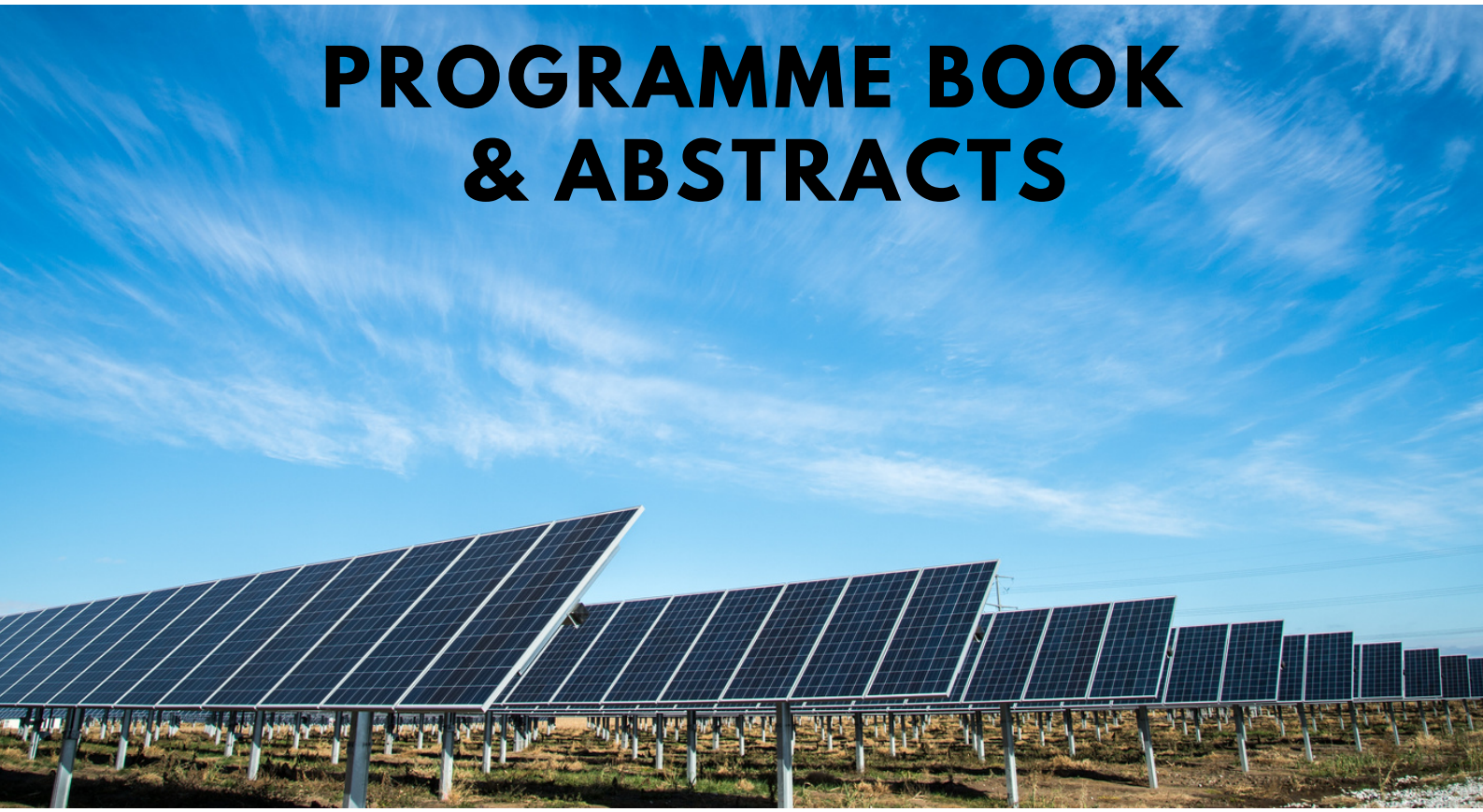
SASEC 2023

SOUTHERN AFRICAN SUSTAINABLE ENERGY CONFERENCE

15 - 17 November 2023 | Boardwalk Hotel | Gqeberha | Eastern Cape

PROGRAMME BOOK & ABSTRACTS



NELSON MANDELA UNIVERSITY

CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

SOUTHERN AFRICAN SUSTAINABLE ENERGY CONFERENCE

15 - 17 November 2023 | Boardwalk Convention Centre | Gqeberha | Eastern Cape

Preface

The SASEC 2023 organising committee would like to extend a warm welcome to the Southern African Sustainable Energy Conference (SASEC) 2023. It is a pleasure to be a part of this prestigious event and engage with the sustainable energy community. The commitment of South Africa to the Just Energy Transition and to a more sustainable future is indeed commendable and is essential for the global transition to renewable energy and energy efficiency.

The diverse range of topics covered in this conference, including solar energy, biomass, wind energy, hydrogen and energy storage, reflects the growing importance of sustainable technologies. It is clear that this event will provide valuable insights into the latest developments and research in the field of renewable and sustainable energy.

We look forward to learning from the high-quality academic papers and the expertise of the keynote speakers, Dr Claudia Buerhop-Lutz and Mahandra Rooplall. Their contributions will undoubtedly add great value to the conference. We also look forward to hearing from our dinner guest speaker, Dr Morné du Plessis from World Wide Fund South Africa (WWFSA).

We also extend our gratitude to the Department of Science and Innovation (DSI), the South African National Energy Development Institute (SANEDI) and all the sponsors for their support to make this conference possible.

