



# CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES











# CONTENTS

ForewordI	
Building human capital	
Training6	
Renewable energy market transformation projects 8	
Awareness and outreach	
Research contribution	
International cooperation	
Publications	
Financial position of the Centre	
Statement of income and expenditure	
Staff	

Contact details









### FOREWORD

The Centre for Renewable and Sustainable Energy Studies at Stellenbosch University (SU) was established in 2007 as the national hub of the Postgraduate Programme in Renewable and Sustainable Energy Studies. The Centre acts as a central point of entry into SU for the general field of renewable energy and its research focus includes solar, thermal and photovoltaic systems; wind, geothermal and bioenergy, and using the ocean as source of energy. Our projects range from initial feasibility studies for the deployment of renewable energy to highly technical studies on specific technologies. In this respect, innovation and building human capital in the field are seen as two of the main contributions made by the Centre.

In 2016, the Centre completed its tenth academic year. After one decade we can look back on a very productive period over which 122 students graduated with master's degrees and 16 with doctoral degrees – a truly remarkable accomplishment. The Centre established itself as the best known research centre in renewable energy based at a university in South Africa, and is also internationally acknowledged as a centre of excellence in certain renewable energy disciplines. In the 2016 academic year, nine postgraduate modules were presented, including general modules on renewable energy technology, policy and finance, as well as specialised modules on advanced solar photovoltaic systems and bioenergy. A total of 21 students received bursaries from the Centre in 2016. Nine students graduated; eight with master's degrees and one with a doctoral degree. Eleven peer-reviewed journal papers and 31 conference papers were published.

This is the eleventh annual report of the Centre and spans the period I January to 31 December 2016. It presents an overview of our activities as we look back on 2016 as a year of extending our international collaboration. We were able to meet and exceed the targets set by our various stakeholders because of strong, motivated students and hard-working, well-qualified staff. To them I express my sincere appreciation and gratitude because only with motivated people can an organisation reach and exceed its goals.

The main assets of the Centre remain the excellent staff, both those employed by the Centre as well as the other academics and researchers associated with the Centre, the excellent facilities at Stellenbosch University, and the dedicated students at the different universities cooperating with us.

We look forward to an even more exciting 2017 that will include a number of changes at the Centre. We trust that you will find this report interesting and inspiring to read.

21.2

Prof Wikus van Niekerk Director: Centre for Renewable and Sustainable Energy Studies 4 May 2017





### BUILDING HUMAN CAPITAL

### The Centre's schools' programme

The schools' programme was developed to address socioecological issues; risks of climate change and the accompanying environmental impact; as well as the need for a sustained energy supply in South Africa. It focuses on two of the 17 Sustainable Development Goals (SDGs) from the United Nations Development Programme, namely goal 4 (quality education) and goal 7 (affordable and clean energy for all). In 2016, the focus of the programme was to update the existing learning material and determine, through research, how the materials are being used by teachers; to strengthen the relationship with Fundisa for Change and geography curriculum advisors and to present workshops through these entities, and to secure funding through IPPs.

### Learning material update

The learning material has been updated to keep track with the development of new technologies and applications as well as to incorporate the feedback from teachers who used the material. This was the second update since the start of the schools' programme in 2007. The material is used in the following curriculum areas: geography grade 11, life sciences grades 11 and 12, physical science grade 11, natural science grade 9 and mathematics grade 8. The material can be accessed at http://www.crses.sun.ac.za/service-schools

### Networks

In collaboration with the Western Cape Department of Education's geography curriculum advisors and Fundisa for Change, the learning materials were successfully implemented in two geography workshops in the Western Cape and one in the Northern Cape.

### Teacher professional development workshops

Workshops were presented to Postgraduate Certificate in Education students in the SU Faculty of Education in geography curriculum studies, as well as to teachers who are part of the Green Cape Initiative in Atlantis. During the national science week the learning material was presented to high school learners in Moorreesburg.

### Funding

While securing funding for the schools' programme remains an ongoing challenge, two proposals submitted last year led to successful project implementation. Both projects were done for Economic Development Solutions (EDS): one for the Sishen Solar Facility and the other for the Gouda Wind Farm. The project in Sishen was a follow-up on the 2015 project. This year a session with the headmasters was included in both projects as well as follow-up visits were paid to schools. The Sishen Solar Facility and the Gouda Wind Farm were also visited by the teachers.

### The schools' programme as context for a master's research

By making use of the Anne Edwards learning task sequence, a master's study was completed on how teachers use the learning materials. The use of task sequencing as an analytical tool showed that knowledge representation was the primary use by teachers. They introduced learners to key concepts and broadened their knowledge on renewable energy. The activities served to scaffold a clear learning progression, but the activities were not orientated strongly enough towards Education for Sustainable Development (ESD) as learner-led processes for enquiry and action. The outcomes of the study will be used to update and better align the materials with a need for teachers to strengthen important ESD outcomes in the current curriculum.

> To further expand the footprint of the schools' programme in 2017, the Centre will focus on the timeframe of the workshops and change the strategy to include more engagement with the teachers.

### Challenges and way forward

To further expand the footprint of the schools' programme in 2017, the Centre will focus on the timeframe of the workshops and change the strategy to include more engagement with the teachers. Another aim is to continue the research by implementing activities where learners engage with their own energy use to strengthen ESD outcomes.



