

CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

2020 **CRSES** ANNUAL REPORT













FOREWORD

The year 2020 was a year unique. It was business as usual until Monday, March 26 when the country went into a lockdown due to a global pandemic. From this point, we at CRSES, indeed like all institutions world-wide, have had to learn new ways of working. Despite Covid 19, we had a productive year, and have settled into the routines we now consider our new-normal.

CRSES welcomed the addition of four new members to the team who all began their new roles and brought with them a wealth of experience, ideas and new energy. Prof Neill Goosen assumed the Directorship of the African Research Universities Alliance (ARUA) Centre of Excellence in Energy. Dr. Richmore Kaseke, has been appointed as a Senior Research Engineer whose primary focus is to manage the specialist consulting work undertaken at CRSES. Ms Sedzani Ratsibi was appointed as the Commercialisation Manager, and her focus is to ensure that Intellectual Property developed in the Department of Science and Innovation's Renewable and Sustainable Energy Hub and Spokes Programme are taken to market through the appropriate channels. Ms Carmen Lewis was appointed on a part-time basis to manage the Renewable Energy Specialisation Centre (RE-SC) inter-University programme within the Eskom Power Plan Engineering Institute (EPPEI). The EPPEI appointment was necessitated by the move of Ms Karin Kritzinger who is now managing the Energy part of the Fraunhofer Innovation Platform for the Water-Energy-Food nexus at Stellenbosch University (FIP-WEF @SU).

In terms of Human Capital Development, we trained two new interns and continued our research with three Post-doctoral fellows. We also had 29 students graduating, 24 with a Master's degree and 5 with PhDs. We established the Power Systems Research Group (PRSG) realising that the integration of renewable energy into the electrical power system is multifaceted and a peer support network for students conducting related research in the field is necessary. Our renewable energy short courses were well attended, as well as the training workshops for the SOLTRAIN project.

Enabling the uptake of renewable energy is key to the objectives of CRSES. As such, we entered into an Institutional Framework Agreement with the Eastern Cape Rural Development Agency (ECRDA) where we have identified several areas of cooperation pertinent to renewable energy and rural development. This project gives us a unique opportunity to make a real difference in the energy transition currently underway. Also relevant to the Eastern Cape is the launch of solar powered products designed for small business entrepreneurs through Solar Turtle, one of the spin-out companies of the DSI's RSE Hub and spokes Programme. The products are enabling economic activity in areas currently experiencing energy poverty. Through ARUA and FIP-WEF @SU we continue to research cross sectoral solutions for water, energy and food security. Building research capacity in the food-waterenergy nexus is critical, pertinent to the African context.

Although our revenue shows a significant decline, this is only due to a delayed transfer of funding from the SANEDI Energy Secretariat, which is now part of our funding process introduced by the DSI. A new contracting process became necessary, thus delaying the transfer of funds.

Prof Sampson Mamphweli



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. The Centre for Renewable and Sustatinble Energy Studies 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 complete successfully in the global knowledge economy. This is achieved mainly through the training of interns, Masters and PhD candidates as well as Post Doctoral Fellows.

Intern: Mark Reuter

My internship with the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University commenced in April 2019 and ended in March 2020. Completion of the internship ensured that I would obtain my National Diploma in Electrical Engineering from Cape Peninsula University of Technology (CPUT).

During my tenure as an intern I attended two renewable energy courses: Introduction to Solar Energy as well as Advanced Photovaoltaic (PV) systems. Both courses greatly improved my knowledge of renewable energy in general and solar energy in particular.

I began my internship at the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University in August 2020. With lockdown regulations still in place, my first few weeks at CRSES required significant adjusting. Fortunately my mentor, academic supervisor as well as my colleagues were all extremely welcoming and supportive. I have gained significant insight into the general field of renewable energy and have participated in some projects related to contract research. I have in the process learned pragmatic aspects of an engineer's work such as conducting energy audits, solar feasibility studies, tender reviews and reporting back to stakeholders. I am very grateful to have gained insight into the collaborative team work necessary during the process of consulting with clients about potential projects, both in the initial and reporting stages of projects. During the 2021 academic year, I plan to complete the following short courses offered by CRSES:

- · Integrated Supply Side Technologies,
- Integrated Demand Side Technologies and
- Smart Grid Technology Overview.

I expect to gain invaluable information from these courses as I build a holistic understanding of the integration of renewable energy with traditional technologies in South Africa.

During my time at CRSES I was given the opportunity to begin my masters in electrical engineering focussing on thermal unit commitment with a high share of VRE generation using data-driven optimisation methods. This work is done under the supervision of Dr Bernard Bekker and Mr Ndamulelo Mararakanye, whom I have found to be very helpful. In addition to a great academic environment I have also been impressed by the efforts to create a culture emphasising team work. In this regard I particularly enjoyed a recently completed hike in the Jonkershoek nature reserve and a covid-19 sensitive picnic arranged by at CRSES. A personal highlight was the incredible experience of observing the hatching of a spotted eagle owlet on the veranda of the CRSES offices.

Intern:

Ria Xavier

My internship at the Centre for Renewable and Sustainable Energy Studies (CRSES) began in April 2020 and ended in March 2021. During this period I attended a short course on Energy Storage Systems hosted by Dr. Bekker and presented by Prof Bladergroen. I also attended multiple writing workshops hosted by Stellenbosch University. I learned a lot about academic writing during these courses and workshops, and felt more confident in my writing skills. The Energy Storage Systems short course sparked my interest in energy storage as it was highly informative and well presented.



I was given the opportunity to write a conference paper on smart inverter technology and restrictive grid regulations in South Africa, under the supervision of Dr. Bekker, and Dr. Chihota, a Post-Doctoral Fellow at CRSES. Both have given me valuable insight and guidance relevant to approaching research as well as academic writing. I was extremely fortunate to present my conference paper at three events in 2020; namely

- The Power Systems Research Group (PSRG) seminar,
- The Renewable Energy Postgraduate Symposium (REPS)
- The EPPEI Student Workshop

These conferences gave me a chance to present my research and receive valuable feedback from audience members regarding my chosen topic. My confidence relevant to my research and presenting skills has increased due to the experience gained from attending these conferences. I have learned how to defend my research and interact with other senior engineering researchers. I am very grateful for this opportunity given to me by the CRSES as I have grown both professionally and personally.

