CENTRE FOR RENEWABLE &
SUSTAINABLE ENERGY STUDIES

2018

CRSES ANNUAL REPORT

UNIVERSITEIT iYUNIVESITHI STELLENBOSCH UNIVERSITY 100 1918·2018

science & technology Department: Science and Technology REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

Eskom

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FOREWORD

2018 was a busy year at the Centre for Renewable and Sustainable Energy Studies (CRSES) and I am rightly proud of all the achievements of our staff, researchers and students.

Through our work, we acknowledge that climate change has become a phenomenon that necessitates that we, as a populace, learn to 'do things differently'. We certainly need to move away from our reliance on fossil-based fuels for power generation, and rather use clean energy sources. Research and skills development in the field of renewable energy have now, more than ever before, become of paramount importance.

The White Paper on Science and Technology recognises the importance of developing the skills in renewable energy studies, and emphasises the following:

- Human capital development in areas such a renewable energy in anticipation of market growth (Young researchers less than 40 years old)
- Knowledge creation and transfer on science and technology
- Skills development
- Innovation to support economic growth
- 4IR
- Product certification facilities
- Transformation in Science and technology in general
- Cultivating greater awareness for Science and Technology

At the Centre, our priorities are human capital development, knowledge creation and transfer, and skills development through the training of Masters and PhD students, Postdoctoral Fellows, and offering internships. Our five-year Strategic Development Plan (2018 – 2022) records that by 2022 we need to have produced 70 Masters and PhD students, 5 Postdoctoral Fellows and we should have trained 10 interns. We performed well against these targets in 2018, producing 19 Masters and PhD students, trained 1 Postdoctoral Fellow, and welcomed five interns, ensuring that we are well on our way to achieving the 5-year targets.

To support our knowledge creation and transfer objective, we delivered a specialised course for professionals on solar cooling and air conditioning to 39 participants from South Africa, Namibia, Botswana, Zimbabwe, Mozambique and Lesotho. Additional short courses presented on renewable energy were well attended by people from industry, the public sector, and students intending to stay in academia.

With regards to innovation that supports economic growth, in line with the 4IR, we augmented our Smart Grid technology programmes which is important as students are already receiving training on a future distributed-power system. This system will become an important feature in the economy of South Africa.

We continued to raise awareness for science and technology through our outreach programme, where renewable energy training was given to educators and learners in schools. 149 educators and 961 learners from 88 schools participated in our renewable energy outreach efforts.

Our own students were also given an opportunity to present their renewable energy research at the Renewable Energy Post-graduate Symposium (REPS) as well as the Southern African Solar Energy Conference (SASEC). Staff members also presented academic research at various national and international conferences, and the CRSES continues to publish extensively in internationally recognised journals.

CRSES performed very well financially in 2018, with a significant growth in income compared to the previous year: our income more than doubled, from R17 million in 2017 to R41 million in 2018.

We continue with our resolve to achieve the ambitious targets we have set for the CRSES.

Thank you for being part of our journey.

Prof Sampson Mamphweli

Director: Centre for Renewable and Sustainable Energy Studies
November 2018

BUILDING HUMAN CAPITAL

Human capital development is at the heart of the strategic focus areas of the South African government, particularly in scarce skills areas such as renewable and sustainable energy, and power systems research. CRSES is well positioned to assist the national government in developing people in these areas of specialisation and strives to produce highly skilled scientists, engineers and academics who will be able to compete successfully in the global knowledge economy. This is achieved mainly through the training of Masters and PhD candidates, interns and Postdoctoral Fellows.

Practical support is provided in terms of project supervision, financial assistance, practical tasks and mentoring, and training in soft skills. While mostly South African, the Centre does extend intern opportunities to foreign students too, such as Matthias Reich from the University of Luzern, who has been at the Centre from August 2018 and completed his internship at the end of November 2018.

Interns

Simnikiwe Gulwa

I did my internship with CRSES between July 2018 and June 2019. During this period, I attended a few short courses on renewable and sustainable energy. These courses gave me invaluable knowledge about the energy sector and I intend to further my studies in this field.

During my internship, I worked extensively with the Seaweed Bio-refinery Research Group, conducting research on the anaerobic digestion of seaweed to produce biogas for heating. The research was conducted at the department of Process Engineering with a team of experienced researchers and Masters students. I also conducted experimental work on the bio-methane potential of pig manure, and this work feeds into a feasibility study for a biogas plant for Mariendahl farm in Stellenbosch.

At the Centre, I was given the opportunity to manage the teacher training program on renewable and sustainable energy. This is an outreach and awareness programme at the Centre where teachers are trained on a set of materials relevant to renewable energy in line with the Curriculum and Assessment Policy Statement (CAPS). The programme is designed to ensure that awareness of renewable energy and sustainability starts at an early age.

The staff and mentors at CRSES supported me and were a source of great inspiration. I was provided with all the necessary resources for my internship. I learnt both soft and hard skills during my time at the Centre, notably research techniques, communication skills, and report writing skills. I would like to thank both the DST and CRSES for the opportunity provided which has aided in kick-starting my career.

Lavhelesani Maluleke

My twelve-month internship at CRSES was an experience that provided me with significant insight into renewable and sustainable energy. I was given hands-on experience with several projects including:

- Conducting a study on assessing the quantity of waste produced from distillation systems at SU laboratories
- Evaluating the peformance of a Photovoltaic Thermal (PVT) hybrid collector at the CRSES rooftop solar laboratory
- Attending a SOLTRAIN specialised course on solar heat for industrial applications, where I gained knowledge about energy auditing, heat recovery alternatives, and optimisaton of industrial processes for intergration of solar thermal heat
- Accompanying a CRSES engineer to a SAURAN weather station for maintainance where I learned about solar measurement systems
- Assignments that helped me gain knowledge on software modelling of solar thermal and photovoltaic systems

All these projects, site visits, assignments and tasks taught me invaluable skills. I not only learned about renewable and sustainable energy, but I also improved my communication and presentation skills.

Smanga Matebula

My internship with the CRSES at Stellenbosch University began in March 2018 and ended in March 2019. One of my key learnings as this time was professional conduct. I was in the company of colleagues that are much more qualified and accomplished, yet I was treated with immense respect. Their attitude towards me has helped me transition from student to professional, as I follow the example they set.

Perhaps more importantly is the 12-month engineering workplace experience that the Centre afforded me, as this is a requirement to be eligible to graduate with a National Diploma in Electrical Engineering at the Cape Peninsula University of Technology (CPUT).

I had an excellent supervisor who made me feel that he was enjoying being my mentor. Being supervised by a research engineer gave me first-hand experience about the importance of research, and compiling professional reports. I was trained to use renewable energy modelling software – specifically PVSyst – which is used as part of compiling feasibility study reports for clients that plan to install PV systems. I was also given an opportunity to work on a schools outreach programme that the Centre is currently running, where I was allowed to design and build a PV solar demonstration kit for schools. I am very grateful to the Centre for the internship and the knowledge I have gained about renewable and sustainable energy.

Paul Niquet

My internship at the CRSES at Stellenbosch University began in April 2018 and lasted for 5 months. I have a particular interest in the potential of biomass, both from vegetation as well as from animals. Too often, the biomass is reduced to just being waste. At CRSES I was given the opportunity to conduct a feasibility study relevant to installing a biogas plant at Mariendahl farm, an experimental farm owned by SU.

Initially, I conducted a review about anaerobic digestion in order to master its different processes. I conducted several field investigations and chose pig manure as my prefered animal waste to feed the digester. I collected samples on site to determine the amount of manure excreted and its consequent biogas potential. I then conducted several laboratory experiments to establish the bio-methane potential. I used the results of the experiments to suggest a design for the biogas plant. Furthermore, I conducted financial feasibility studies, using two different biogas implementation scenarios: one for electricity generation, the other for cooking and heating.

CRSES provided me with opportunites to discover South Africa, improve my knoweledge and my English skills. For the firt time in my life, I worked as a professional engineer. I would like to sincerely thank the CRSES team for being receptive, for their friendliness, and constantly being available to assist me.