Above: Teachers at Gouda Wind Farm



## BUILDING HUMAN CAPITAL continued

#### 2016 Graduates

The following nine students have graduated in 2016, and copies of their theses, where available, can be found at http://crses.sun.ac.za/research-completed-research.php

All theses from Stellenbosch graduates are also available at https://scholar.sun.ac.za/

#### March/April 2016:

Nikita Zietsman MEng (Research)	SU	SU supervision and bursary
Henk Beukes MEng (Research)	SU	SU supervision
Nikkie Korsten MPhil (Sus Dev)	SU	SU supervision
Richard Padi* MEng (cum laude)	SU	SU supervision and bursary
Adeola Ogunleye*	SU	SU supervision and bursary
JC Lock	SU	supervision and bursary
December 2016		
Dr Paul Gauché PhD	SU	SU supervison
Rhydar Harris MEng (Structured)	SU	SU supervision
Reshmi Muringathuparambil MPhil	SU	SU supervision and

\*non-South African

The following nine students completed the Postgraduate Diploma in Engineering:

bursary

Angelo Buckley
Alex Bunodiere
Rafael Loose
Matome Makgoba
Rohann Mattheus
Ryan Roberts
Frederick Snyman
Varughese Thomas
Piero Trinchero

#### **SANEDI** awards

The recipients of the 2016 SANEA/SANEDI energy awards were announced at a prestigious ceremony and banquet hosted by Brian A Statham, chairman of the South African National Energy Association (SANEA) on Friday, 16 September 2016. This gala event reflected the significance of the both the awards and the recipients. In his keynote address, Statham paid tribute to the many men and women who are striving on a daily basis to ensure that South Africa enjoys a stable and secure energy future.

Imke Meyer was presented the 2016 RECORD RERE Young Researcher Award. Meyer studied the Agulhas current as a potential source for renewable energy for her MEng which she completed cum laude whilst she was employed as a research engineer at the Centre from 2013 to 2015. A Highly Commended Recognition was presented to Toyosi Craig in this same category for his thesis on his MEng, entitled A stand-alone high-temperature (250°C) parabolic dish solar cooker for African conditions. Not only has Craig shown a thorough understanding of the many aspects of engineering required for the manufacture and design of a parabolic dish solar cooker, but he also adapted these to optimise them for African conditions. He completed his thesis within the minimum prescribed time frame of two years, and also presented three full length international conference papers during this time period.

### **SASTA** prizewinner

At the recent SASTA (South African Sugar Technologists' Association) Congress 2016, Dr Stefan Hess was judged the winner of the Robin Renton Award. This award, donated by PGBI, is given annually to the best young engineer who shows leadership and management potential, and who delivers a technical paper at SASTA Congress.

The judges had this to say about the paper by Hess S, Beukes H, Smith GT and Dinter F, entitled *Initial study on solar process heat for South African sugar mills*: "The presenter confidently presented an exciting opportunity for the sugar industry to tap into solar energy. The paper was thoroughly researched, well written and contained novel ideas for the use of solar energy in various factory areas. The paper demonstrated that solar energy could become part of the future sugar industry".

Hess works on solar heating of industrial processes. He holds a German Diploma in Mechanical and Process Engineering, and a PhD in Energy Engineering from DMU Leicester, UK. For a period of about eight years, Hess worked at the Fraunhofer Institute for Solar Energy Systems. There he developed solar thermal collectors and systems, and he coordinated national and international research projects.

Since January 2015, Hess is a postdoctoral research fellow at the Solar Thermal Energy Research Group (STERG) of Stellenbosch University. At the Centre he works as a consultant on feasibility, planning and tendering of solar thermal process heat systems in South Africa.

#### **Graduated bursary students**

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Totals
MPhil/MEng/MFor	2	2	4	5	6	3	6	0	5	2	2	37
MSc/MScEng/MCom/MEng (Research)	2	2	5	9	8	8	10	4	16	15	6	85
PhD	I			2	I		3	2	4	2	I	16
Total	5	4	9	16	15	П	19	6	25	19	9	138

Right: 2016 SANEA/SANEDI ENERGY AWARDS: Toyosi Craig and Imke Meyer



### TRAINING

The Centre provides short courses and in-house training for companies to train their staff on the different technical, financial and policy aspects of renewable energy. Various modules are available from which to choose. Companies select a combination of appropriate modules for each training course, with the duration and focus of each course determined by the company's areas of interest and time available.

The following modules were presented in 2016:

- Renewable Energy Systems
- Renewable Energy Policy
- Renewable Energy Finance
- Introduction to Solar Energy
- Advanced Photovoltaic Systems
- Bioenergy
- Wind Energy
- Hydro and Ocean Energy
- Thermal Energy Systems

Below are some examples of workshops presented to industry and other institutions in 2016:

- · As part of George and KwaDakuza municipalities' participation at this year's Earth Hour City Challenge, ICLEI Africa, in partnership with WWF South Africa and the Centre, presented two half-day workshops on renewable energy solutions and decision-making tools. The workshops were presented at KwaDakuza Municipality on 19 February 2016 and George Municipality on 5 April 2016. The workshops included a background on the South African electricity landscape, the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP), and different renewable energy sources. Case studies on Riversdale, Stellenbosch, Cape Town and Drakenstein were also presented. The Centre also developed a tool, presented at the workshops, to better understand the solar resource. This can be individualised for specific locations and it also calculates the implications that installation options will have with different tariff options.
- In November 2016, the Centre hosted a specialised course on solar heat for industrial applications as part of the SOLTRAIN 3 project. It gave insight on state-of-the-art design, simulation, planning and installation of advanced high quality solar thermal systems for industrial applications in southern Africa. Only participants with previous experience in solar thermal system design and installation were admitted to this course. Despite this, the number of