We are excited about the opportunity to network with fellow sustainable energy enthusiasts and contribute to the shared goal of building a more sustainable and green future. Thank you once again for your interest and attendance, and we look forward to the fruitful discussions and engagement at SASEC 2023.

Prof Ernest van Dyk
Conference Chair

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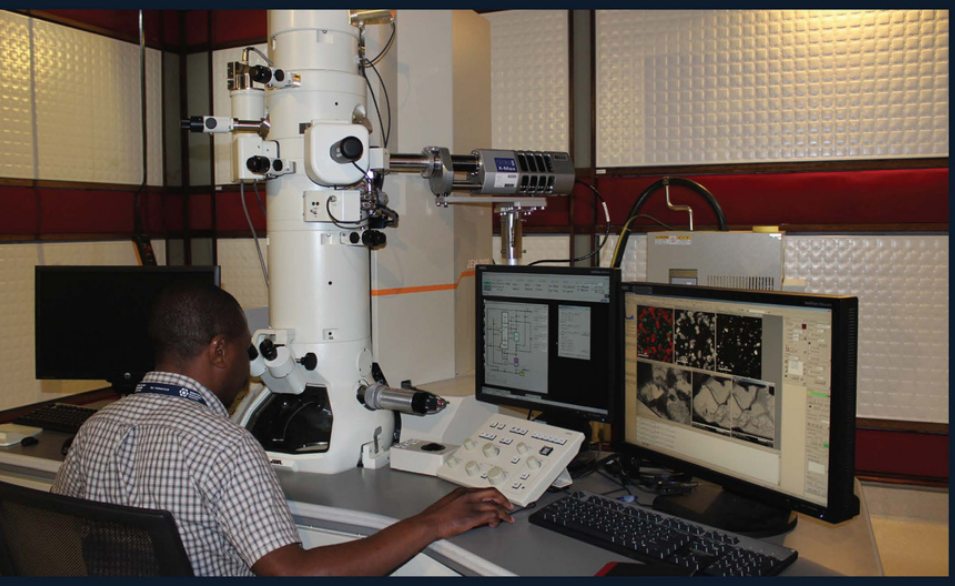

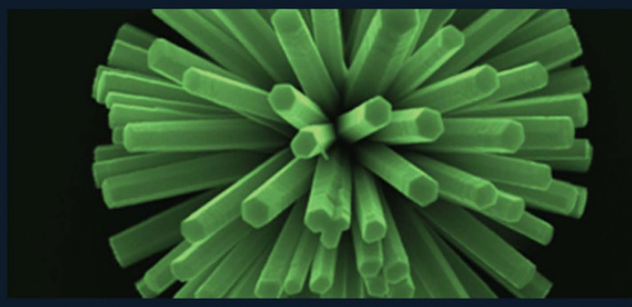

Department of **Physics**

Electron Microscopy for Materials Research

The Centre for High Resolution Transmission Electron Microscopy (Centre for HRTEM) at Nelson Mandela University houses four state-of-the-art electron microscopes including the only aberration-corrected atomic resolution electron microscope in Africa. The wide range of research projects and MSc and PhD topics include:

- HRTEM and in situ HRTEM investigation of nanoparticle catalysts
- Irradiation damage and fission product transport in nuclear reactor materials
- Corrosion resistant nuclear reactor materials
- Refining of weldability limits of creep-aged power plant stainless steel
- Lifetime assessment of high value power plant components
- Characterisation of diamond, Pt, Ti and Al alloys, compound semiconductor structures and gold and platinum bearing ores

Prof Jaco Olivier
E jaco.olivier@mandela.ac.za

Semiconductor Materials Development

This research focuses on vapour phase and solution-based deposition of semiconductors for opto-electronic devices.

The Physics Department has unique equipment for the synthesis and characterization of semiconductor thin films and nano-structures, including a state-of-the-art reactor for compound semiconductor deposition.

We currently develop:

- Epitaxial InAsSb and related compounds for infrared detectors
- ZnO nanorods for high efficiency white LEDs and hybrid solar cells
- Nanostructured TiO2 for solar water splitting

Our active collaborations with several local and overseas universities over many years, including groups in Sweden, Germany and the UK, have forged excellent academic links.

For information on these exciting research topics contact:

Prof Reinhardt Botha
E reinhardt.botha@mandela.ac.za

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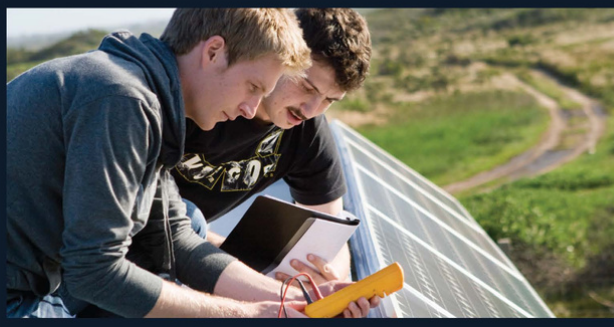

Department of **Physics**

Photovoltaics

Sustainable Energy for the Future

The Photovoltaics Research Group focusses on the characterisation of Photovoltaics (PV) materials, devices and systems. The facilities include:

- Photovoltaic Research Laboratory (PV Lab) for advance solar cell and PV module characterisation
- Outdoor Research Facility (ORF) for PV module and system monitoring and characterisation
- ISO17025 accredited Photovoltaic Test Laboratory (PVTL) – PVinsight (Pty) Ltd

The following Applied Physics skills are also acquired:

- Advance solar cell and PV module characterisation and evaluation
- Data acquisition an analysis, including curve fitting and parameter optimisation
- LabView programming and computer interfacing
- Data acquisition system design

For further information on student projects please contact the PVRG.