Post Doctoral Fellow: Dr. Fumni Faloye

Bioenergy continues to show great potential as a renewable alternative to fossil fuel with tremendous growth potential when properly annexed. My research is focused on the development of production technologies for anaerobic digestion of organic wastes for biogas production.

I have been actively involved in research focusing on strategies for enhancing anaerobic digestion while exploring the new potential for biogas technology application in the household, agricultural, and industrial

sectors. Results from these research engagements have yielded positive outputs such as the potential for an integrated anaerobic digestion technology and agroindustrial system to harness the benefit of a circular bio-economy.

My roles also include developing research capacity by providing support to postgraduate students who are also funded by the CRSES on projects that bridge the knowledge gaps in the development of viable bioenergy system and unlocking the potential for biogas production as a source of renewable energy in South Africa.

The support from the Centre has been enormous not only by funding my research but also by providing mentorship and guidance that has helped to broaden my research expertise.

Post Doctoral Fellow: Dr. Justice Chihota

The integration of distributed energy sources (DERs) and the coupling of inverter-based systems to power distribution networks continues to increase. The uncertainties associated with the operation of these new technologies challenge traditional approaches to power system planning, design, and operation. In such a context of uncertainty, probability theory and stochastic processes are needed for accurate and detailed modelling of power system variables and the simulation of random processes in various technical applications.

My research explores the evolution of planning and design techniques in response to the demands of new technologies such as electric vehicles, distributed energy storage, and photovoltaic systems. Building on existing network design tools prescribed in South African's national standards, my research provides application extensions relevant to present-day and future power system operation contexts. The research scope is threefaceted: (1) conducting load research studies for new DERs and load-types, (2) formulating appropriate probabilistic tools for analyzing their technical impact, and (3) developing risk-based decision-making frameworks on network hosting capacity. The outputs from our ongoing research prove to be significantly beneficial to planners and grid-operators encountering critical challenges with executing planning tasks in the face of numerous uncertainties. My research's progress and success have been fueled by CRSES's support in data resources, finances, mentorship, and professional networks. I am also immensely grateful to the Centre's leadership that ensured minimal setbacks to our research work in a challenging period last year.

Post Doctoral Fellow: Dr. Adebayo Adenyika

My engagement with the Centre for Renewable and Sustainable Energy Studies (CRSES) started precisely in June 2020, during the peak lockdown of the covid-19 pandemic. After serving as a research fellow for over a year at the University of Cape Town, I joined the centre as a post-doctoral fellow focussing on renewable energy integration, power system monitoring and power system loss allocation.

In the past few months, I have actively involved in in investigating the problem of allocating losses in a renewable integrated transmission/distribution system, to be able to determine tariffs in a transparent and economical justifiable way.

CRSES, with its facilities in conjunction with Stellenbosch University, has exposed me to a great resource of knowledge relevant to my research. More also the centre has from time-to-time organized career development which exposes me to a great resource of knowledge, relevant to my research.

I have enjoyed working with Dr Bernard Bekker as my principal investigator and the chair of the Renewable Energy Research division of Eskom's power plant engineering institute (EPPEI). He has highly integrated creativity, critical and analytical thinking in me.

As further development of the ongoing research, I intend to investigate the principles of the general power theory (GPT) and the application of Thévenin's theorem in practical power systems, as well as energy management systems, protection, and analysis of the integration of inverter-based generation into distribution and transmission systems. This research forms the scope of my anticipated role as a post-doctoral fellow in the 2021-2022 calendar year.



2020 Graduates

The following students have graduated in March 2020.

Name	Initial	Programme
	March 2020	
Mr Banza	MJ	MEng Structured
Mr Kondo	GK	MEng Structured
Mr Marggraff	Р	MEng Structured
Mr Mondlane	HS	MEng Structured
Ms Moodley	S	MEng Structured
Mr Rae	G	MEng Structured
Mr Richardson	LN	MEng Structured
Ms Simelane Dlamini	NSL	MEng Structured
Mr Stevens	RG	MEng Structured
Mr Sullivan	SP	MEng Structured
Mr Van Romburgh	К	MEng Structured
Mr James	G	MEng Structured
Ms Daniel	F	MEng Structured
Mr Landman	С	MEng Structured
Mr Louw	J	MEng Structured
Mr Ssebabi	В	PhD

The following students have graduated in December 2020.

Name	Initial	Programme				
	December 2020					
Ms Daniel	F	MEng				
Mr Dundas-Starr	М	MEng (Structured)				
Mr Erasmus	DJ	MEng (Research)				
Mr Janse van Vuuren	RJ	MEng (Research)				
Mr Jardine	Т	MEng (Research)				
Ms Rhoda	С	MEng				
Mr Dudley	D	MSc				
Mr Chen	Q	MSc				
Mr Pretoruis	D	MSc				
Mr Khan	A	PhD				
Mr Clark	S	PhD				
Mr Pan	CA	PhD				
Mr Van der Westhuizen	R	PhD				

The Students below graduated with a Postgraduate Diploma in Engineering: **Renewable Energy**

Name	Initial
December 2020	
Ms Bedford	Α
Mr Hanghuwo	WS
Mr Neldje	DS
Ms Allie	S
Ms Van Wyk	JKD
Ms Shipena	HG

Graduated bursary students

	2006- 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
MPhil/MEng/MFor	19	3	6	0	5	2	2	2	8	2	18	67
MSc/MScEng/MCom/MEng (Research)	26	8	10	4	16	15	6	12	7	9	6	119
PhD	4	0	3	2	4	2	I	3	4	3	5	31
Total	49	н	19	6	25	19	9	17	19	14	29	217