applications exceeded the capacity and only 40 participants could be accepted. About half of these were planners from the solar thermal industry. The remaining participants were SOLTRAIN partners, researchers and members of public institutions. The course was presented by Werner Weiss from AEE Institute for Sustainable Technologies in Austria and Dr Stefan Hess from CRSES and STERG. On the first day, the TIA Helio100 demonstration site and the CBC brewery solar thermal installation in Paarl, Western Cape, were visited. The focus on the second day was the status of large-scale stationary systems in southern Africa and provided extensive theoretical background on planning and installation of such systems. The third day was used for a simulation exercise, for which all participants had been provided with a free T\*SOL license in advance. A realistic example of a laundry facility was used to determine the optimum collector area and storage volume for different framework conditions. The feedback of participants was that they benefitted tremendously from the course and would like to participate in further SOLTRAIN courses in the future. All course material was made available for download.

The Centre also developed a tool, presented at the workshops, to better understand the solar resource. This can be individualised for specific locations and it also calculates the implications that installation options will have with different tariff options.

 During 2016, the Centre was tasked by eThekwini Municipality to develop online educational material for short courses on renewable energy and energy efficient technologies to be used for the training of municipal staff. This included video recordings presenting the material and a train-the-trainer contact course at their facilities. Topics covered included solar photovoltaic, solar thermal, wind energy and energy efficiency technologies.



### RENEWABLE ENERGY MARKET TRANSFORMATION PROJECTS

The Centre plays a facilitating role to bring new technologies to market, or to assist public and private entities to deploy existing technology but with new business models. In 2016, the projects focused on solar thermal and photovoltaic systems as well as a biomass plant.

The Centre, supported by the **SOLTRAIN 2** project which is funded by the Austrian Development Agency and co-funded by the OPEC Fund for International Development, approached the Cape Brewing Company (CBC) with the proposal to investigate the potential of using solar thermal (ST) technology to produce hot water for the brewery. The ST system would be aimed at reducing their paraffin fuel consumption and boiler load which in turn would generate financial savings for the company. A prefeasibility study was conducted by the Centre and the results indicated that a ST system of about 120 m<sup>2</sup> collector area and 10 000 I storage would provide 60% of the company's current hot water needs and reduce the company's dependence on paraffin and its associated costs. The financial outcomes of the pre-feasibility study indicated that the ST solution was a good financial investment for the company especially considering the EUR II 000 subsidy from SOLTRAIN 2.

> The Cape Brewing Company installation is a successful example of how solar thermal systems for large-scale applications could provide financial benefit to industrial sector of the country.

With favourable pre-feasibility results, CBC decided to proceed with the tender process. After an on-site walk through and opportunities for questions and answers, 10 proposals were received, all from South African companies. From these candidates, a shortlist was prepared for interviews. E3 Energy was awarded the tender and carried out construction of the 120 m<sup>2</sup> ST system. E3 Energy is also responsible for the maintenance and monitoring of the system to date. The system further serves as one of the SOLTRAIN Solar Thermal Demonstration Systems in South Africa which is regularly visited by SOLTRAIN participants and market stakeholders. The CBC installation is a successful example of how ST systems for large-scale applications could provide financial benefit to industrial sector of the country.

The Centre continues to assist the **V&A Waterfront** with achieving their renewable energy goals. The V&A Waterfront

requested the assistance of the Centre in identifying the most suitable installation sizes and locations for photovoltaic (PV) arrays with the intention of generating electricity for own consumption.

The first phase of the study investigated the technical and financial feasibility of installing PV arrays on various buildings owned by the V&A Waterfront. Suitable installation locations, orientations and capacities were identified and the electricity production potential determined through conducting detailed system simulations and evaluating the historic electricity consumption profiles. The PV installation capacities were limited by the available roof spaces and low electricity consumption. This was followed by a detailed financial evaluation to determine the expected system cost and financial savings through the reduction in their monthly electricity bills. Suitable PV installation locations were identified based on long-term financial returns and technical suitability.

The Centre further assist the V&A Waterfront by drafting the technical specifications used in the tender process and participating in the tender adjudication as an independent technical advisor. Most of the proposed PV systems from the first phase of the project were installed and commissioned in 2016, and the Centre will continue to assist the V&A Waterfront through conducting further studies in 2017 on a selection of buildings.

The Centre supported the **East London Industrial Development Zone (EL-IDZ)** with a feasibility study for a woody biomass-to-electricity power plant. The study was presented in a report that provides background to sources of biomass and conversion technologies, descriptions of possible sites under the control of EL-IDZ as well as possible business models. A biomass-to-electricity power plant is exceptionally complex with a number of technical and logistical issues to consider, such as procurement contracts (including quality and logistics) of the feedstock, operation and maintenance of the equipment, and selling of the heat and power from the plant. A biomass-to-electricity financial calculating tool was also developed. Using this tool it is evident that the running cost is too high compared with the low electricity prices to make it financially viable, even if the capital cost is sponsored.

A workshop with a wide range of stakeholders was held at EL-IDZ in October 2016. At this workshop participants agreed that the following is needed: more coordination among role-players; a database of available biomass resources; a database of existing coal-fired boilers; identifying 'low-hanging fruit' opportunities for biomass plants and investigating the feasibility thereof; recalculating the financial viability by using time-of-use (TOU) tariffs and ramping down the generator at night to optimise the income; conducting a sensitivity analysis to determine important parameters, and developing a set of key parameters that will make the biomass power plant financially viable.