Prof Ernest van Dyk
E ernest.vandyk@mandela.ac.za

Optical Fibre Telecommunication Research

Escalating bandwidth demands fuelled by smartphones, tablet computers, social media and cloud computing makes Telecommunications an extremely challenging and rewarding field.

Nelson Mandela University has one of the best equipped Optical Fibre Research laboratories in Africa.

We offer an exciting range of MSc and PhD projects featuring:

- Dispersion measurement, compensation and emulation
- Fibre-to-the-home (FTTH) technologies
- Square Kilometer Array related optical fibre topics
- Polarization effects, wavelength division multiplexing, non-linear effects
- Modelling and simulation, OTDR, fusion splicing, bit error rate testing

The Optical Fibre Research Unit is part of the Telkom-sponsored Centre of Excellence.

Scholarship opportunities are available for good, motivated students.

Dr David Waswa
E david.waswa@mandela.ac.za

Committees

ORGANISING COMMITTEE

Prof Ernest van Dyk (Chair)	Nelson Mandela University
Dr Frederik Vorster	Nelson Mandela University
Dr Chantelle Clohessy	Nelson Mandela University
Dr Jacqui Crozier McCleland	Nelson Mandela University
Ms Chanie Neveling	Nelson Mandela University
Ms Bailey Muir	PVInsight
Ms Inge-Rae Scholtz	Centre for Renewable and Sustainable Energy Studies
Ms Fhatuwani Mulaudzi	Centre for Renewable and Sustainable Energy Studies
Dr Richmore Kaseke	Centre for Renewable and Sustainable Energy Studies

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Arnold Rix	Stellenbosch University
Ashmore Mawire	North West University
Azeem Khan	University of Cape Town
Béatrice Morel	University of Reunion
Benton Otieno	Vaal University of Technology
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Chantelle Clohessy	Nelson Mandela University
Chantelle van Staden	Stellenbosch University
Dominique Grondin	University of Reunion
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Ernest van Dyk	Nelson Mandela University
Frederik Vorster	Nelson Mandela University

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Pontsho Mbule	University of South Africa
Robbie Pott	Stellenbosch University
Warren Brettenny	Nelson Mandela University
Willem Le Roux	University of Pretoria
Zelalem Nigussa Urgessa	Nelson Mandela University

REVIEW OF PAPERS

All submissions to the Southern African Sustainable Energy Conference have undergone peer review by members of the Technical Review Committee. This includes an initial review of submitted abstracts and a second, full paper review of final submissions.

Invited Speaker

Mr Mahandra Rooplall

Biography

Mahandra Rooplall is an industry strategist and industry planner. Mahandra Rooplall previously worked as a Project Investment Specialist focusing on energy economics, project development, risk management, project management and business development. In his career, Mahandra has advised State Owned Entity Clients, Lenders to Power Projects and Independent Power Producers in an Owner Engineering, Lenders Technical Advisory, Programme Management and Risk Management capacity. Mahandra also worked in the petrochemical and energy for 11 years undertaking investment analysis and risk management on major investments, business development on green field projects, project management on multidisciplinary projects and design of plant optimization systems. Mahandra has a degree in Electronic Engineering and an MBA. Mahandra is registered as a professional engineer (PrEng) and as a project management professional (PMP).

Title : Green Hydrogen Commercialisation Strategy for South Africa

Abstract: The Green Hydrogen Commercialisation Strategy (GHCS) was developed by the Green Hydrogen Panel and approved by Cabinet and is now in the public domain. This GHCS shows strong policy support from government in providing a conducive environment for investment in developing this new GH industry for South Africa. A roadmap and action plans are clearly presented in this GHCS. This presentation will summarise the GHCS, showing the key elements, enablers, action plan and next steps.

Invited Speaker

Dr Claudia Buerhop-Lutz

Biography

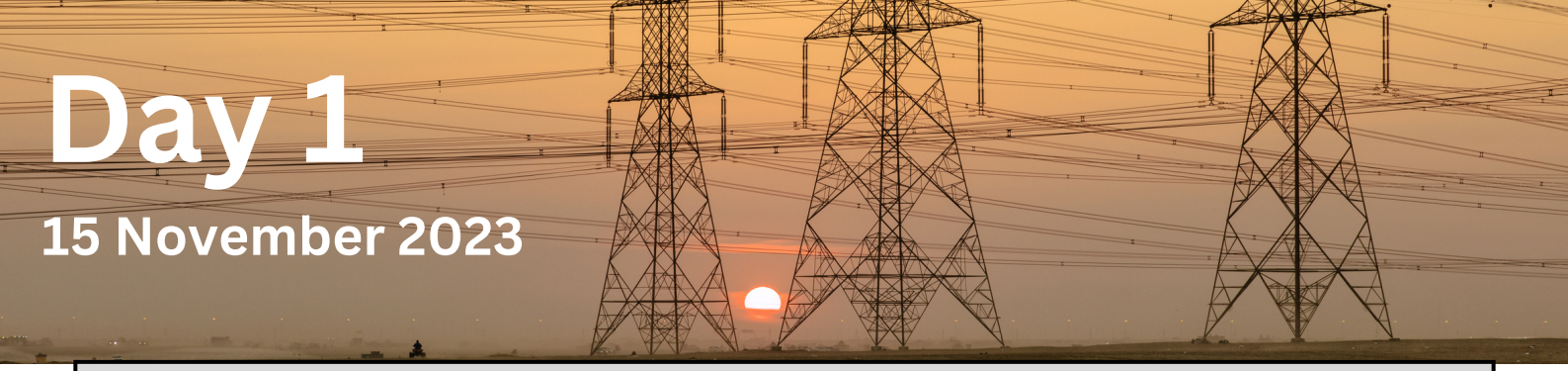
Dr.-Ing. Claudia Buerhop-Lutz is a Principal Scientist at Helmholtz Institute Erlangen-Nuremberg for Renewable Energy, HI ERN (Forschungszentrum Jülich GmbH) since 2018. She recieved her PhD. in Material Science (1994) from Friedrich Alexander University in Erlangen-Nuernberg in Germany. Before HI ERN, she was a group leader for infrared -IR-imaging at the Department of Renewable Energies at the Bavarian Centre for Applied Energy Research (ZAE Bayern, 2008-2018). She has a stron g reaserach interest in installing more renewable energy for a successful energy transition, as well as ensuring high quality, efficiency and long lifetime of the PV installations. Dr. Claudia Buerhop-Lutz is the author of more than 50 publications in peer-reviewed Journals; she organized several topic-specific workshops and participates in standardization committees.