EPPEI Collaboration

The following universities of technology or previously disadvantaged universities have been officially collaborated with in 2020 under the EPPEI programme

Name of partner institution	Co-operation Topic	Specialisation Centre Lead	Partner Lead
CPUT	7 students working on Eskom-approved EPPEI research topics	Bernard Bekker	Carl Kriger
СИТ	2 students working on Eskom-approved EPPEI research topics SAURAN station calibration	Bernard Bekker	Herman Vermaak
MUT	SAURAN station calibration	Bernard Bekker	Ewa Zawilska
NMU	2 students working on Eskom-approved EPPEI research topics SAURAN station calibration	Bernard Bekker	Peter Freere Ernest van Dyk
тит	7 students working on Eskom-approved EPPEI research topics	Bernard Bekker	Josiah Munda
UniVen	SAURAN station calibration	Bernard Bekker	Sophie Maluadzi
UniZulu	SAURAN station calibration	Bernard Bekker	Brian Rawlins

Power Systems Research Group established to support EPPEI post-graduate research

Post-graduate research's aims are not only the generation and consolidation of new knowledge, but also the building of human capacity to support current and future industry and academic activity. This fact was recognised in the establishment of EPPEI, where the building of human capacity is central to the objective of finding solutions to Eskom's technical challenges.

The SC-RE funds and coordinates the study of more than 60 post-graduate students at a variety of South African academic institutions. Interaction with these students have identified a potential challenge: the post-graduate student's journey to graduation risks being insular and lonely, with interaction limited to the academic supervisor and one or two mentors in industry. This challenge is especially prevalent in multi-faceted and multidisciplinary research fields such as the integration of renewable energy into the electrical power system, where the likelihood is low of strong peer support networks, based on closely related research topics.

To address this challenge, a group of academic supervisors came together to form the Power Systems Research Group, with the following aims:

- to support the establishment of a "community of practice" or peer support network amongst students in the field,
- to provide a public repository of published research by the group,
- to train students to become subject matter experts able to clearly communicate ideas and contribute meaningfully within a collaborative environment, and
- to provide a central point of entry for power systems research expertise.

In order to achieve these aims, weekly Zoom-based research seminars have been held since end January 2020, where students present their work to their peers, academics and members of industry.

A website has also been launched for the Power Systems Research Group, where the group's focus areas and publications are presented and disseminated:

grid.sun.ac.za



Secured funding and started the project to establish the EPPEI / GIZ power system planning and operations capacity building programme

EPPEI SC-RE secured R8 million of GIZ funding to develop and present a series of subsided continuing professional development (CPD) and post-graduate (PG) diploma courses to Eskom and municipalities, targeting 350 attendees by June 2022.

The aim of this programme is to build power system planning and operation capacity within South African industry and government, specifically acknowledging a future power system with significantly increased amounts of VRE generation.

The programme will offer short learning courses closely aligned to real-world industry applications, presented at NQF8 level (i.e. honours / fourth year post-matric) and integrated into existing EPPEI training offerings to ensure sustainability.

> "Post graduate research's aims are not only the generation and consolidation of new knowledge, but also the building of human capacity"



Site visit briefing

TRAINING

Continuous learning structured in a flexible manner is key to staying abreast of today's fast changing engineering landscape. CRSES acknowledged this fact back in 2013 already, when the Centre was instrumental in launching the Renewable and Sustainable Energy post-graduate programmes within mechanical and mechatronic engineering department. The offering has been broadened to include programmes in Electrical and Electronic Engineering as well as the School of Public Leadership.

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 course attendance in 2020

Module	Total	Coursework	Research	Staff	Executives
Smart Grid Technology Overview	19	18	0	I	0
Renewable Energy Systems	14	12	0	0	2
Integrated Supply Side Technologies	14	П	0	0	3
Bioenergy	15	14	0	0	I
Advanced PV Systems	25	18	0	0	7
Wind Energy	20	18	0	0	2
Ocean and Hydro Energy	13	13	0	0	0
Energy Storage Systems	37	24	0	0	13
Total students trained 2020	157	128	0	I	28

SOLTRAIN: Train the Trainer Course

CRSES offers training and support on renewable energy software. The 2nd Train the Trainer Course was hosted by the Centre for Renewable and Sustainable Energy Studies (CRSES) and AEE-Intec as part of the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN). The course was presented at the Stellenbosch Institute for Advanced Study (STIAS) on 17 and 18 September 2020. Seven delegates from local solar thermal installation companies in the region as well as AEE-Intec attended the course. Mr Rudi Moschik from AEE-Intec was the presenter.

The course material covered technical aspects of solar thermal systems for small- to large-scale applications and was aimed at providing attendees with the necessary skills for effectively designing and dimensioning systems. Furthermore, the course was used to train local installers on the use of solar thermal simulation programmes as well as methods for conducting energy audits.

This training course was the second of three to be hosted by the CRSES during Phase 4 of the SOLTRAIN project, which will be in effect from 1 July 2019 to 31 December 2022.

SOLTRAIN: Workshop on Solar Heat for Policy Makers

The 2nd SOLTRAIN Workshop for Local Government Policy Makers on Solar Heat was held at Workshop 17 in the V&A Waterfront, Cape Town on 17 November 2020. This workshop was aimed at exploring and discussing opportunities for accessing and mobilising funds for the implementation of the solar thermal roadmap developed for South Africa.

The workshop was attended by representatives from the Western Cape Government (WCG) the Department of Human Settlements, the Department of Health, as well as representatives from the City of Cape Town Metropolitan Municipality (CoCT) and the South African Renewable Energy Business Incubator (SAREBI). Mr Dave Liddell, from Solarex SA, presented the company's profile and project experiences of solar thermal installations for the local housing sector.



Training at Mariendahl Farm

RENEWABLE ENERGY RESEARCH AND 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.