Postdoctoral Fellow

Dr. Fumni Faloye

Diversifying sources of renewable energy remains a vital key in achieving sustainable energy generation, hence the appointment of Dr. Fumni Faloye as a Postdoctoral Fellow on 1 November 2018. Specialising in Industrial Microbiology, Dr. Faloye's research is focused on the development of production technologies for anaerobic digestion of organic wastes for biogas production.

"Since my resumption as a Postdoctoral Fellow, I have been actively involved in research focusing on strategies for enhancing anaerobic digestion while exploring new potential for biogas production, most importantly for industrial applications. My roles also include developing research capacity by providing support to postgraduate students who are funded by the CRSES on projects that bridge the knowledge gaps in the development of viable bioenergy systems and unlocking the potential for biogas production as a source of renewable energy in South Africa.

I have enjoyed tremendous support from the Centre, not only by funding my research but also by providing mentorship and guidance that has helped to broaden my research expertise. I am deeply grateful for the opportunity as this continues to propel my career in the right direction", says Dr. Faloye.

Simnikiwe Gulwa conducting an anaerobic digestion test at the Biogas laboratorium, Process Engineering at Stellenbosch University

2018 Graduates

The students listed below graduated during the year under review. Where available, their theses and dissertations can be found at www.crses.sun.ac.za/research-completed.php.

Name	Initial	Programme	Supervisor/Bursary
March 2018			
Geldenhuys	J	MEng (Research)	SU Supervisor & Bursary
Asoba	FA*	MEng (Structured)	SU Supervisor
Prinsloo	LPJ	MEng (Structured)	SU Supervisor
Krog	W	MEng (Research)	SU Supervisor & Bursary
de Meyer	OAJ	PhD	SU Supervisor
Prinsloo	GJ	PhD	SU Supervisor
Janse van Vuuren	JC	MEng (Structured)	SU Supervisor & Bursary
Lotter	JC	MEng (Structured)	SU Supervisor
December 2018			
Engelbrecht	R	PhD	SU Supervisor & Bursary
Craig	OO #	PhD	SU Supervisor & Bursary
Amadi	C	MEng (Research)	SU Supervisor & Bursary
Mabaso	M	MEng (Research)	SU Supervisor & Bursary
Joss	A	MEng (Research)	SU Supervisor & Bursary
Hendriks	JC	MEng (Structured)	SU Supervisor
Kambo	P	MEng (Structured)	SU Supervisor
Mashiri	RL	MEng (Structured)	SU Supervisor
Mukwati	TB	MEng (Structured)	SU Supervisor
Karsten	L	MEng (Research)	SU Supervisor
Gouws	JE	MEng (Research)	SU Supervisor

*This student is not a South African citizen but has a valid study permit
#This student is not a South African citizen but has permanent residence status

The students below graduated with a Postgraduate Diploma.

Name	Initial
March 2018	
Pinheas	ET
December 2018	
Banza	MJ
Dingilizwe	K
Gugwana	NM
Haggard	R
Kalala	T
Matshoba	VW
Mohlotsane	TV
Nongogo	IS
Ortell	RN
Pieterse	G
Tanner	AJ
Van Rooyen	JA
Viljoen	ZN

Graduated bursary students

	2006-2010	2011	2012	2013	2014	2015	2016	2017	2018	**Total**
MPhil/MEng/MFor	19	3	6	0	5	2	2	2	8	**47**
MSc/MScEng/MCom/MEng (Research)	26	8	10	4	16	15	6	12	7	**104**
PhD	4	0	3	2	4	2	1	3	4	**23**
Total	**49**	**11**	**19**	**6**	**25**	**19**	**9**	**17**	**19**	**174**

Awards

CRSES was well represented at the POWER-GEN and DistribuTECH Africa 2018 Conference held at the Sandton Convention Centre in Johannesburg on 17-19 July 2018. This conference brings together international business leaders and technical experts committed to powering up the continent. Featuring a comprehensive conference programme and extensive exhibit floor, the event covered all aspects of centralised and distributed power generation along with leading technologies in power transmission and distribution.

According to organisers, the event was attended by over 2100 industry professionals from all over the world, including 35 sub-Saharan VIPs. In all, 85 presentations were given to an estimated 650 delegates.

The conference ran in four simultaneous tracks as follows:

- Track A: Electricity Industry Strategy
- Track B: Thermal Power Generation
- Track C: Renewable Energy
- Track D: Power Delivery and Customers

Ndamulelo Mararakanye, a research engineer from CRSES, gave a presentation on a methodology for assessing the impact of intermittent renewable energy systems on the grid. This paper won him the award for the Best Paper within Track A – Electricity Industry Strategy.

The Centre congratulates Ndamulelo for his achievement and will continue to facilitate cutting-edge research and development activities and human capacity development in renewable and sustainable energy.

Ndamulelo Mararakanye receiving his award from Dr Willem de Beer, session chair at POWER-GEN DistribuTECH Africa 2018 Conference

TRAINING

Continuous learning structured in a flexible manner is key to staying abreast of today's fast-changing engineering landscape. CRSES acknowledged this back in 2013, when we were instrumental in launching the Renewable & Sustainable Energy post-graduate programmes within the Mechanical & Mechatronic Engineering department. Two programmes are offered, structured as week-long course modules with assignments and projects that can be executed mostly off-campus, thereby broadening the audience to include part-time students:

- *Structured Master's degree, consisting of eight week-long block modules at NQF9 level, and a 60-credit project, or*
- *Diploma in Engineering, catering for B.Sc and B.Tech graduates, consisting of eight week-long block modules at NQF8 level.*

In addition, a wide variety of stand-alone block modules can be attended towards Continuing Professional Development (CPD) points, allowing members of industry to increase their knowledge of specific subjects without the time-commitment required for enrolling in a post-graduate programme.

Short courses in 2018

1. Introduction to Solar Energy
2. Renewable Energy Policy
3. Thermal Energy Systems
4. Advanced PV Systems
5. Wind Energy
6. Renewable Energy Finance
7. Integrated Supply Side Technology – new 2018
8. Bioenergy
9. Energy Storage Systems
10. Ocean & Hydro Energy
11. Renewable Energy Systems

CRSES enables new Smart Grid Technology programmes

Based on the success of the Renewable & Sustainable Energy post-graduate programmes (176 CPD attendees, 49 Diplomas and 30 Masters qualifications awarded since inception), funding was negotiated by CRSES via DAMOC (Development of a Harmonized Modular Curriculum for the Smart Grid) to develop and launch two Smart Grid Technology post-graduate programmes in 2018. Located within the Electrical & Electronic Engineering department, the two programmes and various CPD modules aim to reach the widest possible audience while maintaining the high academic standards for which Stellenbosch University is known.

Smart Grid Technology leads the prospective student into the fascinating world of the future inter-connected power system, through a variety of subjects ranging from smart grid communications to the technologies driving the supply and demand sides of the power system. The programmes prepare the student for a renewable energy generation future, covering crucial technologies like photo-voltaics and energy storage, while providing the necessary understanding on how to plan for the uncertainty introduced by the increasing uptake of variable renewable energy in the power system.

Renewable Energy Software training

CRSES also offers training and support on renewable energy software. This support is structured flexibly rather than offered as a fixed-term short course. During 2018, clients were required to bring an existing project and the training consisted of working through the specific problems encountered during the modelling of that project. The training is conducted by one or more research engineers at CRSES and is suitable, but not limited to, installers, engineers, technicians, architects or researchers.

During the period under review, individualised training was conducted for the following renewable energy software:

- **PVSyst –** This software allows for the solar simulation of Photovoltaic (PV) systems in order to investigate the feasibility of projects, establish performance predictions of systems and to optimise installations or additions to installations.
- **PolySun –** This software supports the modelling and simulation of small to large scale solar thermal systems for residential, commercial and industrial applications.
- **Power Factory (DigSilent) –** This is a power analysis software application for use in analysing generation, transmission, distribution and industrial systems.
- **Homer Pro –** This is a software application for optimising microgrid design in all sectors.