Title: Impact of polymers on the operation of PV modules

Abstract: The experience of recent years shows that polymers are of great importance for the trouble-free operation and a long service life of PV power stations. We studied thousands of PV modules in PV power stations in different climates. At that, we observed different degradation mechanisms. We will show that modules from the same manufacturer can degrade differently in one location depending on the polymer materials (backsheet and encapsulant). The degradation patterns range from well-performing to corrosion to potential induced degradation -PID- to insulation defects resulting in inverter tripping (and income losses), among others. The paper will provide an overview of known polymer-driven degradation processes; it is intended to raise awareness for the quality of polymers in PV modules for future installations, which are expected to last 20 years or more at environmental conditions in PV power stations.

SOUTHERN AFRICAN SUSTAINABLE ENERGY CONFERENCE

PROGRAMME



Day 1

15 November 2023

1.1 Opening Session - Venue: Boardwalk Tsitsikamma C2 Chair: Ernest van Dyk		
08:30	Introduction and Address by Conference Chair *Prof Ernest van Dyk - Conference Chair*	
08:45	Welcome to SASEC on behalf of Nelson Mandela University *Prof Zenixole Tshentu - Deputy Dean: Faculty of Science, NMU*	
09:00	SASEC Opening address *Prof Sampson Mamphweli - Head of DSI Energy Secretariat at SANEDI*	
09:30	Keynote Address *Dr Claudia Buerhop-Lutz - Principal Scientist: Helmholtz Institute Erlangen-Nuremberg for Renewable Energy*	
10:00	**Tea Break**	
1.2a Session: Solar PV Energy Systems - Venue: Tsitsikamma C2 Chair: Lawrence Pratt		
11:00	#4 The recent accelerated pace of rooftop solar installations in South Africa - *Hartmut Winkler*	**p 19**
11:20	#44 The Social and Economic Potential of Closing the Loop on Photovoltaic (PV) Module Waste - *Marguerite Crozier, Catherina Schenck, Jacqueline Crozier McCleland, Ernest van Dyk*	**p 20**
11:40	#49 Photovoltaic Module Testing: developing a South African Circular Economy for PV Modules - *Jacqueline Crozier-McCleland, Monphias Vumbugwa, Marguerite Nicole Crozier, Ernest van Dyk, Frederik Vorster*	**p 21**
12:00	#64 Analysis of individual cell characteristics in a mismatched module string - *Poland Michael, Monphias Vumbugwa, Ernest van Dyk, Frederik Vorster, Petja Dobreva*	**p 22**
12:20	#7 Effects of cell shading level on thermal and electrical characteristics of a crystalline PV module under different operational I-V points - *Monphias Vumbugwa, Jacqueline Crozier McCleland, Frederik Vorster, Ernest van Dyk*	**p 23**
12:40	**Lunch**	

1.2b Power Planning and Operations, and Wind Energy - Venue: Wood Rooms Chair: Arnold Rix		
11:00	#24 Wind Power Forecasting: A Review - *Schalk van der Merwe, Arnold Rix, Armand du Plessis*	**p 24**
11:20	#65 Wind Resource Allocation Technique for Optimal Placement of Wind Power Plants: A Case Study in the Coastal Region of South Africa - *Saarty Mikka, Chantelle van Staden*	**p 25**
11:40	#6 The Value of Energy Storage in Reducing Wind Energy Forecast Error Penalty Costs in South Africa - *Panduleni A Ndengu, Bernard Bekker, Amaris Dalton*	**p 26**
12:00	**#**52 Review of electrification modelling approaches for rural areas of sub-Saharan Africa - *Basilio Zeloso Salvador Tamele, Erik O. Ahlgren, Alberto Julio Tsamba*	**p 27**
12:20	**#**22 A Review of Electrolyser Modelling for Hydrogen Production coupled with Renewable Energy Sources - *Joshua Woods, Arnold Rix, Chantelle van Staden*	**p 28**
12:50	**Lunch**	
1.3a Session: Solar PV Energy Systems - Venue: Tsitsikamma C2 Chair: Edson Meyer		
14:00	#15 A comparison of heat dissipation factors for open-rack, building-attached and floating solar photovoltaic installations - *Brendan Willemse, Hannes Pretorius, Michael Owen, Arnold Rix*	**p 29**
14:20	#21 Agrivoltaic Systems: Techno-economic Analyses of Potential PV Configurations for South Africa - *Nicholas Chapman, Alan C. Brent, Imke H de Kock*	**p 30**
14:40		
15:00	#13 Analysing the influence of the reflected light spectrum on the rear side modelling of a bifacial PV module - *Mayur Rabadia, Arnold Rix*	**p 33**
15:20	#38 Current-voltage characterization of bifacial module with a single light source solar simulator - *Siyabonga Ndzonda, Jacqueline Crozier McCleland, Ross Dix-Peek, Monphias Vumbugwa, Ernest van Dyk*	**p 34**