SOLTRAIN Information & Support Workshop for Western Cape Government: Health

The SOLTRAIN Information and Support Workshop for the Western Cape Government (WCG) Department of Health was hosted on I3 March 2020 at Karl Bremer Hospital in Cape Town, South Africa. The workshop was presented by Mr Angelo Buckley from the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University. The workshop was attended by technical representatives from the WCG Department of Health, with the capacity of planning and implementing the first solar thermal demonstration which could potentially be co-funded by the SOLTRAIN project. Mr Dave Liddell from Solarex SA, a recognised solar thermal installing within the SOLTRAIN project, also attended the workshop and presented about the company's experiences on large-scale solar thermal installations for the healthcare sector in the country.

The workshop was aimed at providing the WCG Department of Health with the necessary information about:

- I. the SOLTRAIN project and its opportunities;
- 2. the potential of solar thermal technologies for solar cooling and heating at hospitals,
- **3.** the technical and financial considerations for the implementation of these technologies in hospitals;
- 4. share research done at the university through SOLTRAIN relating to solar thermal technologies for hospitals in South Africa;
- 5. showcase the performance of SOLTRAIN demonstration systems at hospitals in the region and
- 6. discuss challenges and opportunities for WCG: Health relating to the implementation of solar thermal technologies at their hospital facilities.

The workshop was well received by participants from the WCG Department of Health, where the focus has now been shifted to identifying the most suitable hospital with technical assistance from the CRSES to potentially implement a first demonstration system.

CRSES and Eastern Cape Rural Development Agency agree to collaborate on strategic development projects

The Centre for Renewable and Sustainable Energy Studies (CRSES) and the Eastern Cape Rural Development Agency (ECRDA) have entered into an Institutional Framework Agreement. The two entities will be collaborating on energy related projects relevant to rural development. Several areas of cooperation have been identified. Among these is research, innovation and development in the areas of:

- Renewable energy uptake in rural areas
- Grid Integration of Renewable Energy as well as Grid stability studies
- Smart Grids, Mini Grids and Smart Energy Systems
- Energy Efficiency and Demand Side Management
- Strategic projects that seek to promote water, food and energy security (Water-Food-Energy nexus).

"Rural Development presents unique opportunities for the uptake of renewable energy" says Prof Sampson Mamphweli, Director of CRSES, who believes collaborations of this kind are beneficial and pertinent to development in South Africa.

The two organisations will also jointly package projects that require funding, collaborate on community-oriented research and innovation and coordinate strategic initiatives in the Eastern Cape.

From 28 – 29 October, a delegation from the ECRDA visited several research project sites at Stellenbosch University including a wind turbine testing station, heliostats, a photovoltaic technology research project, a biogas digestor, as well as solar water heater research and testing sites. Visiting delegates from ECRDA included Mr Zingisa Somlotha, Anchor for the Green Energy and Biofuels project, as well as Mr Roger Maclachlan who provides technical oversight to the Green Energy and Biofuels project. Also present in the delegation was Mr Vuyani Somyo Chief Executive Officer at Thapi Aqua-Kulcha. The site visits were followed by further discussions to concretise collaboration plans.

On 29 Novemeber to 04 December 2020, a team from The CRSES visited several sites in the Eastern Cape. The delegation was split into two groups in order to visit as many projects as is possible.

The first group visited the following sites:

- Mqanduli RED Hub
- Mbizana RED Hub
- Magwa Tea project
- Majola Tea Estate

The second group visited the following sites

- Ntabakandoda biodigester project
- Upper Blinkwater renewable energy project
- Cradock
- Emalahleni RED Hub
- Ncora RED Hub
- Zigudu Feedlot

The ECRDA is tasked with formulating, promoting and ensuring the implementation of a comprehensive Integrated Rural Development Strategy for the Eastern Cape province. (See <u>www.ecrda.co.za</u>). With climate change being a global reality and energy being central to development, the partnership with a research institution such as CRSES seems appropriate.

EPPEI Research area progress in 2020

The EPPEI Specialisation Centre for Renewable Energy and Power System Simulation (SC-RE) is situated within the Centre for Renewable and Sustainable Energy Studies (CRSES) in the Faculty of Engineering at Stellenbosch University. Stellenbosch University has established itself as the foremost university in South Africa in the area of renewable energy research, education and training. CRSES completed its fourteenth academic year in 2020, and acts as an ideal host for the SC-RE due to its academic footprint and close collaboration with industry and government.

In April 2020 the Renewable Energy Specialisation Centre research roadmap was completed. The research focus defined in this new roadmap has largely move away from renewable energy generation technology towards a focus on the impact of variable renewable energy on the power system. The majority of SC-RE's research themes for the next 5 years will therefore be executed under the PSS roadmap, detailed in the most recent version of the EPPEI PSS IUP Research Roadmap document.

Research themes important to Eskom were however identified that do not exist / fall within the PSS research scope. These themes have been identified in consultation with the SC-RE's Industrial Coordinator as follow, and will be the research focus for the SC-RE in 2021 along with the identified PSS research areas:

Mini- and microgrids. Renewable Energy-based off grid and grid-connected mini- and microgrids offers an alternative to national grid-only solutions in a variety of applications, including

- rural electrification,
- grid-connected solutions for increased resilience given increasing severe weather events,
- grid-connected solutions for increased power availability during load shedding, conditions of network constraint, etc,
- as a mechanism in municipalities to reduce the impact of pricing misalignment between their supply (from Eskom) and demand (regulated consumer tariffs) which has been identified as one of the contributing factors to municipal debt to Eskom,
- and other emerging opportunities driven by falling energy storage costs and a general movement away from centralised towards distributed energy resources.