Workshops presented in 2018

SOLTRAIN Quality Inspectors – Solar Water Heating course

The Soltrain Quality Inspectors Course was held at the Stellenbosch Institute for Advanced Study (STIAS) in Stellenbosch from 24-25 October 2018. The course provided training on the quality inspection of thermo-syphon and pumped solar thermal systems. The presenter, Mr. Rudi Moschik, is from AEE Institute for Sustainable Technologies (AEE–Intec), the managing institution of the SOLTRAIN initiative. Twenty participants of varying backgrounds and skills attended. These included qualifed plumbers, Masters students, municipal representatives, and installers. A wide range of topics pertinent to solar water heating was discussed, including international solar thermal markets and technologies, solar collector types and efficiencies, system overviews, assessment of solar resources, dimensioning guidelines for solar thermal systems and components, as well as tools required for performing quality inspections.

SOLTRAIN 2018 Specialised course for professionals on Solar Cooling for Industrial Applications

A specialised course for professionals on Solar Cooling and Air Conditioning was presented in Stellenbosch, South Africa, from 28 - 30 November 2018. The course was organised by SOLTRAIN in cooperation with the Solar Heating and Cooling programme from the International Energy Agency (IEA SHC).

Participants were priviledged to have this course presented by international experts, Dr Daniel Mugnier and Dr Christian Holter. Dr Mugnier is the chairman of IEA SHC and also heads up research and development at TECSOL, an innovative technology company that operates in all sectors of solar energy. Dr Holter is the Chief Executive Officer of SOLID Solar Installation and Design, a company that has installed most of the largest solar cooling plants around the world. He has vast practical experience, having been a pioneer in the field of solar thermal energy for over 25 years.

The course was attended by 39 participants from South Africa, Namibia, Botswana, Zimbabwe, Mozambique and Lesotho. Participants included academics and researchers, industry and NGO participants.

The course covered both the state of solar cooling worldwide as well as the design and technical details of solar cooling installations. The response from those who attended the course was overwhelmingly positive. The course will hopefully stimulate interest and result in the installation of more solar cooling technologies in Southern Africa.

Angelo Buckley, a research engineer at CRSES presented *"The Status of Large Scale Solar Thermal Systems for Industrial Applications In South Africa and the Promotion of Solar Thermal Research at CRSES, Stellenbosch University"* at the couse, which was well received. This paper was co-authored by Prof NS Mamphweli and Ms Karin Kritzinger.

"Continuous learning structured in a flexible manner is key to staying abreast of today's fast-changing engineering landscape."

SOLTRAIN Quality Inspectors course participants

RENEWABLE ENERGY MARKET TRANSFORMATION PROJECTS

CRSES aims to facilitate the transformation of the energy sector in South Africa and other African markets, by moving away from fossil-based energies to exploring the viability of installing renewable energy systems.

Namibian Electricity Control Board

As the installed capacity of renewable energy systems increases worldwide, the need to understand how these systems will impact the traditional grid also increases. CRSES has the expertise to conduct a variety of studies on the impact of integrating renewable energy into a national grid, with a specific focus on sub-Saharan Africa. These studies include:

- Load flow analysis
- Contingency analysis
- Fault level analysis
- Power quality studies
- Stability analysis (transient, frequency and voltage stability)
- Reliability assessment

CRSES was contracted by the Namibia Electricity Control Board to:

- conduct a study to assess the impact of grid integration of intermittent renewable energy,
- develop and implement a plausible methodology to reliably quantify the optimal renewable energy capacity that can be integrated into the Namibian national grid.

The project lasted a year, and was concluded in February 2018.

CRSES worked closely with the electricity industry and government partners to help Namibia in planning and achieving its long-term climate change goals.

Eskom Potential PV Penetration in the Western Cape

CRSES conducted a study to determine the potential impact from disaggregated solar photovoltaic (PV) electricity generation on the municipal and state-owned (Eskom) distribution and transmission networks in the Western Cape, to assess and explore the following:

- Penetration levels, location and ownership of PV systems
- Consumption patterns, including potential changes in these patterns and associated load on the grid
- Power flows, including changes due to future small-scale embedded generation
- Measures of safety risk on the grid
- Potential need for strengthening and supporting of the grid
- Monitoring needs and equipment
- Requirements for investment in the network by the state-owned utility and municipalities
- Changes in network maintenance and operation procedures, for the state-owned utility and the municipalities
- New dynamic response devices to support the power quality on the national grid
- Integration of energy storage

The study aimed to stimulate investment in private and public PV installations by supporting informed decision-making by both the private and public sector. The client was Eskom Holdings, and CRSES partnered with both the University of Cape Town and the Western Cape Government.

Klein Karoo International Tannery

In 2016, the CRSES was contracted to conduct a techno-economic feasibility study pertinent to a solar thermal system for the Klein Karoo International Tannery, located in Oudtshoorn in the Western Cape. The study culminated in the CRSES drafting technical specifications and providing technical advisory services for the tender evaluation process to install the said system. E3 Energy was the winning bidder and was commissioned by the tannery for the installation.

In November 2018, a 556 m2 solar thermal system with 40,000 L of hot water storage was installed at the tannery. The system is designed to reduce heavy fuel oil consumption, generate financial savings, and reduce the carbon footprint of the Klein Karoo Tannery.

CRSES's technical services account and the system installation costs were co-funded by the SOLTRAIN III Initiative.

"CRSES aims to facilitate the transformation of the energy sector in South Africa and other African markets"

Stellenbosch Infrastructure Innovation Committee (IIC)

CRSES is part of the **Stellenbosch IIC** which aims to prioritise short- and medium-term actions to address the backlog of the Stellenbosch Municipality and ensure local economic development and socio-economic growth. The Centre is responsible for the energy aspects of the IIC and it is envisaged that the learnings from this participation will inform the implementation strategies of other municipalities. Prof Brent assisted Stellenbosch Municipality to develop a policy document on rooftop PV.

This is an ongoing collaboration with the Stellenbosch Municipality, and CRSES initiated a working group with Stellenbosch Municipality and the Faculty of Engineering at Stellenbosch University to focus on challenges the Municipality face that can be addressed by appropriate research in the University.

This working group will encourage collaboration between the two institutions and has a dual purpose: to identify appropriate projects, and enable regular communication to collaborate at the technical level. The municipality is represented by their Director of Engineering Services as well representatives from the Electrical -, Water -, Waste Management-, Transport- and Development Services Departments.

The University is represented by the Dean of Engineering as well as representatives from CRSES, Civil Engineering, Electrical Engineering, and Facilities Management with the relevant expertise to address the challenges faced by the municipality in their areas of concern.

Klein Karoo International Tannery solar thermal systems installed by E3 Energy

AWARENESS AND OUTREACH

The Centre's Schools Programme

The CRSES hosted its eighth annual national symposium to provide Climate change, renewable energy and sustainability are relatively new concepts in South African schools. Gradually, curricula are introducing these concepts, and renewable energy related teaching is gaining momentum. A large number of educators, however, are not familiar with the topics.

At CRSES we realise that it is imperative to raise children's awareness of climate change and renewable energy options. As such, we developed a set of materials for teachers, in line with South Africa's Curriculum and Assessment Policy Statement (CAPS).

The material developed enhances the renewable energy sections in the curriculum of the following subjects:

- Geography for grades 10 – 12
- Natural Science for grades 7 – 9
- Mathematics for grades 7 – 9
- Physical Science for grades 10 – 12

The table below summarises the number of educators and learners that have been trained since inception.

Year	Schools	Educators	Learners	Students
2008	3	3		
2009	18	27		
2010	119	117		
2011	72	110		
2012	30	40		376
2013	99	103		257
2014	277	376	230	25
2015	73	167	963	242
2016	88	146	70	20
2017	20	52	546	54
2018	88	149	961	
Total	**863**	**1,288**	**2,695**	**974**

School children visiting SUNstep laboratory at Stellenbosch University

SASEC 2018 delegates and speakers (Photo credit: University of Kwa-Zulu Natal)

SASEC - Southern African Solar Energy Conference

The **5th SASEC conference** was held from 25-27 June 2018 at the Blue Waters Hotel in Durban. The conference focused equally on solar photovoltaic and solar thermal energy technologies at both system and component levels, as well as on policy issues related to technology implementation. The conference also included presentations on solar resource mapping. SASEC 2018 proceeded smoothly and provided a good opportunity for researchers, developers and students to share and discuss recent developments in the field. It was pleasing to note that about half of the attendees were postgraduate students for whom the event represented a good opportunity to showcase research progress, develop knowledge of solar energy technologies and strengthen professional networks.