1.3b Bioenergy - Venue: Wood Rooms **Chair: Richmore Kaseke**		
14:20	#32 Biogas conversion to electricity from food waste and waste-activated sludge digestion - *Selebogo Khune, Benton Otieno, John Kabuba, George Ochieng, Peter Osifo*	**p 35**
14:40	#35 Enhancing anaerobic digestion of organic wastes through micro-aeration (WIP) - *Judi Kuyler, Ntshengedzeni Sampson Mamphweli, Johann Görgens, Eugene Van Rensburg*	**p 36**
15:00	#54 Industrial waste valorisation for managing the food-energy-water nexus towards a circular bioeconomy (WIP) - *Yeshona Sukai*	**p 37**
15:20	#61 Direct valorisation of fresh potato peels for pretreatment, simultaneous saccharification and bioethanol production: Eliminating drying processes, reducing freshwater usage, and enhancing hydrolysate processability (WIP) - *Isaac Sanusi, Adeniyi P. Adedule, Yeshona Sewsynker-Sukai, Edson L. Meyer, Gueguim E.B. Kana*	**p 38**
15:40	**Tea Break**	
1.4 Session: Solar Thermal Energy Systems - Venue: Tsitsikamma C2 **Chair: Alan Brent**		
16:00	#5 Thermal characteristics of an indirect solar dryer for drying bananas - *Ashmore Mawire*	**p 39**
16:20	#34 Development of a pilot low temperature solar thermal co-generation system for water distillation and energy generation - *Jacobus van Zyl, Michael Owen*	**p 40**
16:40	#48 Upgrading the Compressor Stage of a Solarised Micro Gas Turbine - *Michael Fivaz*	**p 41**
17:00	#69 Feasibility study on the use of a water-cooled shell and tube heat exchanger for a sCO2 Brayton recompression cycle in CSP applications - *Mubenga Carl Tshamala, Zinhle Dlamini*	**p 42**
17:30	**Networking Evening**	

PVinsight

PV MODULE TESTING & INSPECTION SERVICES

For all your *Quality Testing* needs

ABOUT US

PVinsight is a SANAS accredited Photovoltaic module testing laboratory offering a range of testing solutions from Pre-/post installation to regular inspections for long-term needs. Tests can be performed on entire shipments or just a sample of modules.

SERVICES

In-Lab Tests

We conduct testing of photovoltaic modules according to IEC 61215 international standard as well as our in-house procedures.

On-Site Tests

Testing services are available on-site in order to verify performance and determine module failures and degradation.

WHY CHOOSE US?

We provide you with valuable insight into the performance of your PV modules. This allows you to:

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Day 2

16 November 2023

2.1 Opening Session - Venue: Boardwalk Tsitsikamma C2 Chair: Freddie Vorster		
08:30	Address from SANEDI *Ms Faith Mkhacwa - General Manager in Energy Efficiency SANEDI*	
09:00	Address from The Energy Secretariat/Applied Energy SANEDI *Prof Sampson Mamphweli - Head of DSI Energy Secretariat at SANEDI/Prof Prathaban Moodley- General Manager*	
09:30	Keynote Address *Mahandra Rooplall - Industrial Development Corporation*	
10:30	**Tea Break**	
2.2a Session: Solar Thermal Energy Systems - Venue: Tsitsikamma C2 Chair: Hartmut Winkler		
11:00	#10 Testing basic solar irradiance models on measurements at Southern African localities - *Sindiswa M. Figlan, Hartmut Winkler*	**p 43**
11:20	#18 Comparison and validation against in-situ measurements of the SARAH-3 solar irradiance satellite estimates over the South West Indian Ocean - *Christella Igihozo, Béatrice Morel*	**p 44**
11:40	#19 DNI estimation from SPN1 pyranometer and satellite for the assessment of solar radiation availability for concentrating solar systems in Reunion Island (WIP) - *Blaise Manzi Habamungu , Mathieu Delsaut*	**p 45**
12:00	#20 Intercomparison and validation of ERA5, ERA5-Land and AROME against in-situ measurements for wind energy applications over Reunion Island - *Liliane Uwajeneza, Beatrice Morel, Chao Tang, Mouhamadou Bamba SYLLA*	**p 46**
12:20	#25 An assessment of available renewable energy resources and the models integrating technical and economic structures in Limpopo province - *Pfesesani Shammah Netshilonwe, Mukovhe Ratshitanga, Fulufhelo Nemangwele*	**p 47**
12:40	**Lunch**	