Eskom-owned or operated renewable energy and energy storage plants. The SC-RE will in general not focus on generation technology research, based on the perspective that South Africa in general and Eskom specifically will typically procure such technologies from OEMs. The planning, design, operation & maintenance of existing (like Sere wind farm and various PV arrays) and future (possibly projects flowing from the REIPPP) Eskom renewable energy plants is however an important aspect covered in this research and includes, but is not limited to:

- protection designs and standards ranging from lightning design to personnel safety,
- financial viability modelling based on pricing, optimal site location, etc,
- maintenance aspects linked to plant condition monitoring and digital twin operational models,

Concentrated solar technology applications. Within

Stellenbosch University internationally recognised capabilities and expertise exists in concentrated solar technology, through its STERG entity. Eskom indicated an interest in continued research on ways in which such technologies can be utilised in economically viable applications like desalination, generation of hydrogen, and food production.

End-of-life considerations for renewable energy

technologies. PV panels, wind turbines, power electronics and energy storage technologies are designed for maximum operational lifetimes, but once their end-of-life is reached these technologies need to be safely decommissioned to mitigate potential environmental and safety threats. Such disposal can take many forms including recycling and 'second-life' applications. Further research is required into the various aspects associated with the end-of-life state of renewable energy technologies, as seen from the perspective of Eskom as current and future owner and operator of such technologies. The research covers a wide scope, from quantifying the impacts and risks of incorrect disposal, to technical, financial, regulatory and business-development aspects.

Beneficiation of locally mined or produced materials within the renewable energy value chain. A number of materials mined or produced in South Africa have the potential to play a central role in international renewable energy technology value chains, for example vanadium as primary component of Vanadium-Redox Batteries' electrolyte. The various opportunities and hurdles to maximising the beneficiation of such materials for South African industries, and specifically the role that Eskom can play in realising this beneficiation, will be a research focus area of the SC-RE.

Repurposing of coal-fired power plants. Several of Eskom's coal-fired power plants are scheduled for decommissioning in the next decades. This represents opportunities for the repurposing of sections of these plants to support the future power system, for example by using turbines as synchronous condensers, or by converting the power plant through the addition of molten salt-based technology into a grid-connected thermal energy storage unit. Research are required on various levels, from system level answering questions on the efficiency / feasibility of such repurposing concepts, to sub-system level challenges such as the practicalities and cost of transporting molten salts at high temperatures over distances within the power plant.



Site visit at Upper Blinkwater in the Eastern Cape

The Centre's Schools Programme

At CRSES we realise that it is imperative to raise children's awareness of climate change and renewable energy. As such the Centre has 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
2008	3	3	
2009	18	27	
2010	119	117	
2011	72	110	
2012	30	40	
2013	99	103	
2014	277	376	230
2015	73	167	963
2016	88	146	70
2017	20	52	546
2018	88	149	961
2019	15	18	183
2020	26	41	0
Total	904	1,347	2,878



Delegates on a technical tour

Renewable Energy Training for Educators in Limpopo

CRSES together with University of Venda (Univen) organised a renewable energy teacher training workshop in Limpopo. The workshop was held over two days from 5 to 6 March 2020. Participants were educators of physical sciences, mathematics, life/natural sciences and geography from the Vembe district. The workshop is designed to create awareness and improve/transfer knowledge on renewable energy to educators. A total of 41 teachers from 26 schools in the region were in attendance on the 1st day which was held at UNIVEN Sports hall.

Simnikiwe Gulwa from CRSES facilitated the workshop, focussing on various renewable energy technologies including solar, wind, hydro, geothermal, and bio energy. Energy efficiency as well as an overall overview on energy were also presented. The workshop is part of wider advocacy by CRSES to have renewable energy become part of the school curriculum thereby increasing interest in the sector long before tertiary education. Teachers in attendance agreed that renewable energy would be a valuable addition to the curriculum.

The second day of the workshop was a technical tour of the Vele school situated in Gogogo village outside Mutale. A total of **39** teachers attended the tour. Vele school is an example of excellent sustainable design. Passive low energy design principles were followed in the building of the school, renewable energy is used (solar panels and anaerobic digesters), rain water is harvested, and grey water is recycled. The teachers experienced practical demonstrations of the material covered the previous day.

Department of Science and Innovation Schools Project

A team of engineers from CRSES, led by Prof Sampson Mamphweli and Dr Bernard Bekker, made a visit to two schools currently under the Department of Science and Innovation (DSI) schools' project. These included Vuwani and Vele Secondary schools, located in Limpopo.

The purpose of the visit was to carry out a walk-through audit to assess the energy requirements for Vuwani Secondary School. Plans are currently underway to build a PV system for the school in order to offset the cost of energy for the school. During the visit, the team met and held discussions with the principal on how the school could best use the resources in order to manage the energy bills and increase the utility obtained by the students.

The team then proceeded to Vele school for the installation of a pilot remote energy monitoring system developed at CRSES. Funded by the DSI, this project seeks to spur the development and use of South African innovations in the renewable energy sector. Once completed and commissioned, the monitoring system will allow facilities, in this case the schools, the funders and implementors of the project to monitor energy usage both locally and remotely. This will assist in impact assessment of the project while providing these institutions with accurate information, which in the long run is key to energy management within institutions and development of rural communities.

ASEZ Knowledge Sharing Session

Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN) was represented at the Atlantis Special Economic Zone (ASEZ) Knowledge Sharing Session hosted by the official tourism, trade and investment promotion agency for Cape Town and the Western Cape, WESGRO, on 20 February in Atlantis, Cape Town. The event was aimed at sharing business opportunities in the renewable energy sector with new and aspiring business owners in the region and surrounding communities. Mr Angelo Buckley from Stellenbosch University Centre for Renewable and Sustainable Energy Studies presented the SOLTRAIN project at the event, showcasing its objectives and successes over the years. The event also allowed the opportunity for exhibiting the SOLTRAIN project and sharing material and further information with attendees. Attendees showed a large interest in learning about the project, its potential benefits for ASEZ and communities in Atlantis as well as the solar thermal training courses offered.

Ms Linda Joka, showcased the services conducted by CRSES. This included Training, Awareness building, Research, Consulting services as well as Flagship projects.