The conference technical programme was compiled by 33 leading solar energy experts, including several international researchers. The opening session included addresses by Professor Sampson Mamphweli (Director: CRSES), Professor Deresh Ramjugernath (DVC Research: UKZN), Councillor Ntando Khuzwayo (eThekwini Municipality), and Dr Rebecca Maserumule (Chief Director of Hydrogen and Energy: DST).

Keynote speakers included Dr. Michael Geyer, the Chief Development Officer of Abengoa-Algonquin Global Energy Solutions, on the global roll-out of concentrating solar power systems and how the cost of generating electricity from these systems continues to fall as plants are scaled up in size; Professor Kumar Venayagamoorthy of Clemson University on integrating solar PV within microgrids, and Dr. Claudia Buerhop-Lutz of the Bavarian Center for Applied Energy Research (ZAE Bayern) in Germany, who discussed novel techniques for inspection of photovoltaic panels, including the use of aerial drones.

In total ninety-three delegates attended SASEC 2018 from multiple countries, including the USA, Chile, Switzerland, Namibia, Brazil, Italy, and the United Kingdom.

REPS - Renewable Energy Post Graduate Symposium

REPS is an annual event in which postgraduate students conducting research in the renewable energy field are afforded the opportunity to present their work to their peers, in a friendly and accepting environment. The symposium is organized by the Centre for Renewable and Sustainable Energy Studies.

The 9th REPS took place from 13-14 September 2018 at the Knowledge Centre, Faculty of Engineering, Stellenbosch University. This year the symposium attracted more than 30 research papers in solar photovoltaics, solar thermal, wind energy, biomass energy as well as power systems integration.

We also had Mr Horst Unterlechner from Ibert (Pty) Ltd as a guest speaker who presented on biogas as a sustainable green solution. His presentation was well received by the audience and it gave a good insight into the biogas industry in general. Ms Kubeshni Bhugwandi from Eskom RT&D also gave a keynote address about the Eskom research strategy, touching on their research priorities. Dr Rebecca Maserumule, Chief Director at the Department of Science and Technology (DST) responsible for the Hydrogen and Energy program also gave a keynote address focusing on Research, Development and Innovation for Sustainable Energy Future.

REPS 2018 delegates and speakers

RESEARCH CONTRIBUTION

CRSES plays a coordinating role for a variety of renewable energy related contract research projects where specialists from various disciplines participate in the following broad fields:

- *Solar energy(photovoltaics and thermal systems)*
- *Wind energy*
- *Hydro energy*
- *Ocean energy (current, wave and tidal energy)*
- *Bioenergy (biofuels, biogas and biomass-based energy)*

Specific areas of expertise facilitated through the CRSES include:

- *energy efficiency*
- *renewable energy finance*
- *renewable grid integration and micro grids*
- *energy storage*

CRSES has dedicated renewable energy engineers and researchers and can call on the expertise of the University as well as topical experts from the broader renewable energy community, both locally and abroad, to provide specialised and customisable services.

Modelling South Africa's future power system

The EPPEI Specialisation Centre for Renewable Energy and Power System Simulation (SC-RE) is situated within the CRSES, and coordinates a wide range of research across several South African universities with other research institutions both locally and internationally. In 2018, collaboration agreements were signed with University of Cape Town (UCT), Tshwane University of Technology (TUT), and Cape Peninsula University of Technology (CPUT), Nelson Mandela University (NMU), and Central University of Technology (CUT).

To strengthen collaboration between the EPPEI SC-RE partners, a workshop on modelling South Africa's future power system was held at Lanzerac Wine Estate on 16-17 May 2018. The aim of this workshop was to identify and coordinate the research activities of the research partners associated with the SC-RE.

Day 1 of the workshop focussed on high-level information sharing by the research partners, feedback from industry on this, and shared perspectives on future priority research areas. During technical sessions were on Day 2, research partners presented their models, datasets and methodologies in more detail.

Representatives from SU, UCT, TUT, CPUT, as well as the Energy Group at the Council for Scientific and Industrial Research (CSIR) shared current research activities, models and skillsets. Industry was represented by Eskom's Network Planning, System Operations department, and Energy Planning & Market Development department, and the City of Cape Town's Electricity Services, International Council on Large Electric Systems (CIGRE), and the South African Institute for Electrical Engineers (SAIEE).

Dr. Ndaona Chokani, an expert in the field of future power system modelling at the Swiss Federal Institute of Technology in Zurich (ETH Zurich), provided an international perspective and shared his group's modelling platform, EnerPol – a novel, bottom up, integrated simulation framework that is used to provide holistic scenario assessments of energy, transport, urban infrastructures, and population dynamics.

The workshop was successful in several aspects: it informed industry on the expertise and capabilities of each research partner, it improved the understanding of the support that academia could provide to industry, and it gave both industry and the research partners an opportunity to share perspectives on future priority research areas.

Investigating the cost of large-scale solar thermal systems in SADC countries

A study entitled "Investigation into the Costs of Large-Scale Solar Thermal Systems in SADC Countries" authored by Mr Angelo Buckley and co-authored by Ms Karin Kritzinger and Prof Sampson Mamphweli for the CRSES was presented at the 2018 Southern African Solar Energy Conference (SASEC) which was held in Durban in June.

The goal of the study was to investigate the variation of the specific costs in EURO/m2 installed of both thermosiphon and pumped-type solar thermal systems in the partnering SADC countries of the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN). These countries include South Africa, Lesotho, Botswana, Namibia, Zimbabwe and Mozambique.

The study highlighted the following average specific costs:

- Pumped solar thermal systems: 470-1000 Euro/m2 across five of the six countries, with Lesotho exhibiting the highest costs
- Thermosiphon systems: 500-700 Euro/m2 across four of the six countries, with South Africa presenting the highest costs
- Pumped and thermosiphon systems over the period from 2010 to mid-2017: 745 Euro/m2 and 613 Euro/m2, respectively.

The study shows that there is a large variation in specific costs of both pumped and thermosiphon installations in the SADC countries in relation to the gross collector area installed and that this variation is noticeably larger for pumped systems compared to thermosiphon systems.

The findings of this study aim at providing clearer approximation of the average specific costs for particular solar thermal technologies attributed to each of the SADC countries, and also to investigate the behaviour of cost trends through the growth of the technology's deployment within the SADC region.

Future electricity generation at local level – national household solar photovoltaic adoption survey

WWF-SA initiated a three-year project which involves an in-depth investigation into the existing electricity distribution systems at municipal level in South Africa. This project is executed in partnership with CRSES and funded by the Nedbank Green Trust. The aim of the project is to assist local governments in South Africa with the development of policies and workable models in facilitating the integration of decentralised renewable energy while securing municipal finances.

A fundamental part of the project included the roll-out of a national survey to gain a better understanding of the typical household profile and motivations that drive private investment in rooftop solar PV technologies and what it tells us of the future trajectory of solar rooftop PV investments. An electronic survey was conducted from May to August 2018 and had a national response of 2,678 people. This included 242 respondents who, combined, have 751.5 kWp installed PV capacity. 2,141 respondents indicated they might install rooftop PV, while just less than 300 respondents indicated that they are not planning to install rooftop PV at all.

Based on the responses received, there was a marked increase in uptake in rooftop PV installations from 2014 and onwards, with a high correlation between the installation of rooftop PV and other energy saving devices such as solar geysers, energy saving light bulbs and heat pumps. In most of the instances (70%), PV owners also had batteries installed. A very significant finding is that only 25% of the rooftop PV owners indicated that their municipality is aware of their installation.

The results of the survey also showed that financial motivations in combination with influences from the social environment are the most important factors in the investment decision of installing rooftop PV. Although all financial factors are viewed as significant during decision making, the upfront investment cost and having access to capital are considered most important. The lack of trust in government and Eskom is also a push factor in considering self-generation.

The results of the survey were presented at the Association of Municipal Electricity Utilities (AMEU) convention in Pretoria, South Africa from 7-10 October 2018, and the paper presented can be accessed on the CRSES website.

Representatives from academia and industry during a workshop on Modelling South Africa's Future Power System.

INTERNATIONAL COOPERATION

At CRSES we believe that in order to succeed in our field, we need collaborations. The Centre, therefore, collaborates with research universities and other institutes nationwide, on the African continent and at international level.