2.2b Session: Renewable Energy Resource - Venue: Wood Rooms Chair: Arnold Rix		
11:00	#51 Initial experimental testing of solar-salt thermal energy storage unit coupled to a solar dish - *Tlou Mokobodi, Willem Le Roux*	**p 48**
11:20	#36 Magnetite Thermal Energy Storage for CSP Plants - *Muhammad Sheik, Tshiamo Segakweng, Karabelo Sekhuthe*	**p 49**
11:40	#9 Optimizing the Energy Mix for Eco-Industrial Parks in South Africa: A Techno-Economic Analysis Study Using PyPSA (WIP) - *Frank Zandamela, Jan-Hendrik Grobler*	**p 50**
12:00	#11 Optimal battery storage and PV sizing of hybrid power plants in South Africa (WIP) - *Darren van Wyngaardt, Arnold Rix*	**p 51**
12:20	#39 Investigation of Sodium Acetate Trihydrate as a Low-Grade Heat Storage Material in South African Domestic Water Heating - *Cayley Hillier*	**p 52**
12:50	**Lunch**	
2.3 Session: Solar PV Energy Systems - Venue: Tsitsikamma C2 Chair: Jacqui Crozier-McCleland		
14:00	#17 Towards Improved Solar PV Module Characterisation: Correlating Specific Electroluminescence Defects with I-V Curve Features using Multi-class Segmentation-Based Detection - *Frank Zandamela, Lawrence Pratt,Thabang Mabeo, Siyasanga May, Wisani Mkasi*	**p 53**
14:20	#41 Photovoltaic Module Fault Classification Using Optical and Thermal Imagery - *Edward James Westraadt, Chantelle Clohessy, Warren Brettenny, Ernest Van Dyk*	**p 54**
14:40	#8 Sensitivity Analysis of Aerosol Optical Depth and Ozone for Spectral Mismatch of Three South African Locations - *Francisca Daniel-Durandt, Arnold Rix*	**p 55**
15:00	#43 Metal oxide nanomaterials and nanocomposites for photocatalytic hydrogen production through water splitting (WIP) - *Zelalem Urgessa, Assane Talla, Johannes Reinhardt Botha*	**p 56**
15:20	#33 A novel autoclave and microwave-assisted seawater pretreatment for the enhancement of sugar recovery from banana pseudostem: Process modelling and optimization (WIP) - Thandi Hute	**p 57**
15:40	**CLOSING REMARKS PROF SAMPSON MAMPHWELI/DR FREDDIE VORSTER**	
16:00	**Tea Break**	

Day 3

17 November 2023

Technical Tour	
09h00	Meet at Ocean Sciences campus (1104 Venue 4) and tour arrangements
09h15	NMU sustainability and overview of NMU 1 MW PV plant
09h45	Tea and walk to PVinsight
10h15	PVinsight tour
10h45	Travel to South Campus
11h00	PV Plant tour
11h30	Travel to Outdoor Research Facility (ORF)
11h45	Outdoor Research Facility (ORF)
12h15	Lunch at ORF
12h45	Optional visit to PV laboratory

sanedi

South African National Energy Development Institute

DSI ENERGY SECRETERIAT

The Department of Science and Innovation (DSI) established the Energy Secretariat during the second quarter of the 2020/21 Financial Year (FY). The strategic role of the Energy Secretariat is to ensure effective implementation, monitoring and evaluation of innovation policies relevant to the energy landscape and the management of the following four DSI-supported Energy Research, Development and Innovation (RDI) Flagship Programmes

Coal Co2-X RDI Flagship Programme

1 Demostrate technologies that caputure CO2 From flue gas of coal fired boilers/ power plants convert the flue gas components together with(green Hydrogen) tovalue added products such as green ammonia, fertilizer salt and suphuric acid.the programme supports government'S goal to increase mineral benefication of platinum Group Metal ores, by creating a local hydrogen consumption industry.

Energy Stoarage RDI Programme

2 Supports research and development of energy storage technologies which include lithium-ion batteries which support stationary and mobile applications. The objective of this research is to develop value-added precursor materials, like lithium manganese oxide and lithium nickel manganese cobalt. Such research involves computational modelling, precursor material development, cell manufacturing, and battery testing through a consortium of universities and science councils. The Programme focuses on Battery Grade Aluminium foil development, Battery powered Cool transport, Battery pack development, Energy Storage Internships.

Hydrogen SA Flagship Programme

3 Originates from the National Hydrogen and Fuel Cell Technologies (HFCT): Research, Development, and Innovation (RDI) strategy. This programme contributes actively to energy security, and is linked to renewable energy resources, like solar and wind. It further supports South Africa's ambition to be a global exporter of green hydrogen. Through the support of development of hydrogen and fuel cell technologies.

Renewable Energy Hub & Spokes Flagship

4 Supports research and technological innovation which advances Renewable Energy (RE) technologies and skills development at a postgraduate level, thus increasing the knowledge base.The programme conducts research on wind energy technologies (turbines from 3 kW to 300 kW), Solar Photovoltaics, Solar Photovoltaics, materials, modules, and building integrated Photovoltaics systems.

Notes

sanedi

South African National Energy Development Institute.

PROGRAMMES

- Administration
- Applied Energy Research
- Energy Efficiency
- DSI Energy Secretariat

Contact us

Block C, Upper Grayston Office Park, 152 Ann Crescent,Strathavon, Sandton 2146
Tell: 011 038 4300

ABOUT SANEDI

The South African National Energy Development Institute (SANEDI) was established in 2011 under the National Energy Act, 2008 (Act No. 34 of 2008) (NEA). The Act provides for SANEDI to direct, monitor and conduct energy research and development, promote energy research and technology innovation as well as undertake measures to promote Energy Efficiency (EE) throughout the economy.