### AWARENESS AND OUTREACH

#### **SASEC 2016**

The 4th Southern African Solar Energy Conference (SASEC 2016) was held from 31 October to 2 November 2016 at the conference facilities of the Faculty of Theology at Stellenbosch University. The conference focused on both solar photovoltaic and solar thermal energy technologies, systems and applications. The conference provided the opportunity for researchers, engineers, technologists and individuals to share and discuss recent developments in the field and showcase their recent research results and achievements.

It started with a plenary session whereafter delegates split into separate tracks for photovoltaic (PV), solar thermal and general solar energy topics. The delegates were welcomed to South Africa and Stellenbosch by the Mayor of Stellenbosch, Advocate Gesie van Deventer, who emphasised her personal commitment to renewable energy and especially solar energy connected to municipal networks. Prof Wim de Villiers, SU Rector and Vice-Chancellor officially opened the conference before Mmboneni Muofhe, Deputy Director-General for Technology Innovation at the Department of Science and Technology, delivered the opening address.

Three internationally acclaimed keynote speakers addressed the delegates over the three days. Prof Carsten Agert from the University of Oldenberg spoke on how the future electrical grid will be able to accommodate distributed, intermittent generation. He cited a number of examples where this has already been accomplished. Dr Werner Platzer from the Fraunhofer Chile Research Center for Solar Energy in Santiago spoke on the opportunities for concentrating solar power (CSP) in South Africa and Chile. He drew the different parallels between the two countries that showed the value that CSP could bring to a more diversified supply of electricity. Dr Dave Renné, the President of the International Solar Energy Society, discussed the opportunities for largescale solar technologies as part of the 100% renewable target for the world's energy supply. He highlighted how electricity production from large, utility-scale PV plants and CSP plants with thermal energy storage complement each other to ensure security of supply.

The technical papers presented at the conference focused on research, technology development and deployment of solar energy in the southern African context and shared experiences from other parts of the world. The benefit to the solar energy community as a whole, engineers and scientists from academia and industry was the ability to share on-going and completed research, technology developments and experiences with technology deployment at the conference. In total 45 papers were presented at the conference which was attended by over 90 delegates from seven countries.



The conference concluded with a technical visit to the Stellenbosch University's locally developed heliostat field, Helio100, and the solar thermal installation at the Cape Brewing Company's brewery outside Paarl. The next SASEC conference will be hosted in the winter of 2018 by the University of KwaZulu-Natal in Durban.

### **REPS 2016**

The University of Fort Hare hosted the 7th annual Renewable and Sustainable Energy Postgraduate Symposium (REPS) on its Alice campus from 4 to 6 September 2016, bringing together all the relevant stakeholders from different spheres of government, industry, academia, schools, community-based entrepreneurs, and entrepreneur spin-off companies from the Hub and Spokes Funding Instrument managed by the National Research Foundation and funded by the Department of Science and Technology.

A total of 16 South African universities participated in this event, which coincided with the centenary celebrations of the University of Fort Hare. With more than 91 postgraduate student papers presented, REPS 2016 has now set the stage for this initiative to become a fully-fledged national postgraduate conference. Seventeen schools from in and around the Fort Beaufort education district participated in the associated learner and educator programmes on renewable energy.

The theme of the symposium for 2016, Unleashing sustainable solutions for a sustainable industry saw an unprecedented uptake by provincial and national role players in both private and public sectors, engaging and debating in a conducive environment where new solutions were proposed. One fact that came through very strongly was that industry or government or even the research and development fraternity cannot deal with the country's energy issues in unison or isolation. REPS 2016 promoted a multi-facetted approach with all three stakeholders playing an equally pivotal role towards a renewable and sustainable energy platform cutting across the entire energy value chain, from material characterisation at the nano-scale to large energy plants at the megawatt-scale.

#### WESSA 90 Lifetime Conservation Achiever Award

In celebration of the WESSA's 90th anniversary of Caring for the Earth this year, Prof Wikus van Niekerk was awarded one of the 90 Lifetime Conservation Achiever Awards.

"The nominations for this special category of the 2016 WESSA annual awards were received from members, supporters and the media, and we congratulate you on having been selected as a recipient, based on your remarkable achievements and conservation legacy."

Louanne Mostert, WESSA Communications, on behalf of WESSA's CEO Dr Thommie Burger and chairman Dr Richard Lewis



WESSA AWARD LIFETIME CONSERVATION ACHIEVER

PRESENTED ON THE OCCASION OF WESSA'S 90 \*\* BIRTHDAY TO

### Wikus van Miekerk

as one of 90 remarkable individuals who have made a lifetime contribution to environmental conservation in South Africa.





17 SEPTEMBER 2016

Left: Learners from 17 schools from in and around the Fort Beaufort education district participated in the associated learner and educator programmes on renewable energy at REPS 2016

WESSA CEO

### RESEARCH CONTRIBUTION



Stellenbosch University developed a very strong research focus on concentrating solar power (CSP) and three doctoral students graduated in 2016 with topics in this field. With the ongoing drought in the Western Cape, the Centre also focused on the desalination of seawater using renewable energy, and investigated the use of primarily solar energy to drive these processes. In Ghana, the use of bioenergy from the residues of agri-processing to assist developing countries to mechanise these activities was studied. Finally, the energy use in low-cost houses in Cape Town was classified using their energy usage profiles.