SOLTRAIN

The Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN) is a regional initiative aimed at capacity building and demonstration of solar thermal systems in the SADC region. The initiative is funded by the Austrian Development Agency (ADA) and co-funded by the OPEC Fund for International Development (OFID).

CRSES in one of two South African Partner Institutions, the other being the South African National Energy Development Institute (SANEDI). The AEE-Institute for Sustainable Technologies (AEE–Intec) is the Austrian implementing agent and conducts the overall management of the project.

The SOLTRAIN initiative began in 2009 and in 2018 was in its third phase, which will end on 30 June 2019. Participating countries include: South Africa, Lesotho, Mozambique, Namibia, Mozambique, Botswana and Zimbabwe.

SOLTRAIN focuses on four crucial areas namely:

- raising awareness of the potential in solar thermal technologies
- building competence in solar thermal technologies
- creating solar thermal technology platforms and
- demonstrating that solar thermal technologies work

To date, SOLTRAIN has co-funded more than 200 solar thermal systems across the participating SADC countries. In addition, SOLTRAIN has provided training on thermosiphon solar heating systems, quality inspection of solar thermal systems and advanced applications of solar thermal technologies.

Visit by Austrian Development Agency

Dr Martin Ledolter, MD of ADA, visited CRSES between 22-23 October 2018. In addition to meetings with CRSES staff, Dr Ledolter visited the Mechanical Engineering Solar rooftop and then toured the sites funded by the SOLTRAIN initiative.

Karin Kritzinger, a senior researcher, and Angelo Buckley, a research engineer at CRSES, accompanied Dr Ledolter to two of the large-scale solar installations in the Western Cape:

- the 120 m^2 solar thermal system at the Cape Brewing Company in Paarl installed during the second phase of SOLTRAIN
- the 100 m^2 solar thermal system at Melomed Hospital in Gatesville, Cape Town installed during the third phase of SOLTRAIN

DAMOC

Funded under the Erasmus+ Key Action 2 (Capacity Building in Higher Education), the Centre, together with Technische *Universität* Dresden, initiated a cooperation project on the Development of a HArmonized MOdular Curriculum for the Smart Grid (DAMOC). Together with two other European university partners in Sweden and Italy, and three other African university partners, two of whom are based in Tanzania, the project aims to develop education programmes on smart grid technology.

Under this initiative, CRSES successfully developed a Masters programme in Smart Grid Technology, housed in the Department of Electrical and Electronic Engineering. The MEng in Smart Grid Technology now offers students an opportunity to qualify in modules on smart grid communications, cyber security, renewable energy systems within smart grids, integrated supply-side and demand-side technologies, and energy storage systems. This programme has already commenced with its first enrolments, and is part of a network of postgraduate programmes offered by members of the consortium, listed below:

Partners:

- **Partner countries in the European Union:**
  Sweden: Karlstad University
  Italy: Universita Degli Studi Guglielmo Marconi - Telematica
- **Partner countries in Africa:**

  South Africa:
  1. Cape Peninsula University of Technology
  2. Stellenbosch University
  3. University of Pretoria

  Tanzania:
  1. The Nelson Mandela African Institute of Science and Technology
  2. University of Dar Es Salaam
- **Associated partner:**
  South African National Energy Development Institute (SANEDI)

During the student exchange part of the programme, Simon Puteanus from TU Dresden came to Stellenbosch University to design printed circuit board to measure the impedance of inverters and transformers connected to the grid. Furthermore, he assisted on the creation of course materials in the field of power electronics for the Structured MEng in Smart Grid Technology at SU.

The student exchange was funded by Erasmus+ in the DAMOC Project as stated in the use of the grant in Section 1.7 - https://eacea.ec.europa.eu/sites/eacea-site/files/guidelines_for_the_use_of_the_grant_cbhe_8.12.16.pdf

Simon Puteanus (left) and Alford Mbongeni Sibanda (right)

AIR

The Academic Initiative for Renewables (AIR) is a three-year initiative aimed at the development of undergraduate and postgraduate programmes in renewable energy at participating African universities. Funded by DAAD, the project consortium is led by Technische Hochschule Ingolstadt (Germany) and includes NMU, University of Malawi, University of Zimbabwe, University of Zambia, Eduardo Mondlane University (Mozambique), Botswana International University of Science and Technology, and Stellenbosch University, represented by CRSES. The project also provides exchange opportunities for students to attend block courses or conduct short-term projects at partner institutions.

The consortium meets twice a year, with workshops scheduled at each of the participating universities. The most recent workshop was held in Stellenbosch from 16-20 April 2018. Besides engaging in the curriculum design and development activities, members had the opportunity to visit the Palmiet Hydropower Plant, the SA Renewable Energy Technology Centre, and a sustainable community project in Belhar. The next meeting was held at the University of Zambia in Lusaka during October 2018. The accompanying table shows the list of project participants:

Status	Partner	Title	Surname	Name
Coordinator	Technische Hochschule Ingolstadt	Prof.	Zörner	Wilfried
Coordinator	Technische Hochschule Ingolstadt	Ms.	Beer	Petra
Partner	Botswana International University of Science & Technology	Dr.	Bader	Tobias
Partner	Botswana International University of Science & Technology	Mr.	Nduse	Russ
Partner	Nelson Mandela University	Prof.	Freere	Peter
Partner	Stellenbosch University	Prof.	Mahomed	Nawaz
Partner	Stellenbosch University	Prof	Mamphweli	Sampson
Partner	Universidade Eduardo Mondlane	Prof.	Cuamba	Boaventura Chongo
Partner	University of Malawi	Mr.	Tenthani	Chifundo
Partner	University of Malawi	Dr.	Masangwi	Salule
Partner	University of Zambia	Prof.	Muya	Mundia
Partner	University of Zambia	Dr.	Zulu	Ackim
Partner	University of Zimbabwe	Mr.	Madiye	Luxmore
Partner	University of Zimbabwe	Mr.	Chikuku	Tauyanashe
Partner	University of Zimbabwe	Mr.	Hove	Tawanda

NICHE Programme

Innovative ways to transfer technology and know-how, developing skills and expertise for gas, renewable energy and management in Mozambique

This programme is run together with Eduardo Mondlane University in Mozambique and the University of Groningen in the Netherlands. The expected outcome of the project is the academic and organisational capacity to develop, implement and maintain a comprehensive education programme in the field of gas and renewable energy, delivering graduates and applied research results that respond to the demands of the labour market and human needs. As part of the programme's PhD training, CRSES supervises 1 PhD student, Miss A Chicombo, from Eduardo Mondlane University, Mozambique. The project runs until May 2019.

ARUA

The ARUA is pursuing its goal of enhancing research and graduate training in member universities through a number of channels, including the setting up of Centres of Excellence (CoEs) to be hosted by member universities. A CoE is defined as "a team, a shared facility or an entity that provides leadership, best practices, research, support and/or training for a focus area."

The **ARUA CoE: Energy** is hosted by Stellenbosch University with Professor Johan Gorgens (Process Engineering, SU) and Professor Sampson Mamphweli (Director: CRSES) serving as co-directors. The aim is to bring together world-class researchers from member universities to undertake collaborative research in Energy, and is therefore an assembly point for good and committed researchers and students seeking to do cutting-edge work, with a specific focus on achieving socio-economic development in the African context.

The ARUA CoE Energy has prioritized the integration of Renewable and Sustainable Energy (RSE) into systems that address the food, nutrition and water supply challenges of Africa. Whereas energy, water and food are often described as stumbling blocks in socio-economic development, the CoE: Energy considers such integration of technologies to offer opportunities for socio-economic advancement through the associated self-sufficiency. Such integration of RSE into water and food supply systems is expected to enable sustainable intensification of agriculture, improved postharvest processing and preservation of foods, and the supply of water, as these are critically dependent on energy availability.

"The aim is to bring together world-class researchers from member universities to undertake collaborative research in Energy"

AIR delegates on a city tour through Stellenbosch

ENERGY RESEARCH PROGRAMME

Introduction

In line with the National Development Plan (NDP), the Department of Science and Technology (DST) seeks to facilitate the achievement of economic development and social equity by including locally developed cleaner energy technology solutions in South Africa's energy system. The DST supports the implementation of government policies and initiatives relevant to clean energy, such as:

- transition to clean energy system,
- mineral beneficiation, and
- climate change mitigation.