Renewable Energy Postgraduate Student Symposium

The IIth Renewable Energy Postgraduate Student Symposium (REPS2020) was hosted virtually by the Centre of Excellence in Carbon-based Fuels of the Faculty of Engineering of the North-West University.

Dr Karen Surridge-Talbot (Centre Manager: Renewable Energy Centre of Research and Development (RECORD/SANEDI)) gave a broad overview of both the global and local energy situation in her keynote address. She specifically highlighted the necessity to expand the contribution of sustainable and renewable energy to the international energy mix to keep the impact of global warming below the 2° level. She also explained the role that load shedding plays in stabilizing South Africa's electricity grid and the need for each individual to use electricity more efficiently and sparingly in our everyday lives.

The virtual nature of the symposium challenged students to develop new skills in presenting their work to a broader virtual audience. Fifty-three postgraduate students presented high-quality research papers on solar energy, wind energy, advanced biofuels, biogas, bio-based chemicals and polymers and integration of renewable energy into South Africa's electricity grid. Presentations on clean coal technologies and carbon capture and storage technologies presented a path to help ease South Africa's transition from a coal-powered economy to a green-powered economy incorporating a wide variety of alternative energy solutions.

Presentations were from various institutions, including North-West University, Stellenbosch University, University of Fort Hare, Vaal University of Technology, Nelson Mandela Metropolitan University and the Centre for Science and Industrial Research (CSIR). A total of 88 attendees attended the virtual symposium, including postgraduate students (45%), study leaders (33%), other interested academics (19%) and representatives from industry (3%). Demographically, 42% of postgraduate students were from previously disadvantaged backgrounds, and 38% were female.

ENERGY RESEARCH PROGRAMME

The Energy Research Programme (ERP) is a programme of the Department of Science and Innovation, which seeks to develop renewable energy research capacity and expertise within the national system of innovation using a hub and spokes model.

Department of Science and Innovation launches solar powered products designed for small business entrepreneurs

On Thursday, 20 August 2020, the Department of Science and Innovation (DSI) launched the Spark range of solar powered mobile kiosks virtually. The Spark products are part of the BabyTurtle Initiative, a partnership between SolarTurtle, the DSI and the South African Energy Development Institute (SANEDI).

SolarTurtle is a spin-off company of the DSI's Energy Research Programme co-ordinated by the <u>Centre for Renewable and</u> <u>Sustainable Energy Studies</u>.

The initial Solar Turtle products are mobile solar kiosk solutions designed using shipping containers. The BabyTurtle products, however are smaller, more affordable solutions designed to supply informal traders and micro-entrepreneurs with power and connectivity.



The SparkBike, a bicycle trailer

Baby Turtle products come in three versions:



The SparkCase which is a suitcase



The SparkCart, a motor vehicle trailer

Minister of Higher Education Science and Innovation, Dr. Blade Nzimande gave the keynote address, emphasising the importance of power and internet connectivity for the informal sector and marginalised communities.

Prof Eugene Cloete, Vice Rector: Research Innovation and Postgraduate Studies, spoke on behalf of Stellenbosch University, giving words of support. Prof Cloete is also the Chairperson of the Board of the Centre for Renewable and Sustainable Energy Studies. Mr James van der Walt, Chief Technical Officer and founder of SolarTurtle believes that the Spark range will make it easier for young people to become the green entrepreneurs the African continent requires.

Prof Sampson Mamphweli, Director of the Centre for Renewable and Sustainable Energy Studies believes that SolarTurtle products are a good example of the relevant innovations emanating from the Energy Research Programme.

Solar executive M com "Connecting offreliable, mobile create untold but for micro entre those in rund

DSI delegation visits CRSES

gation visits CRSES

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SolarTurtle chief executive Ms Lungelwa Tyali commented:

"Connecting off-grid communities to reliable, mobile energy sources will create untold business opportunities for micro entrepreneurs especially those in rural areas and the informal sector."



A wind turbine at Mariendahl farm for wind energy research

At CRSES we believe that in order to succeed in our field, we need collaborations. CRSES, therefore, collaborates with research universities and other institutions on the African continent as well internationally, outside the continent.

ARUA

Capacity Building Project

The ARUA network has partnered with the Grand Challenges Research Fund (GCRF), and each ARUA CoE received an award to build the research capacity of African researchers. The fund supports research to address challenges faced by developing developing countries. The fund is part of the UK's official development assistance, (ODA) and addresses the United Nations sustainable development goals, by maximising the impact of research and innovation to improve lives and opportunity in the developing world.

The ARUA CoE in Energy has set out a program of activities where young African researchers will be engaged and afforded the opportunity to enhance their research skills and capabilities, firstly through some of the structured courses designed and presented by the <u>African Centre for Scholarship at Stellenbosch University</u>, and secondly by giving opportunity for 'learning-while-doing', where young researchers will participate in research projects and learn from seasoned African academics while doing so. Through this programme, the ARUA CoE hopes to contribute toward the development of some of the promising young African academics, strengthen the renewable energy research on the continent, and build lasting partnerships between African institutions.

The EcoAfrica Project

The EcoAfrica project aims to enhance agricultural output on smallholder farms by employing agro-ecological techniques. EcoAfrica is an intergrated research project that will be conducted in a collaborative, multidisciplinary manner and at a multiscale level. The holistic approach is used to address diverse constraints faced by family-run farms in Africa today. It can make a meaningful contribution to certain critical issues by promoting agro-ecological measures such as diversitification of farming activities and intergrating biomass resource management into family farms and the agrarian system as a whole.

The role of Stellenbosch University in the project via the ARUA Centre of Excellence, is to investigate what contribution anaerobic digestion technology can make toward achieving this aim. Anaerobic digestion technology lends itself to small-scale agricultural systems, where it can convert spare biomass into renewable energy and fertilizer, and can therefore possibly improve farming economics. The project sets out to determine whether such benefits can be realized in South African and Madagascan smallholder farming systems, and what the potential impacts of anaerobic digestion are on the farming system as a whole.