**Dr Paul Gauché** is currently the manager of the CSP Department at Sandia National Laboratories in Albuquerque, New Mexico, and is also appointed as an extraordinary associate professor in energy systems analysis at the Department of Industrial Engineering at Stellenbosch University. He graduated in 2016 with a PhD from Stellenbosch University where he was the founder of the Solar Thermal Energy Research Group (STERG). He was also the grant holder of the DST-NRF Solar Thermal Spoke and the project leader and director of the TIA Helio100 technology development project funded by the Technology Innovation Agency.

**Dissertation title:** Spatial-temporal model to evaluate the system potential of concentrating solar power towers in South Africa

A state-of-the-art concentrating solar power (CSP) central receiver system uses mirrors to reflect sunlight to a tower where a working fluid is heated, then stored as thermal energy and ultimately converted to electricity in a steam turbine. A novel model is presented that predicts the performance of these plants suitably in an electricity system, within available means, to a 7% accuracy. The value of CSP was studied in various scenarios, demonstrating its potential and value leading to the 2030 timeframe. Dependent on many factors, a large CSP capacity allocation arguably benefits the South African electricity system significantly.

**Dr Matti Lubkoll** obtained his PhD from Stellenbosch University in mechanical engineering with research on novel concentrating solar power technologies at STERG. His interest lies in renewable energy and in particular in concentrating solar power. He is currently a postdoctoral research fellow at SU and the manager of the STERG.

**Dissertation title:** Performance characteristics of the Spiky Central Receiver Air Pre-heater (SCRAP)

Solar receivers such as SCRAP are important components of combined-cycle CSP plants which provide the ability to deliver electrical power on demand using built-in thermal energy storage. The potential of the novel SCRAP technology was evaluated by developing analytical and computational models to enable performance prediction. The computer models were validated against results from an experimental test setup developed and built for this purpose. The SCRAP receiver was shown to equal or exceed current technologies in terms of solar-thermal efficiency as well as the system pressure drop across it.

**Dr Lukas Heller** pursued his studies in mechanical engineering at the Karlsruhe Institute of Technology and the Technical University of Dresden, both in Germany. After working for six months on CSP construction logistics for Siemens Solar Thermal Energy, Israel, he joined the STERG at Stellenbosch University in 2011 where he focused on CSP system analysis and the development of a dual-pressure air receiver. He finished his doctoral dissertation on this topic in 2016 and is currently a postdoctoral research fellow at the STERG.

**Dissertation title:** Development of a dual-pressure air receiver system for the SUNDISC cycle

Combined-cycle CSP plants with solarised gas turbines have the potential to generate dispatchable electricity at a high efficiency. The SUNDISC cycle has been proposed to overcome shortcomings by adding an additional, nonpressurised air receiver that directly charges the storage. In this dissertation, the techno-economic performance of a SUNDISC cycle plant was shown. Additionally, the feasibility of a hybrid a pressurised/non-pressurised air receiver system was investigated for the cycle. The basic concept of this receiver was shown to not satisfy the demand in terms of efficiency and outlet temperature. However, proposed enhancements are expected to improve the concept's performance.



Dr Paul Gauché
Dr Matti Lubkoll
Dr Lukas Heller
Jessica O'Brien
Reshmi Muringathuparambil

Jessica O'Brien obtained a bachelor's degree in mechanical engineering from Stellenbosch University. She completed her master's degree in mechanical engineering cum laude. She is passionate about renewable energy and sustainability, and as a result of the rampant drought in parts of South Africa, her postgraduate thesis revolved around renewable ways to obtain freshwater in developing communities. She is currently working for General Electric in Johannesburg in their digital department, which is developing software solutions to drive the digital transformation in industrial companies.

### **Thesis title:** Renewable small-scale freshwater production and harvesting methods for the west Coast of South Africa

This thesis presents an extensive literature review of the various small-scale renewable freshwater production and harvesting methods. A thorough review is provided of the conventional desalination technologies which can be combined with renewable energy resources to provide a sustainable and reliable source of potable water. The selection process for determining which renewable freshwater production or harvesting method is optimal is illustrated by two case studies. Case study I focused on satisfying the freshwater demands of a small community situated along the water scarce west coast region of South Africa and the second case study focused on a small subsistence family. Small-scale renewable freshwater production and harvesting methods show great potential in mitigating the freshwater shortages in the water-scarce regions of South Africa. It is recommended that this research should be continued to further enhance the technologies as described.

**Richard Kingsley Padi** holds a BSc in chemical engineering from the Kwame Nkrumah University of Science and Technology, Ghana (2012), and obtained his MEng in chemical engineering from Stellenbosch University in 2016. He is currently a lead researcher at Stable Corps Consultancy, Ghana. He is interested in sustainable energy and environmental solutions for developing economies.

**Thesis title:** Potential and economic impact of renewable energy in improving African rural food processing

The high cost of modern energy required in mechanised food processing limit the improvement of the African food

processing industry. The study investigated the feasibility and economic impacts of advanced mechanisation in crude palm oil (CPO), maize flour and cassava flour using the energy available from biomass residues of the processes. The study was conducted by developing process and economic models of available bioenergy integration schemes including anaerobic digestion, cogeneration, and combustion in the food processing process using Aspen Plus® simulation software and Microsoft Excel. The study showed the use of energy from the available biomass residue was beneficial for CPO and maize flour, but not for cassava flour.

**Reshmi Muringathuparambil** has degrees in both architecture and sustainable development, and is currently working with the Energy Security Game Changer unit within the Western Cape Provincial Government.