Government's intention with these policies and initiatives is to stimulate the growth of new industries that can assist in addressing the triple challenge of unemployment, poverty and inequality.

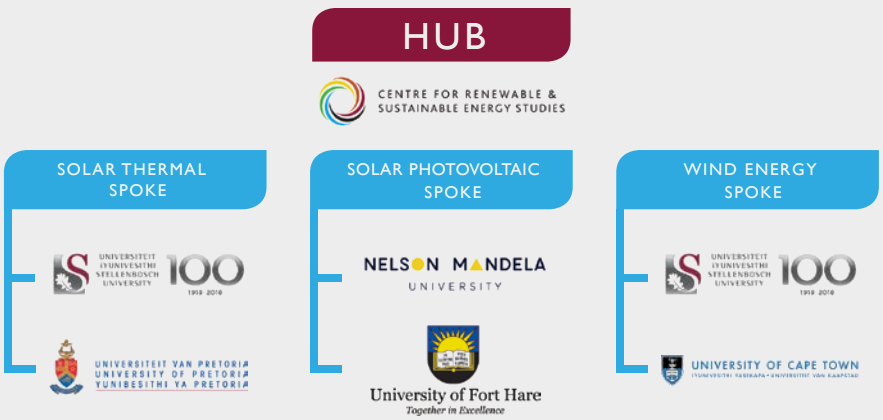
The Energy Research Programme (ERP) is a programme of the Department of Science and Technology, which seeks to develop renewable energy research capacity and expertise within the national system of innovation using a hub and spokes model. The programme focuses on key strategic areas within the renewable energy value chain as follows:

- Deepening knowledge - undertaking research projects for knowledge creation and better understanding of renewable and sustainable energy;
- Technology development and deployment - encompassing all the necessary processes involved in developing renewable energy technologies;
- Human Capital Development - developing the required skills set to service the dynamic energy sector at postgraduate level;
- Market transformation - initiatives with government, industry and academia to assist the energy sector with innovative products and services.

Hub and Spokes model

The Hub-and-spokes model is a collaborative model that recognizes and supports distribution of research capacity and expertise in the renewable and sustainable energy sector, across more than one institution.

The hub is the central institution through which funding, reporting and general activities are coordinated. The spokes are paired institutions which focus on a specifi c area of renewable energy. The current hub and spokes is constituted as follows:



Governance of ERP

The DST is responsible for determining the strategic direction of the energy research programme, assisted by the ERP Advisory Board. The Board has an oversight role to ensure that the programme delivers on strategic objectives in the renewable and sustainable energy sector. The Advisory Board consists of not less than seven (7) or more than nine (9) members comprising of at least the following people:

- Vice Rector: Research and Innovation (Stellenbosch University)
- Vice Dean: Research (Stellenbosch University)
- Director of CRSES
- Representatives of :
  - Faculty of Engineering
  - Department of Science and Technology
  - National Research Foundation
  - Department of Energy
  - The ERP Spokes
  - Industry and Research (Eskom/Sasol/CSIR)

PUBLICATIONS

Articles in peer-reviewed journals

Thapelo Mokomele, Leonardo da Costa Sousa, Venkatesh Balan, Eugéne Rensburg, Bruce E Dale, Johann F Görgens. (2018) *Ethanol production potential from AFEX™ and steam-exploded sugarcane residues for sugarcane biorefineries*, Biotechnology for biofuels, 11(1):127

Timothy Malcolm Baynes, **Josephine Kaviti Musango**. (2018) *Estimating current and future global urban domestic material consumption.* Environmental Research Letter, IOP publishing, https://doi.org/10.1088/1748-9326/aac391

Cheddi Kiravu, François Diaz-Maurin, Mario Giampietro, **Alan C Brent**, Sandra GF Bukkens, Zivayi Chiguvare, Mandu A Gasennelwe-Jeffrey, Gideon Gope, Zora Kovacic, Lapologang Magole, **Josephine Kaviti Musango**, Ulpiano Ruiz-Rivas Hernando, Suzanne Smit, Antonio Vázquez Barquero, Felipe Yunta Mezquita. (2018) *Proposing a Master's programme on participatory integrated assessment of energy systems to promote energy access and energy efficiency in Southern Africa,* International Journal of Sustainability in Higher Education, 19(3):622-641

H Immink, RT Louw, **AC Brent** (2018). *Tracking decarbonisation in the mining sector.* Journal of Energy in Southern Africa 29 (1), 14-23

M Kriechbaum, **AC Brent**, A Posch (2018) *Interaction patterns of systemic problems in distributed energy technology diffusion: a case study of photovoltaics in the Western Cape province of South Africa.* Technology Analysis & Strategic Management 1:15

Mokomele T, Leonardo da Costa Sousa, Bryan Bals, Venkatesh Balan, Neill Goosen, Bruce E. Dale and Johann F. Görgens (2018). *Using Steam Explosion or AFEX™ to Produce Animal Feeds and Biofuel Feedstocks in a Biorefinery based on Sugarcane Residues.* Accepted for publication in Biofuels, Bioproducts & Biorefining

Mokomele T, L da Costa Sousa, V Balan, E van Rensburg, BE Dale and JF Görgens (2018). *Ethanol production potential from AFEX™ and steam exploded sugarcane residues for sugarcane biorefineries.* Biotechnology for Biofuels 11:127

Frank Duvenhage, **Alan C. Brent,** *William Stafford. The need to strategically manage CSP fleet development and water resources: A structured review and way forward.* Renewable Energy. 132. 10.1016/j.renene.2018.08.033.

Conference proceedings

N. Korsten, K. Kritzinger, L. Scholtz, *"Comparative analysis of residential PV installation development across the world"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

K. Kritzinger and T. Covary, *"The Insurance Industry as a Residential Solar Water Heater Driver in South Africa"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

Stephen R. Clark, J. L van Niekerk and J. Petrie, *"Review of large independent electric grid systems transition to renewable generation and its relevance for South Africa"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

W.J. Farmer and Dr. A.J. Rix, *"Current methods for PV generation to participate in the inertial response of a power system"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

K.M. Coetzer, P.G. Wiid and A.J. Rix, *"An investigation into the failure mechanisms of Schottky barrier diodes, specifically when implemented as bypass diodes in photovoltaic modules"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

A.F.W. Steyn and A.J. Rix, *"Investigating the effects of distributed PV generation on electrical distribution grids: A Cape Town residential network case study"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

Nyathi, W., Mouton, H.duT., *"Evaluation of leakage current and inductor ripple current in a transformerless single-phase full-bridge grid-tied PV inverter"*. SAUPEC2018, 24-26 January 2018, Johannesburg, South Africa

Farmer, W.J., Rix, A.J. *"Using inverter-based wind turbine generation to provide virtual inertia for the future South African power system"*. SAUPEC2018, 24-26 January 2018, Johannesburg, South Africa

André Pieter Troost, **Josephine Kaviti Musango, Alan Colin Brent** (2018) *"Strategic Investment to Increase Access to Finance Among Mini-Grid ESCOs: Perspectives from sub-Saharan Africa"*. 2018 2nd International Conference on Green Energy and Applications (ICGEA), 24-26 March 2018, Singapore

E.J.J. Basson, J.E. Hoffmann and **A.B. Sebitosi**, *"Design and testing of externally finned tube cavity receiver for Brayton cycle preheating purposes"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

O.O. Craig, A.C Brent and F. Dinter, *"Expert elicitation of the impact of R&D budget on CSP in South Africa"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

D. Grobbelaar, *"Improving the heat transfer characteristics of the spiky central receiver air pre-heater (SCRAP) using helically swirled fins"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

M. Lubkoll, S.A.C. Hockaday, T.M. Harms, T.W. von Backström, L. Amsbeck and R. Buck, *"Integrating solar process heat into manganese ore pre-heating"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

D. McDougall, T.W. von Backström, M. Lubkoll and **A.B Sebitosi**, *"Jet impingement heat transfer effect on SCRAP"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

C.A. Pan, F. Dinter and T.M. Harms, *"Validation of a Molten Salt Parabolic Trough Receiver Model Based on an Empirical Heat Loss Model"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