Utrecht University Collaboration

The ARUA CoE in Energy is collaborating with Utrecht University on a project to determine possible pathways to utilise biomass for energy generation, and to quantify the environmental impacts of these different pathways. The work specifically investigates whether alien invasive trees in the Eastern Cape can be profitably converted into energy products, and to apply life cycle assessments to indicate which pathway is the most environmentally friendly. Stellenbosch University is busy engaging a wide range of stakeholders to contribute toward meaningful results for the Eastern Cape province.

> "The ARUA CoE hopes to strengthen the renewable energy research on the continent."

> > The EcoAfrica Project

FIP

The FIP-WEF@SU was established in 2020 by Stellenbosch University (SU) and the Fraunhofer-Gesellschaft (Fraunhofer). The aim of this long-term cooperation is to jointly develop needs-based technological and cross-sectoral solutions for water, energy and food security.

The FIP-WEF@SU develops systemic solutions in integrated environmental protection for industry, cities and regions. The field of activity extends to the development of concepts, processes as well as individual technologies and products with the aim of achieving the highest possible resource efficiency, keeping recycling management in mind.

SU is a leading research university in South Africa and Fraunhofer is one of Europe's leading research organisations serving the needs of society and industry.

Through the FIP-WEF@SU, SU's Faculties of Engineering, Science and AgriSciences, under the auspices of the SU Water Institute (SUWI) and the Centre for Renewable and Sustainable Energy Studies (CRSES) collaborate with the SysWasser and Energy Alliances of Fraunhofer to share resources and co-develop project proposals.

Within the FIP-WEF@SU, SU and Fraunhofer cooperate in project areas related to materials, processes and technologies relevant to the Water-Energy-Food-Nexus, to enable the implementation of research in industry, the improvement of the quality of life for all the people of Africa, as well as the training of technical and research staff. Applied- and demand-oriented research and development is jointly promoted through close cooperation with industry and within the framework of publicly funded projects. The FIP-WEF@SU covers the entire innovation chain from basic research to industrial implementation.

The FIP-WEF@SU develops systemic solutions in integrated environmental protection for industry, cities and regions. The field of activity extends to the development of concepts, processes as well as individual technologies and products with the aim of achieving the highest possible resource efficiency, keeping recycling management in mind.

Main focus areas of the FIP-WEF@SU;

- Joint research projects within the FIP-WEF@SU and at various Fraunhofer Institutes to gain new knowledge based on specific technology development areas and requests from industry, application of knowledge already gained to specific areas, joint development of products and services, and production procedures;
- Testing and pre-production piloting of new technology and processes at Fraunhofer Institutes and the FIP-WEF@SU, and development of application-oriented procedures;
- Joint evaluation of, and expert opinions on general or specific problems;
- International research programs (funded by province/state, federal, or other sources);
- · Joint lectures and training courses on selected topics;
- Student and academic exchange programs;
- Commercialisation and Technology Transfer of the Intellectual Property developed as part of the research; and

The FIP-WEF@SU was officially established with signing of the agreement in Stellenbosch in February 2020 by the President of the Fraunhofer Gesellschaft, Prof-Dr Reimund Neugebauer and the Vice-Rector (Research, Innovation & Postgraduate Studies), Prof Eugene Cloete.

The official kick-off meeting of the FIP-WEF@SU took place online in May 2020 and the first online strategic workshop was conducted in July 2020.

Visit: fip.sun.ac.za.



Damoc

Funded under the Erasmus+ Key Action 2 (Capacity Building in Higher Education), CRSES 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, 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.



Students studying smart grid technologies.

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CRSES has three main sources of income:

A core grant from the **Department of Science and Innovation**, annual funding from **Eskom**, and income from **research projects and short courses** offered.

CRSES received a core grant from the Department of Science and Innovation. The annual grant from the DSI is mainly 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 2020 this grant came to R26 921 975.49 and a total of R19 377 464,13 was paid to the Centre. This includes a total of R 8 154 000.00 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. An amount of R9 781 334.11 was spent on salaries of chair, senior academic staff and administrative staff. R3 867 766.54 was paid out as postgraduate bursaries. An amount of R7 544 511.36 remains at SANEDI and the funds will be paid over fully once the RE Hub and Spokes commercialization plan is approved.

The contribution of Eskom to the EPPEI programme for 2020 was R6 724 605.63. An amount of R1 751 705.40 was spent on bursaries for postgraduate students and R2 084 974.86 was spent on salaries for the Chair, Programme manager, other academic and an administrative staff.

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 comprehensive income statement of the Centre for all cost points, including Eskom EPPEI and project funds, is included on page 22 and 23. The overall income of the Centre until December 2020 was R12 360 145.32. This is due to the late payment of the DSI Funding of R19 377 464.13 that was only received in the beginning of 2021 and the R7 544 511.36 that still needs to be allocated to the Centre.

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:

Funds available at CRSES

	31 Dec 2019 (12 months)	31 Dec 2020 (12 months)
Total Income to Date	R39 662 197.77	RI2 360 145.32
Total Expenditure to Date	R22 094 979.47	R25 421 813.21
Total Transfers	R8 504 351.54	RI 553 931.48
Total Equipment Acquisitions	R45 235.59	R193 549.74
Total Post-graduate bursaries	R3 867 766.54	R4 706 631.00
Total Remuneration	R7 769 213.28	R9 781 334.11
Nett Surplus for period	R9 062 866.76	RI4 615 599.37
Accumulated funds from previous year	R22 219 447.00	R 31 282 313.76
Funds available 31 December	R3I 282 3I3.76	R 16 666 714.39