**Thesis title:** Typology of representative building designs within townships for energy efficiency in the City of Cape Town

In the case of City of Cape Town, the built environment is responsible for almost 40% of the total primary energy use. However, there is currently limited understanding of the energy profiles of the various types of low-cost buildings in South African townships, and successful implementation of sustainable energy provision is uncommon. To fill this knowledge and data gaps, this study developed typologies of representative low-cost building types based on their energy profiles in two selected townships in Cape Town: Gugulethu and Manenberg. The buildings within these two townships were classified into eight representative types based on their similar building properties, energy consumption and thermal efficiency determined from energy and thermal comfort modelling, as well as semi-structured interviews. Results of the study revealed that the main reasons for high energy consumption within township buildings were due to the often poor orientation of buildings on site; high occupancy rates; uninsulated walls and roofs; lack of ceilings; air leakage due to a lack of (properly) fitted window and door frames; the use of kettles as a primary source of water heating, and inefficient incandescent lighting. Suggestions to enable future energyefficient design interventions in townships were made based on these findings.

## INTERNATIONAL COOPERATION

### 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 based 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. The Centre is particularly interested in the application of smart grid technology in distributed renewable energy systems. The initiative is supported by SANEDI (an associate partner), who started the SA Smart Grid Initiative aimed at developing a smart grid vision for the country.

Smart grid technology requires knowledge from different disciplines such as power generation and distribution, information technology, protection and control, standardisation and economics. Furthermore, potential risks, such as information privacy, must be managed. These requirements imply an interdisciplinary approach for capacity building in the field of smart grids. The project also involves the development of rural in-situ laboratories as part of the capacity building initiative, as well as the exchange of senior students and teaching staff for capacity building.

### AIR

The Academic Initiative for Renewables (AIR) is aimed at the development of undergraduate programmes on renewable energy at participating African universities. Funded by DAAD, the project consortium is led by Technische Hochschule Ingolstadt (Germany) and includes Nelson Mandela Metropolitan University, University of Malawi, University of Zimbabwe, University of Zambia, Eduardo Mondlane University (Mozambique) and Botswana International University of Science and Technology. The Centre plays a pivotal role in the curriculum development activities. The project also provides exchange opportunities for students to attend block courses or conduct short-term projects at partner institutions.

### **EDULINK II**

During 2016 two EDULINK II (ACP-EU Cooperation Programme in Higher Education) projects were completed. The first project, with the principal-funded institution, the Instituto Superior de Educação e Tecnologia (ISET), and One World University (OWU), was for the initiative: HEI's cooperation contributing to rural development in Mozambique. For this project a curriculum in renewable energy for rural communities was introduced at the teacher training college OWU, and a number of students and teachers participated in learning engagements over the period 2014 to 2016. Low-cost energy solutions were also identified for the Mozambique context, which can be included in further curriculum developments.

The second three-year funded project, PARTICIPIA – Participatory Integrated Assessment of Energy Systems to

Promote Energy Access and Efficiency, aimed at developing and implementing innovative and competitive master's modules and/or programmes in participatory integrated assessment of renewable energy systems in the African Caribbean and Pacific (ACP) member states Botswana, Namibia and South Africa. In this way, the project sought to foster access to alternative energy technologies and their efficient utilisation in different socio-economic and geographical contexts in southern Africa. PARTICIPIA was a cooperative effort between three universities from southern Africa, Stellenbosch University (South Africa), the University of Botswana, and the Namibia University of Science and Technology (formerly Polytechnic of Namibia); five universities from Europe, Universidad Autònoma de Barcelona (Spain), the University of Bergen (Norway), Universidad Autónoma de Madrid (Spain), Universidad Carlos III de Madrid (Spain), and Universitat Pompeu Fabra (Spain); and two international organisations, FAO and NEPAD. PARTICIPIA was coordinated by the Universidad Autónoma de Barcelona (Spain).

### NUFFIC: The Dutch organisation for internationalisation in education

The Dutch NUFFIC project – Innovative ways to transfer technology and know-how, developing skills and expertise for gas, renewable energy and management, was also continued in 2016. For this project, the University of Groningen leads a consortium which includes the Energy Academy Europe, Stellenbosch University, Universidade Eduardo Mondlane, Unilurio, ISPSongo, and Universidade Católica de Moçambique. The project aims to establish academic and organisational capacity at the four Mozambique institutions 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 the needs of men and women. The envisaged outputs of the project will be to:

- Develop three MSc curricula on oil and gas, renewable energy and cross-disciplinary themes in energy systems, which fulfil labour market needs and are gender sensitive, at universities and polytechnic institutions.
- Develop 6 to 18 short courses for professionals in oil and gas, renewable energy, and cross-disciplinary themes in energy systems, which fulfil labour market needs and are gender sensitive.
- Establish two testing and laboratory facilities in renewable energy technologies (RETs) and oil and gas for teaching and research purposes, and appropriately train lab staff.
- Complete 16 BSc and MSc trainings of staff members in disciplines relevant to the energy labour market needs, to upgrade knowledge and teaching capacity.
- Complete 10 PhD trainings of staff members in energyrelated disciplines, relevant to the energy labour market needs, to strengthen research capacity.
- Implement a cross-national governance structure (including, for example, centres of excellence, a national 'graduate school' and/or an 'Energy Academy' model) to sustain project outcomes.

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# FINANCIAL POSITION OF THE CENTRE

The Centre depends on external funding to support its various activities and was able to diversify its income streams over the last ten years in order to increase the financial sustainability as well as augment the primary funding from the DST-NRF.