C.O. Piessou, M.T.F. Owen and M. Lubkoll, *"Pre-feasibility of incorporating non-concentrating solar thermal energy systems in the Kenyan tea industry"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

R. van der Westhuizen and R.T. Dobson, *"Transient Simulation of a Supercritical Carbon Dioxide (sCO2) Concentrated Solar Power (CSP) System"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

AP Troost, **JK Musango, AC Brent**, *"Strategic Investment to Increase Access to Finance Among Mini-Grid ESCOs: Perspectives from sub-Saharan Africa."* 2nd International Conference on Green Energy and Applications (ICGEA), 2018, Singapore. Publisher IEEE

R.L. Mashiri and B. Bekker, *"Mitigating residential tariff uncertainty: the viability of combining off grid PV and grid supply"*. SASEC 2018, 25-27 June 2018, Durban, South Africa

L.S. Waswa and B. Bekker, *"Impact of PV Small Scale Embedded Generation on South Africa's system Demand Profile"*. SASEC 2018, Durban South Africa, 25-27 June 2018

C.J.J. Labuschagne and M.J. Kamper, *"Performance analysis of direct-drive PM synchronous wind generator for maximum power point direct battery charging"*. International Conference on Electrical Machines (ICEM), Alexandroupoli, Greece, September 2018

C.J.J. Labuschagne and M.J. Kamper, *"Design optimisation and comparison of non-overlap winding PM wind generators for active and passive battery charging systems"*. International Conference on Electrical Machines (ICEM), Alexandroupoli, Greece, September 2018

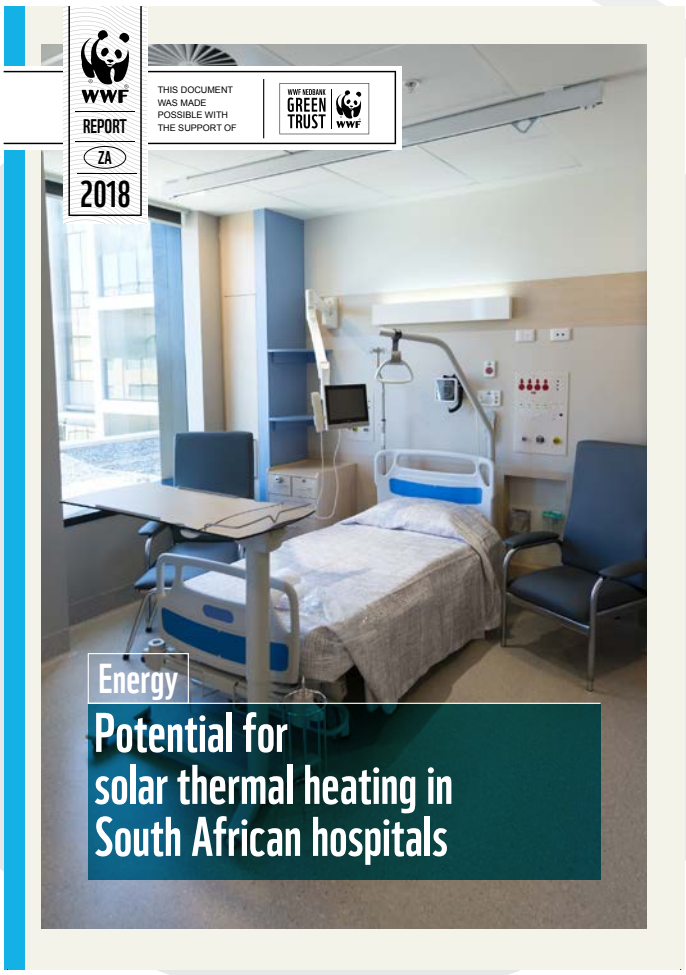
AI Buckley and K Kritzinger, *"The Potential of Large-Scale Implementation of Solar Thermal Technologies in South African Hospitals"*. International Sustainable Energy Conference (ISEC) 2018, 3-5 October 2018, Graz, Austria

T Lambrechts, *"An account on the development of energy audits for Grade 9 Natural Science and Grade 11 Physical Science for the South African school curriculum"*. 36th EEASA Conference, 17-21 September 2018, Livingstone, Zambia

Technical reports

Buckley, D. Fitzgerald, U. Terblanche, K. Kritzinger. *"Potential for solar thermal heating in South African hospitals"*, WWF-SA, South Africa. Online at www.wwf.org.za/report/solar_thermal_hospitals. 2018.

N. Korsten, K. Kritzinger and L. Scholtz. *"Understanding Solar Photovoltaic Investment Decisions in the Residential Sector: Outcomes from the Household Solar Energy Survey"*, WWF-SA, South Africa. Online at www.crses.sun.ac.za/research-publicationstech-reports. 2018.



FINANCIAL POSITION OF THE CENTRE

The Centre has three main sources of income: from the DST, Eskom, and from project and training income. More specifically, the CRSES receives an annual core grant from the Department of Science and Technology (DST); as the Specialisation Centre in Renewable Energy Technology for the Eskom Power Plant Engineering Institute (EPPEI)- Phase2, the Centre hosts the Eskom Chair in Power System Simulation and receives annual funding from Eskom; and the remainder of the income comes from a number of private and public entities for contract research projects, and from short and in-house training courses.

The annual grant from the DST is mainly used to support the appointment of three senior academics at Stellenbosch University, provide bursaries for postgraduate students and contribute to the running expenses of the Centre as well as funding for the renewable energy spokes. In 2018, this grant came to R24,954 million, of which R3,05 million was used for the appointment of staff. These funds include a total of R11,668,000 earmarked for the various spokes, i.e. Solar Thermal Spoke at SU and UP, the Wind Spokes at SU and UCT, the Photovoltaic Spokes at UFH and MNU. Contracts with the respective spokes were finalised and the bulk of the funds has been transferred to the spokes. An amount of R4,383 million was spent on salaries of senior academic staff, and R1,04 million was paid out as bursaries during 2018.

The contribution from Eskom on the EPPEI programme for 2018 was R6,295 million. An amount of R1,07million was spent on bursaries for postgraduate students and R 2,01 million was spent on salaries for the Chair, programme manager, academic staff and an administrative assistant.

The comprehensive income statement of the Centre for all the cost points, including the Eskom EPPEI and project funds, is included on page 22 and 23. The overall income of the Centre until 31 December 2018 was R41,630,813, a substantial increase from 2017 due to the DST funding of the renewable energy spokes that was paid via the Centre. Total expenditure increased to R20,06 million, up from R13,60 million in 2017. The total actual funding available at the end of December 2018 was R17,966 million, as can be seen in the table that follows.

Historically, the Centre showed sustained growth in income from 2007 to 2011. In 2012, the income decreased slightly, mainly due to the decision of the DST to transfer the Renewable Energy Bursary Programme from the Centre to the NRF. In 2013, the income of the Centre more than doubled, predominantly due to the large projects completed for Eskom and GIZ. Due to the project nature of 2013's growth, it was not sustainable, as reflected in the reduced income in 2014 and 2015. This trend again reversed and income to the Centre increased in 2017 and 2018.

"With more than R17 million in reserves, the Centre is in a favourable financial position for 2019."

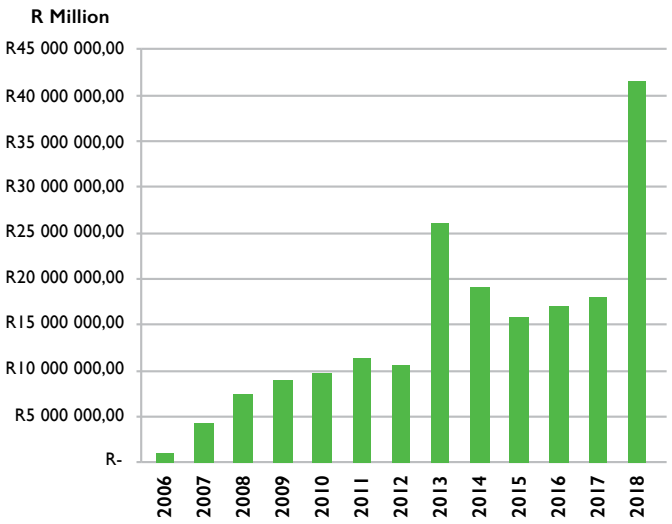
It is however anticipated that the current financial constraints within Eskom will negatively affect the future income of the Centre and it is therefore important that the Centre further diversifies current income streams.