Annual income of the Centre

STATEMENT OF INCOME AND EXPENDITURE

Until December 2020

For the period ending :	31/12/2020	31/12/2019
TOTAL INCOME	(12 360 145.32)	(39 662 197.77)
CONFERENCE/CONGRESS	(17 764.00)	(15 000.00)
CONTRACT RESEARCH	(200 000.00)	(919 826.09)
INCOME FOREIGN EXEMPT	(1 079 341.87)	(902 411.05)
INCOME: BURSARY	-	(2 355 000.00)
INCOME: DST	-	(25 958 698.45)
INCOME: FOREIGN	(2 642 819.79)	(1 190 601.14)
INCOME: SUNDRY	(128 662.71)	(631 132.10)
INTEREST RECEIVE: INTERNAL	(831 100.93)	(943 672.97)
PROFIT/LOSS: EXCHANGE RATE DEB	(7 128.39)	-
PROFIT: EXCHANGE RATE FOREIGN	(3 145.81)	(1 735.48)
SALES: TO INTERNAL ORG UNITS	(252 261.19)	(14 000.00)
SHORT COURSES	(273 315.00)	(270 380.00)
SUNDRY INCOME	(6 924 605.63)	(6 459 740.49)
TOTAL EXPENDITURE	25 421 813.21	22 094 979.47
CURRENT EXPENDITURE		
ADVERTISEMENTS: GENERAL	24 725.00	70 950.00
AFFILIATION & REGISTRATION EXP	207 791.81	159 128.79
AUDIT FEES: EXTERNAL	44 212.50	93 820.00
BURSARY POST GRADUATE	4 706 631.00	3 867 766.54
BURSARY UNDERGRADUATE	30 000.00	137 065.00
CELL PHONE AIRTIME	1.74	470.5
CELL PHONE RENT	3 948.07	583.53
CLEANING COSTS - EXTERNAL FIRM	35 743.61	33 628.85
CLEANING MATERIALS	3 045.12	8 9.27
CLEARANCE FEE NON-CAPITAL	-	5 396.23
COMPUTER MATERIALS	5 877.15	-
CONSULTATION FEES	018 932.62	544 629.56
CONSUMABLE MATERIALS	5 312.63	2 972.92
COPY AND PRINTING	32 805.29	59 802.04
COURSES	-	13 928.26
ELECTRONIC COMPONENTS	6 363.62	99.00
ENTERTAINMENT: GENERAL	21 597.86	34 592.07
FOREIGN EXCHANGE LOSS	121 482.93	27 245.84
FUEL	2 089.66	620.55
GENERAL OFFICE COSTS	2 999.00	696.53
GENERAL VEHICLE EXPENDITURE	135.00	120.00
GIFTS	980.00	2 354.88
INDIRECT COST	439.17	2 622 106.52
INSURANCE AND LICENSES	I 308.34	63 614.47
INTEREST PAID: INTERNAL	80.07	177.41
INTEREST: CREDITORS	<u>-</u>	185.62
INTERNET NETWORK EMAIL LEVY	62 332.60	70 192.50
LEVY: SPACE AND FACILITY	-	(0.02)
LIQOUR AND SOFT DRINKS	I 082.48	-
MAINTENANCE OF APPARATUS	24 562.53	-
	_	730.00

For the period ending :	31/12/2020	31/12/2019
PHOTOGRAPHIC EXPENDITURE	100.00	160.00
POSTAGE AND COURIER SERVICES	20 829.56	5 336.46
PRIZES AND MEDALS	-	2 500.00
PROMOTION MATERIAL	1 315.89	-
REFRESHER COURSES AND SEMINARS	-	2 800.00
REFRESHMENTS: ACADEMIC	-	1 014.00
REFRESHMENTS: NON ACADEMIC	18 515.07	112 457.64
RENT OF EQUIPMENT GENERAL	14 584.52	6 173.19
RENT OF ROOMS	16 699.05	49 053.80
RESEARCH CONTRACT CONDUIT PAYMENT	5 655 799.15	3 170 500.00
ROADS AND PARKING EXPENDITURE	-	200.00
SERVICES	I 403 I33.69	64 95 .5
SMALLER FURNITURE AND EQUIPMENT	102 378.74	10 692.64
SOFTWARE	147 647.87	84 073.70
STATIONERY	20 656.87	22 380.15
SUBSCRIPTION & MEMBERSHIP FEES	21 363.13	18 098.61
TELEPHONE: CALLS	4 682.76	11 007.29
TELEPHONE: RENT	26 620.23	23 564.28
TOTAL REMUNERATION	9 781 334.11	7 769 213.28
TRANSLATION AND EDITING		22 045.00
TRAVEL: LOCAL	132 451.45	206 994.50
TRAVEL: FOREIGN	176 325.45	199 808.28
TRAVEL:DAILY ALLOWANCE	124 947.38	415 296.59
WORKSHOPS	84 078.75	457 313.05
ASSET TRANSACTIONS		
PROFIT/LOSS: ASSETS	(680.00)	(586.96)
ASSET PURCHASES	193 549.74	45 235.59
OPERATING LOSS/(SURPLUS) FOR THE YEAR	13 061 667.89	(17 567 218.30)
FUNDS TRANSFERS	1 553 931.48	8 504 351.54
TRANSFERS FROM	39 535.46	20 293 552.74
TRANSFERS TO	(9 837 603.98)	(11 789 201.20)
NET LOSS/(SURPLUS) FOR THE YEAR	14 615 599.37	(9 062 866.76)
Plus: ACCUM FUNDS AT THE BEGINNG OF THE YEAR	(31 282 313.76)	(22 219 447.00)
ACCUM FUNDS AT THE END OF THE YEAR	(16 666 714.39)	(31 282 313.76)

ÆllyJ

Reinet Uys: Director Financial Services

27/2/2021 Date

STAFF



Director



Associate Director



Prof. Neill Goosen Director: Arua



Ms Karin Kritzinger Researcher



Mr Ndamulelo Mararakanye **Research Engineer**



Mr Angelo Buckley Research Engineer



Mr Donald Fitzgerald Research Engineer



Nikkie Korsten Researcher



Mr Simnikiwe Gulwa Engineer



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