
- Electricity, gas and water: 3%
- Construction: 5%
- Wholesale and retail trade: 15%
- Transport, storage and comms: 6%
- Finance, insurance, real estate: 13%
- General government: 13%
- Community social: 4%

Limpopo: 6%
Gauteng: 19%
Mpumalanga: 34%
Northern Cape: 7%
Western Cape: 16%
Eastern Cape: 8%
Free State: 14%
Kwazulu Natal: 5%
Most affected province employment status

- SA Unemployment: 29%
- Mpumalanga Unemployment Rate: 30%
- Nkangala District: 32%
- Emalahleni: 29%
- Steve Tshwete: 21%
### Solar PV local panel manufacturing assessment techno-economics results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Economic evaluation inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant size</td>
<td>10 GW solar panel manufacturing plant</td>
</tr>
<tr>
<td>Units produced p.a</td>
<td>3,225,806.45</td>
</tr>
<tr>
<td>Capital investment cost</td>
<td>$30 million</td>
</tr>
<tr>
<td>Equity</td>
<td>30%</td>
</tr>
<tr>
<td>Amortisation</td>
<td>70%</td>
</tr>
<tr>
<td>Interest rate</td>
<td>10%</td>
</tr>
<tr>
<td>Capacity factor</td>
<td>80%</td>
</tr>
<tr>
<td>Calculated MSP</td>
<td>$43 per 310 watt module ($0.14/W)</td>
</tr>
</tbody>
</table>

#### Solar PV Module Weekly Spot Price

<table>
<thead>
<tr>
<th>Item</th>
<th>High</th>
<th>Low</th>
<th>Average</th>
<th>AvgChg</th>
<th>AvgChg %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poly Solar Module</td>
<td>0.300</td>
<td>0.190</td>
<td>0.207</td>
<td>-0.001</td>
<td>-0.48%</td>
</tr>
<tr>
<td>Poly Module in China</td>
<td>0.240</td>
<td>0.190</td>
<td>0.204</td>
<td>-0.003</td>
<td>-1.45%</td>
</tr>
<tr>
<td>Poly High Eff / PERC Module</td>
<td>0.340</td>
<td>0.215</td>
<td>0.243</td>
<td>-0.001</td>
<td>-0.41%</td>
</tr>
<tr>
<td>Mono High Eff / PERC Module</td>
<td>0.390</td>
<td>0.235</td>
<td>0.260</td>
<td>-0.001</td>
<td>-0.38%</td>
</tr>
<tr>
<td>Mono High Eff / PERC Module in China</td>
<td>0.260</td>
<td>0.235</td>
<td>0.239</td>
<td>-0.002</td>
<td>-0.83%</td>
</tr>
<tr>
<td>ThinFilm Solar Module</td>
<td>0.330</td>
<td>0.230</td>
<td>0.245</td>
<td>0.000</td>
<td>0%</td>
</tr>
<tr>
<td>US Multi Solar Module</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mono Silicon Solar Module</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India Poly Module</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit: USD / Watt

**IRR = 1.75%**
Solar PV local panel manufacturing assessment and labour index between China and RSA

Cost of labour is 33% more expensive when manufacturing in South Africa
## Energy transition presents opportunities for RSA

South Africa is well-positioned to be among regional and global leaders transitioning the energy system. Therefore strategic investment in R&D initiatives that speak to technology innovation and industrialisation is paramount.

<table>
<thead>
<tr>
<th>Opportunities – a select few</th>
<th>Research and Development agenda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wind &amp; solar</strong></td>
<td></td>
</tr>
<tr>
<td>• Abundant and inexhaustible wind and solar energy resources</td>
<td>• Planning and operating a power system with high share of renewables (stability/reliability)</td>
</tr>
<tr>
<td>• Even by 2050, RSA would not have used 10% of its exploitable wind and solar resources</td>
<td>• <strong>Technology localisation</strong> (industry, jobs, SMMEs)</td>
</tr>
<tr>
<td>• Strategic global competitive advantage (excellent resource and available land)</td>
<td>• Energy storage (battery development and localisation) – <strong>beneficiating local mineral resources</strong></td>
</tr>
<tr>
<td><strong>Financing</strong></td>
<td></td>
</tr>
<tr>
<td>• Global finance available to decarbonise the energy system and make countries resilient to climate change effects</td>
<td>• <strong>Opportunities to address present liquidity challenges</strong> (Eskom and municipalities)</td>
</tr>
<tr>
<td><strong>Hydrogen economy</strong></td>
<td></td>
</tr>
<tr>
<td>• Hydrogen a fuel source of the future</td>
<td>• <strong>Determining the future role of hydrogen in the RSA energy mix</strong> and end use applications and new industries including hydrogen as a feedstock for CO2 utilisation in the production of clean synthetic fuels</td>
</tr>
<tr>
<td>• Local energy mix diversity, and possible export opportunity (Europe and Japan)</td>
<td>• <strong>Localisation and beneficiation</strong> to supply the global hydrogen value chain</td>
</tr>
<tr>
<td>• Reduce RSA balance of payments displacing imported liquid fuels</td>
<td></td>
</tr>
<tr>
<td>• Platinum beneficiation in fuel cells and electrolysis</td>
<td></td>
</tr>
<tr>
<td><strong>Circular economy</strong></td>
<td></td>
</tr>
<tr>
<td>• Valuation of waste</td>
<td>• Carbon dioxide utilisation</td>
</tr>
<tr>
<td></td>
<td>• Fly ash-based geopolymers binders for <strong>reduced cost building materials</strong></td>
</tr>
</tbody>
</table>