The main income streams of the Centre in 2016 were:

- The DST-NRF grant: The DST-NRF grant for 2016 was R5 165 667, approximately 35% of the total income of the Centre. This grant is mainly used to cover the core staff of the Centre as well as the academics responsible to teach the postgraduate modules and supervise the research of the students. In addition, 30% of this grant is allocated towards postgraduate student bursaries and the remainder is used for running expenses, which amounts to less than 5% of the grant. The contribution of the DST-NRF is supplemented with other funds from the Centre so that in total R9,63 million was spent on the various academic and research activities of the Centre in 2016. An amount of R2,78 million was spent on bursaries for postgraduate students.
- The Eskom EPPEI grant: The EPPEI funds are ring-fenced to support the EPPEI Specialisation Centre in Renewable Energy at Stellenbosch University. This grant, typically in the order of R3 million per year, mainly supported the salary of the Eskom Chair in Concentrating Solar Power, administrative and technical support, some bursaries, equipment and running expenses. The contribution from Eskom on the EPPEI programme for 2016 was R2,6 million, of which R1 450 000 was available to the Centre. The remainder was transferred to the Department of Mechanical and Mechatronic Engineering to support the Eskom Chair in Concentrating Solar Power as well as the Solar Thermal Energy Research Group. An amount of R317 745 was spent on bursaries for postgraduate students.
- **Contract research:** The Centre has been successful to grow the contract research income that supports four engineers and one technician working at the Centre and makes a significant contribution towards the running expenses and other expenditure.
- Short courses: The income from short courses fluctuates from year to year. In 2016, the income from presenting short courses was only R335 000 due to the general down-turn in the economy as well as increased competition from other similar programmes in the country.
- Other income: The Centre also receives additional funding in the form of grants from international agencies, THRIP funding and interest on reserves.

In Table I the annual income and expenses for the last four years are shown. The decline in total income over this period can be attributed to the following:

- From 2010 there was a general down-turn in the economy of the country and this resulted in less contract research work in the Centre.
- In 2013, the Centre completed a number of large projects for Eskom with some of the funds only flowing through to other entities in the University or to external service providers.
- In 2014 and 2015, Stellenbosch University received a reduced allocation from the EPPEI programme due to funding constraints within Eskom.

It is then also evident that during this period the reserves in the Centre were reduced from nearly R13 million to below R7 million. However, if it was not for the available reserves, the Centre would have had to retrench staff and reduce the support of the programme, which was not the case. This speaks to overall conservative and responsible manner in which the finances of the Centre have been managed over the years.

#### Funds available at the Centre

	31 Dec 2016 (12 months) (R)	31 Dec 2015 (12 months) (R)
Total income for the year	14 604 722,26	15 765 242,54
Total expenditure for the year	-12 418 281	-16 305 970
Expenses Equipment	-11 813 213 -737 786	-15 700 902 -605 068
Total net transfers from Centre cost points	-2 972 394	-3 876 492
Net surplus/shortfall for the period	-2 186 441	-540 737
Funds available 1 January	8 372 210	11 885 332
Net surplus/shortfall for the period	-1 690 050	-3 513 122
Subtotal	6 682 160	8 372 210
Balance sheet items	-514 950	-2 254 853
Funds available 31 December	6 167 208	6 117 367

#### Annual income of the Centre





	2013	2014	2015	2016
Total income	R26 068 607,33	R19 042 931,53	RI5 765 242,54	RI4 604 722,26
Total expenditure	RI5 685 151,01	R17 307 739,59	R16 305 970,44	RI2 418 280,61
Nett transfers	R4 565 062,57	R2 514 088,91	R2 972 394,48	R3 876 492,38
Operating surplus/short fall	R5 818 393,75	- R778 896,97	- R3 513 122,38	- RI 690 050,73
Accumulated funds carried	R6 990 823,66	R12 809 217,41	RII 885 332,43	R8 372 210,05
Accumulated funds 31 December	RI2 809 217,41	RI2 030 320,44	R8 372 210,05	R6 682 159,32