Table 19:

Income and expenses for all cost points of the Centre

	31 Dec 2017 (12 months) (R)	**31 Dec 2018** (12 months) (R)
Total Income to Date	R 17 826 832.66	R41 630 813.96
Total Expenditure to Date	R13 606 825.56	R20 069 794.03
Total Transfers	R2 346 504.60	R8 171 862.23
Total Equipment Acquisitions	R 607 972.89	R88 625.19
Total Postgraduate Bursaries	R 2 672 097.46	R3 210 933.38
Total Remuneration	R5 984 971.84	R 6 927 874.93
Nett Surplus for Period	R1 872 502.50	R13 389 157.70
Accumulated Funds from Previous Year	R8 742 370.59	R6 869 868.09
Debtors Control Account	R1 2316 078.87	R4 761 637.43
Funds Available 31 December	**R7 5161 894.86**	**R17 966 006.34**

Annual income of the Centre



STATEMENT OF INCOME AND EXPENDITURE

Until December 2018

For the period ending :	31/12/2018	31/12/2017
TOTAL INCOME	**-41 630 813.96**	**-17 826 832.66**
CONFERENCE/CONGRESS (NO VAT)	-27 123.77	-49 172.10
CONTRACT RESEARCH (TAXABLE)	-28 902 525.81	-1 439 422.00
DONATION: SPECIAL PURPOSES	-43 859.60	-60 000.00
INCOME FOREIGN EXEMPT	0.00	-148 035.00
INCOME: BURSARY	-930 000.00	0.00
INCOME: FOREIGN_ZERO RATE	-3 123 149.58	-3 035 376.98
INCOME: NRF APPORTIONED	0.00	-5 350 000.00
INCOME: SUNDRY TAXABLE	-1 431 171.61	-2 485 710.27
INTEREST RECEIVE: INTERNAL ALL	-720 891.45	-453 604.12
PROFIT/LOSS: EXCHANGE RATE DEB	0.00	-232.71
PROFIT: EXCHANGE RATE FOREIGN	-946.10	-279.48
SALES: TO INTERNAL ORG UNITS	-19 315.65	-430 500.00
SHORT COURSES	-136 371.68	-194 500.00
SUNDRY INCOME: NON TAXABLE	-6 295 458.71	-4 180 000.00
TOTAL EXPENDITURE	**20 069 794.03**	**13 607 825.56**
CURRENT EXPENDITURE		
ADVERTISEMENTS: GENERAL	44 501.50	31 834.50
ADVERTISEMENTS: POSTS	0.00	144 058.57
AFFILIATION & REGISTRATION EXP	191 754.16	54 239.14
ANALYSIS SERVICES	0.00	4 708.00
BANK COSTS	387.59	0.00
BURSARY POST GRADUATE	3 210 933.38	2 672 097.46
BURSARY UNDERGRADUATE	125 088.76	3 675.00
CELL PHONE AIRTIME	1 315.52	12 028.18
CELL PHONE RENT	335.79	1 864.96
CLEANING COSTS - EXTERNAL FIRM	28 207.65	21 663.84
CLEANING MATERIALS	739.19	911.68
CLEARENCE FEE NON-CAPITAL	7 596.52	24 876.70
CLOTHING: OTHER	0.00	1 134.00
COMPUTER MATERIALS	50 772.84	48 238.00
CONSULTATION FEES	666 080.91	97 151.76
CONSUMABLE MATERIALS	10 852.09	2 304.39
COPY AND PRINTING	39 459.51	67 466.89
COURSES	5 630.64	15 290.00
ELECTRONIC COMPONENTS	9 893.03	0.00
ENTERTAINMENT: GENERAL	113 790.41	57 179.59
FLOWERS (NOT GIFTS)	441.14	0.00
FOREIGN EXCHANGE LOSS	17 459.66	45 632.44
GENERAL VEHICLE EXPENDITURE	0.00	96 673.12
GIFTS	4 271.37	3 641.58
GLASS WARE	0.00	158.63
HANDBOOKS AND MANUALS	0.00	2 433.04
INS, LICENSES & 3RD PARTY	1 115.00	1 168.00
INTEREST PAID: INTERNAL APPOR	0.00	1 364.29
INTERNET NETWORK EMAIL LEVY	56 115.77	50 536.39
IP TRANSFER FEE	0.00	121 439.95
LEVY: ICRR (INDIRECT COST)	3 635 142.73	1 075 861.17
LEVY: SPACE AND FACILITY	1 363.50	589.55
MAINTENANCE BUIDINGS-STELLENBO	0.00	1 578.71
MAINTENANCE OF APPARATUS	750.18	1 242.27
POSTAGE AND COURIER SERVICES	8 453.70	6 689.91
PRIZES AND MEDALS	5 500.00	5 500.00

For the period ending :	31/12/2018	31/12/2017
REFRESHMENTS: ACADEMIC	410.00	0.00
REFRESHMENTS: NON ACADEMIC	65 391.47	94 944.29
RENT OF EQUIPMENT GENERAL	1 233.56	0.00
RENT OF ROOMS	560.87	0.00
RESEARCH MATERIALS	71 904.00	35 952.00
RESERCH CONTRACTCONDUIT PAYME	1 911 750.00	0.00
SCW NON-CAPITALISED	0.00	16 050.00
SERVICES	1 480 427.69	1 291 802.85
SMALLER FURNITUREAND EQUIPMEN	4 564.34	3 807.78
SOFTWARE	39 855.21	35 317.92
SPONSORSHIP/DONATION OUT INSTI	3 500.00	0.00
STATIONERY	29 620.31	19 482.58
SUBSCRIPTION & MEMBERSHIP FEES	10 890.00	23 721.95
SUNDRY EXPENSES	18 575.00	0.00
TELEPHONE: CALLS	10 259.76	8 601.31
TELEPHONE: RENT	19 879.77	15 877.21
TOTAL REMUNERATION	6 927 874.93	5 984 971.84
TRANSLATION AND EDITING	8 374.80	12 656.88
TRAVEL: ACCOMMODATION VISUM PA	218 285.72	200 748.25
TRAVEL: FOREIGN TRAVEL SUBSIST	359 741.95	263 053.69
TRAVEL:DAILY ALLOWANCE AIR CAR	271 353.01	322 158.35
WORKSHOPS	296 190.00	129 682.06
ASSET TRANSACTIONS		
ASSET SCRAPPING/TRANSFERS	-109 075.75	-72 505.31
DEPRECIATION	877 205.32	948 256.90
INCOME: INTERNAL ASSETS	-772 136.89	-1 091 732.29
PROFIT/LOSS: ASSETS	-2 366.59	84 772.70
SALE: MOVABLE ASSETS	-1 052.17	0.00
ASSET PURCHASES	88 625.18	604 972.89
OPERATING (SURPLUS) / SHORTFALL FOR PERIOD	**-21 561 019.93**	**-4 219 007.10**
FUNDS TRANSFERS	**8 171 862.23**	**2 346 504.60**
TRANSFERS FROM	16 498 581.13	7 512 100.28
TRANSFERS TO	-8 326 718.90	-5 165 595.68
NET (SURPLUS) / SHORTFALL FOR THE PERIOD	**-13 389 157.70**	**-1 872 502.50**
Plus: ACCUM (FUNDS) / SHORTFALL ON 01/01/2018	**-8 742 370.59**	**-6 869 868.09**
ACCUM (FUNDS) / SHORTFALL ON 31/12/2018	**-22 131 528.29**	**-8 742 370.59**
Min: BALANCE SHEET ITEMS	**4 165 521.95**	**1 180 475.73**
CREDITOR PROVISION BALANCING	0.00	-68.00
DEBTORS CONTROL ACCOUNT	4 761 637.43	1 216 078.87
ICRR CONTROL	-595 385.40	-35 535.14
LOAN ACCOUNT BRIDGING FUNDS	0.00	0.00
SPACE AND FACILITY CONTROL ACC	-730.08	0.00
FUNDS AVAILABLE ON 31/12/2018	**-17 966 006.34**	**-7 561 894.86**

Issued by

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