SANEDI's energy development agenda is a key part of our country's energy journey, and its portfolio of initiatives is closely attuned to technology advancements, declining technology costs and continued innovation in the energy sector. These can enable South Africa to take full advantage of our energy resources and the associated infrastructure development as a vehicle for economic growth, industrialisation, employment creation, and sustainable development. Also, committed to fulfilling the objectives of South Africa regarding energy security and universal access.

SANEDI considers itself as an integral part of the National System for Innovation (NSI) by the definition of the White Paper. White Paper builds on the previous version adopted in 2006 and sets out the medium to long term policy direction for Government to ensure a growing role for Science, Technology, and Innovation in a prosperous, and inclusive society in which the potential of all South Africans is realised. SANEDI will continue its commitment to the policy statements in this White Paper, and the decadal plans that will follow detailing implementation of the policy. Additionally, as an innovation body, SANEDI will continue its long-standing collaboration with the Department of Science & Innovation (DSI), Department of Mineral Resources & Energy (DMRE), and other role players within the innovation value chain, to see to it that there is a realisation of our national objectives.

SOUTHERN AFRICAN SUSTAINABLE ENERGY CONFERENCE

ABSTRACTS

THE RECENT ACCELERATED PACE OF ROOFTOP SOLAR INSTALLATIONS IN SOUTH AFRICA

Hartmut Winkler

Dept. Physics, University of Johannesburg

Abstract

Worsening power shortages in South Africa have precipitated a faster move to alternative electricity supply technologies, especially solar rooftop generation. This study seeks to quantify and explore the timeframe of this growth in solar rooftop installations over the past few years through the inspection of the most recent as well as historical Google Earth imagery. The investigation also attempts to project the rate of embedded solar installations over the next few years, a poorly understood (yet key) factor in South African electricity demand models. Trends in commercial solar installations are analysed by examining bird's eye images of South Africa's larger shopping malls, also exploring whether there are regional differences attributable to site solar irradiance or other factors. Domestic solar installation growth in recent years is estimated by counting households with visible rooftop panels and determining the rate of increase in solar rooftop installations in the demographically well-studied Johannesburg suburb of Parkhurst. Aspects investigated include determining the extent to which rooftop installations have been optimally aligned to receive maximum solar irradiance. The study finds that shopping malls constitute ~60% of the embedded solar facilities with total capacity in the range 0.5-5 MW, and that the dramatic increase in solar installations in malls coincided with the stalling of the REIPPPP programme in 2015. The upturn in domestic household solar installations is much more recent, with the number of households with solar power having more than doubled in the last 10 months.

THE SOCIAL AND ECONOMIC POTENTIAL OF CLOSING THE LOOP ON PHOTOVOLTAIC (PV) MODULE WASTE

MN Crozier[1], C Schenck[2], JL Crozier McCleland[3] and EE van Dyk[4]

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Abstract

An unreliable energy supply is accelerating the transition to solar energy for South African industry and households. As solar photovoltaic (PV) module installations increase, so does the need to create systems to deal with the current and future e-waste produced. PV modules degrade in performance over the 20-25-year lifetime of the module with a normal power loss of less than 1% per year. However, early-life failures can occur if modules are damaged or are of poor quality and thus can degrade faster. With only limited recycling of PV modules occurring, a circular economy approach has yet to be developed in South Africa. A circular economy designs out waste, circulates materials at their highest possible value and is regenerative by design. Recycling is the least desirable of the circular economy activities due to the loss of value in the materials. Reuse and repair are potentially more ideal as they retain the product's inherent value. This paper places PV end-of-life within the context of South Africa's e-waste recycling and energy landscape. The potential benefits around business development and employment for a second-hand market in PV are referred to. The paper provides a context for understanding issues around PV Module reuse and repair in South Africa.

Keywords: Solar PV Modules; Reuse; Recycling; Circular Economy; End-of-Life; E-waste.

#49

PHOTOVOLTAIC MODULE TESTING: DEVELOPING A SOUTH AFRICAN CIRCULAR ECONOMY FOR PV MODULES

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Abstract

As South Africa experiences a dramatic increase in the uptake of solar energy so will Photovoltaic (PV) waste eventually increase either due to end-of-life or due to early failures. In the waste hierarchy, reduction and reuse are preferred to recycling or disposal. The ability to reuse or repair a PV module prevents the need for a new module from being manufactured which ultimately contributes to waste. This paper discusses the testing processes necessary to determine if PV modules can be reused, repaired or recycled at end-of-life. There are currently no standards for the testing of second-hand modules and the modules in this study are evaluated against the IEC 61215 Certification Standard. The testing includes Visual Inspection to identify module defects, Electrical Insulation to confirm module safety, Electroluminescence to detect invisible cracks and Maximum Power measurements to determine the module performance. These are compared to expected values for a module of that age to determine the module's suitability for resale or reuse. Where reuse is not possible repairs or refurbishments of PV modules are suggested and the safety of these repairs is assessed. If reuse or repair is nor possible then the PV modules are recommended for recycling.

Keywords: Photovoltaic; Circular Economy; PV Module Testing

ANALYSIS OF INDIVIDUAL CELL CHARACTERISTICS IN A MISMATCHED MODULE STRING

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Abstract

The purpose of this study is to assess the electrical and thermal characteristics of individual cells of a monocrystalline photovoltaic (PV) module to understand their behaviour when operated in a mismatched module string.