---

4IR at the core of industrialisation; Using IoT, Robotics, VR and AI to improve and enhance our way of life (productivity/efficiency)
The energy transitions needs to be just and requires the development of new industries and business models.

<table>
<thead>
<tr>
<th>Opportunities – a select few</th>
<th>Research and Development agenda</th>
</tr>
</thead>
</table>
| Just Transition | • New jobs in Gas, Storage and Renewables  
• Renewable energy manufacturing and deployment in coal regions  
• Net increase in jobs  
• Localisation and industrialisation of new technologies |
| • Re-purposing aging coal-fired power stations  
• Labour migration and social plans  
• Economic sector diversification in coal regions (e.g. special economic zones)  
• Skills plans for new industries (new skills and re-skilling) |
| Consumers Prosumers | • Consumers participate in the provision of electricity (small scale embedded generation)  
• Off-grid and mini-grid electrification |
| • New business models for prosumers and the municipal utilities. Financial sustainability of new tariff structures and trajectories  
• Democratisation of energy and opportunities for SMMEs  
• New tech for electrification Universal Access |
| Utility business model | • Change from a vertically integrated power utility business model  
• Entrance of new players in the Electricity Supply Industry (ESI) |
| • New energy markets with aggregators  
• Capacitate infrastructure maintenance and creation  
• Ensuring the performance of existing (Eskom) fleet |
| alternative/low-emissions mobility | • Carbon neutral synthetic fuels  
• Battery and fuel cell Electric Vehicles for domestic and export markets  
• Reduce dependency on imported liquid fuels |
| • Electrochemical technologies (batteries, fuel-cells) key to the future transportation system – localisation and industrialisation  
• Revenue opportunities & increased electricity sales |

4IR at the core of industrialisation; Using IoT, Robotics, VR and AI to improve and enhance our way of life (productivity/efficiency)
A just transition will have substantive positive impact

Deliberate choices will enable South Africa to transition from the present pain points and support the NDP

<table>
<thead>
<tr>
<th>Impact</th>
<th>Social</th>
<th>Economic</th>
<th>Enviro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net increase in jobs</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Reduced emissions and water consumption</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>Creation of new industries (Gas, Renewables, Electric Vehicles)</td>
<td>❌</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Lowest cost energy – longer term strategic advantage</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Export hydrogen and clean synthetic fuels</td>
<td>❌</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Increased energy security</td>
<td>❌</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Support universal access to energy</td>
<td>❌</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexibility to respond to changing economic growth and energy demand</td>
<td>❌</td>
<td></td>
<td>✔️</td>
</tr>
</tbody>
</table>
Key energy transition enablers in SA

JUST ENERGY TRANSITION ACTION PLAN COORDINATION

PRESIDENCY / NATIONAL PLANNING COMMISSION

PROVINCIAL LEVEL STREAMS OF WORK

STUDIES

IRP 2019 NEW BUILD CAPACITY

CONSSENSUS

IPPO ESKOM GVNMNT DEPTS PROVINCES MUNICS BUSINESS LABOUR

COAL POWER DECOMMISSIONING PLAN

NATIONAL LEVEL MACRO ECONOMIC IMPACT ANALYSIS

JUST TRANSITION ACTION PLAN
Thank you

Stanley Semelane
SSemelane@csir.co.za
012 841 3464
Key Project Milestones:

- **Meeting with Emalahleni and Steve Tshwete**
  - 2018

- **Presentation to Emalahleni and Steve Tshwete**
  - 2019

- **Economic profiling**

- **Resource Assessment**

- **I-JEDI Modelling**

- **Manufacturing Assessment**

- **Publications (SAAEE)**

- **Outstanding questions**

**Project conceptualisation**

**Project inception**

**Key provinces data collection**

**Jobs and Economic Impact Modelling**

**Market traction**

**Progress report**

**Report Preparation**

**Final report 2020**

**CSIR Just Energy Transition Research (2019)**