Table 1. Income and expenses of the Centre over the period 2013 - 2016

# STATEMENT INCOME AND EXPENDITURE UNTIL DECEMBER 2016

FOR THE PERIOD ENDING:	31/12/2016	31/12/2015
TOTAL INCOME	-14 604 722,26	-15 765 242,54
Conference/congress (no vat)	-86 038,36	-450 110,65
Contract research (taxable)	-689 726.60	-3  43  6 .6
Donation: special purposes	0.00	-25 000.00
Income foreign exempt	0,00	-173 177,50
Income: bursary	-106 250,00	-80 000,00
Income: foreign zero rate	-1 174 675.60	-659 356.79
Income: NRF apportioned	-5 165 667.00	-4 919 683.00
Income: NRF thrip(zero rate)	0.00	-1 385 749.00
Income: subsidy general	0,03	0,00
Income: sundry taxable	-2 001 562.00	-2 053 028,14
Interest receive: internal all	-693 670.11	-547 619.82
Profit/loss: exchange rate debit	-2 220.26	-4 399.48
Profit: exchange rate foreign	8 565.03	-17 056.55
Sales: to internal organisational units	-158 510.00	-59 400.00
Short courses	-334 738.00	-447 500.00
Sundry income: non taxable	-4 200 229,39	-1 800 000,00
TOTAL EXPENDITURE	12 418 280,61	16 305 970,44
CURRENT EXPENDITURE		· · · · · · ,
Advertisements: general	32 611.39	46 031.99
Affiliation & registration expenses	117 708.39	495 944.19
Bicycle maintenance	0.00	136.09
Bursary postgraduate	2 783 833.42	3 707 310.11
Bursary undergraduate	40 855.00	94 000.00
Cell phone airtime	6 088.76	1 254.12
Cell phone rent	2 812.00	4 212.03
Chemicals	-16.62	270 75
Cleaning costs – external firm	20 242 76	17 295 06
Cleaning materials	974.38	166.20
Clearence fee non-capital	52 700.32	0.00
Clothing: other	8 441.73	0.00
Clothing: protective	0.00	1 195.26
Computer materials	3 636.21	38 487.70
Consultation fees	1 329 166.75	1 740 219.66
Consumable materials	32 971.67	183 395.34
Convand printing	196 [3] 3]	95 305 91
Courses	50.00	800.00
Crockery	600.55	186.78
Electronic components	11 070.43	265 206 76
Entertainment: general	81 380.94	54 454 56
Elowers (not gifts)	633.05	0,00
Foreign exchange loss	057.25	18 224.02
Fuel, oil, lubricants	903.38	11 661.94
General vehicle expenditure	51 948.86	76 795.88
Gifts	894.2	5 401.52
Handbooks and manuals	8 000 00	860.00
Insurance, licenses & 3rd party	32 503,62	850.00
Interest paid: internal apportioning	2 377 85	1 961 04
Internet network email levy	68 175 87	62 643 97
IP transfer fee	99 986 22	163 563 94
Irrecoverable debt written off	118 164 66	3 550 00
Levy: ICRR (indirect cost)	349 255 39	674 667 96
Levy: space and facility	_19 185 49	12 657 00
Maintenance of apparatus	116 390 40	829.25
Medical expenses	26.27	0.00
Non-capitalised books	5 344 00	3 950 00
Photographic expenditure	125.00	0.00
Postage and courier services	9 959 44	29 814 24
0		

FOR THE PERIOD ENDING:	31/12/2016	31/12/2015
Prizes and medals	5 500,00	4 950,00
Refresher courses	100,00	0,00
Refreshments: non-academic	74 890,44	51 163,97
Rent of equipment general	820,80	3 242,05
Rent of rooms	0,00	9 593,69
Research materials	0,00	21 301,45
SCW non-capitalised	11 712,66	7 945,39
Seed plants trees	I 022,65	0,00
Services	302 875,57	211 952,27
Smaller furniture and equipment	9 629,41	22 625,53
Software	14 850,00	46 578,67
Sponsorship/donation out institution	7 000,00	1 000,00
Stationery	25 193,75	17 736,96
Subscription & membership fees	86 372,32	67 462,93
Sundry expenses	15 200,00	568 227,25
Table & kitchen ware	131,27	0,00
Telephone: calls	9 860,75	13 478,98
Telephone: rent	18 384,05	27 834,01
Total remuneration	4 552 684,75	5 650 141,46
Translation and editing	27 420.83	6 561,50
Transport cost	5 082,50	45 260.43
Travel: accommodation visum parking	262 233.70	298 102.92
Travel: foreign travel subsistence	219 834.89	336 496.25
Travel:daily allowance air car	340 557.86	333 811.70
Tyres	390.00	0.00
Workshops	119 924,59	142 131,38
ASSET TRANSACTIONS		
Depreciation	1 001 719,43	1 000 350,33
Income: internal assets	-821 738,97	-940 037,07
Profit/loss: assets	112 821,42	75 458,16
Asset adjustments	-292 801,88	-135 771,42
Asset purchases	737 786,23	605 068,36
	2 104 441 45	E 40 727 00
OPERATING (SURPLUS)/ SHORTFALL FOR FERIOD	-2 100 441,03	540 727,90
FUNDS TRANSFERS	3 876 492,38	2 972 394,48
Transfers from	9 146 590,41	9 252 517,61
Transfers to	-5 270 098,03	-6 280 123,13
NET (SURPLUS) / SHORTFALL FOR THE PERIOD	I 690 050,73	3 513 122,38
Plus: ACCUM (FUNDS) / SHORTFALL ON 01/01/2016	-8 372 210,05	-11 885 332,43
ACCUM (FUNDS) / SHORTFALL ON 31/12/2016	-6 682 159,32	-8 372 210,05
MIN: BALANCE SHEET ITEMS	514 950,37	2 254 842,67
Creditor provision balancing	0.00	-12 350,00
Debtors control account	484 222.00	2 556 613,49
ICRR control	-6 657,60	-268 993,73
Loan account bridging funds	50 000.00	0.00
Space and facility control account	2 869,27	-17 288,22
Sundry creditors	-15 483,30	-3 138,87
FUNDS AVAILABLE ON 31/12/2016	-6 167 208.95	-6   7 367.38

Julgiet. F Majiet

Director: Financial Services



### Standing: left to right Mr Angelo Buckley – Junior Engineer Ms Carla Nel – Marketing and Course Coordinator Ms Therese Lambrechts – Schools' Programme Manager Mr Ndamulelo Mararakange – Junior Researcher Prof Wikus van Niekerk – Director Ms Ntombi Nqandela – Intern Ms Karin Kritzinger – Researcher

Mr Ulrich Terblanche – Research Engineer



Seated: left to right



Mr Jason Fairhurst – Research Engineer Ms Jos Liebenberg – Administrative & Financial Officer Prof Josephine Musango – Researcher Prof Alan Brent – Associate Director

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