Modules under operational conditions are prone to mismatch losses, which is the difference in the current and voltage characteristics of series connected cells and substrings in a module or modules in a string of modules. The mismatch in a string of solar cells in a module can be intrinsic (manufacturing mismatches) or extrinsic, which are mismatches due to cells experiencing different environmental conditions (irradiance, temperature, etc.). Mismatch is further enhanced by shadings that may be caused by nearby trees, buildings, adjacent modules, soiling, and degradation of cells among other factors.

To study the performance of mismatched cells, the backsheet of a module was cut to expose the busbars to facilitate electrical connection to the individual cells for monitoring using a data logger. The individual cell voltages were monitored while the module operated on its own and while operating in a string.

This work involves the analysis of individual cell data while operating under different conditions. These include varying irradiance and different shading levels and patterns. The expected behaviour of mismatched cells, cell substrings and modules were also modelled using the PVSIM modelling software.

The results of this study are of importance to PV system owners and operators, enabling them to make suitable maintenance decisions for the best module performance under operating conditions.

Keywords: Shading, mismatch, characterization, strings, PV performance

Effects of cell shading level on thermal and electrical characteristics of a crystalline PV module under different operational I-V points

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Abstract

Photovoltaic (PV) modules deployed in the field experience changes in load conditions, soiling and shading levels. These dynamic operating conditions affect the interpretation of thermal imaging and electrical characterisation measurements. This study investigates the dynamics of the operational current-voltage (I-V) and thermal characteristics of a crystalline PV module (SW240 poly) and individual cells to understand the behaviour of the cells at different cell shading levels and module operational voltages. When the module operates at maximum power voltage (VMP), the voltage of a shaded cell becomes negative (reverse bias) at a shading level of 8% and the temperature of the whole cell is elevated. The operational temperature of a shaded cell increases when the shaded cell area is between 8 to 40% reaching a peak temperature when the shaded cell area is between 40 and 50%. The cell's temperature decreases for shading levels 50 to 100% when the bypass diode of the substring containing the shaded cell appears to be activated. When the operational voltage of the module is < VMP, a small shading level of 4% causes reverse biasing of the shaded cell, while at operational voltages > VMP, the cell becomes reverse biased by shading levels $\geqslant$ 50%. A cell can easily be mismatched, operate in reverse bias and cause abnormal thermal signature when the module's operational voltage is < VMP unlike when operational voltage is > VMP. Therefore, when a PV module is shaded, it is beneficial for the operational point to be > VMP, since the mismatched cells will not become abnormally hot to cause detrimental effects such as module back sheet damage, cracks, risk of fire and increased module degradation rate. This work gives valuable information which can advance the interpretation of thermal images and I-V curves of PV modules.

Keywords: Cell mismatch, current-voltage characteristics, thermal signature

WIND POWER FORECASTING: A REVIEW

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Abstract

Due to the stochastic behaviour of wind power generation, accurately predicting wind speed and power generation is fundamental to the reliable and large-scale adoption of wind power integration onto the electrical grid. In this research paper, a compact review is presented on wind power forecasting, which focuses on the classification of methods and the evaluation thereof. Specific factors related to wind speed and power prediction have also been highlighted. To further ensure the relevance of this paper, the literature review has been limited to research published within the last 5 years. Based on the most common research trends, future recommendations are made to improve accuracy and aid development in underexplored researched domains. This review ultimately provides a framework for enhancing the implementation of wind power forecasting. This, in turn, leads to improvements in ancillary service provision through wind energy, resulting in the optimal integration of wind energy into the electrical grid.

#65

WIND RESOURCE ALLOCATION TECHNIQUE FOR OPTIMAL PLACEMENT OF WIND POWER PLANTS: A CASE STUDY IN THE COASTAL REGION OF SOUTH AFRICA

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Abstract

This paper introduces an approach to enhancing the allocation of wind resources by leveraging unsupervised machine learning techniques. The central objective is to optimize the distribution of wind resources across geographic sites, thereby maximizing both generation profiles and overall system stability. Two distinct clustering methodologies are employed, namely temporal and statistical feature clustering. These strategies effectively cluster regions within the coastal region of South Africa and unveil the unique advantages of each approach.

Both clustering techniques harness the power of the widely utilized k-means algorithm in unsupervised learning. To comprehensively assess the characteristics of the temporal and statistical clusters, a modelling framework utilizing the Weibull distribution is implemented. This approach accounts for seasonal fluctuations and considers wind speed intervals that correspond to different temporal periods. By integrating the Weibull distribution, the modelling technique significantly enhances the accuracy of representing the characteristics of the wind resource potential.

Furthermore, this study incorporates the clustered data as inputs into an optimization model. This model serves as a guiding tool for informed decision-making regarding the strategic placement of wind power plants along South Africa's coastline. The proposed allocation methodology is adaptable, as it can easily incorporate additional critical variables such as wind direction, solar power, and green hydrogen.

Keywords: wind resource allocation; clustering; statistical feature extraction; Weibull distribution; optimisation

THE VALUE OF ENERGY STORAGE IN REDUCING WIND ENERGY FORECAST ERROR PENALTY COSTS IN SOUTH AFRICA

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Abstract

The successful integration of large amounts of wind energy onto the South African network depends on reducing the uncertainties inherent in wind generation. Towards this goal, as of Bid Window 5 of South Africa's (SA's) Renewable Energy Independent Power Producer Procurement Programme independent, power producers are subjected to penalty costs for wind generation forecast errors. This paper explores the financial feasibility of adding a lithium-ion (li-ion) Battery Energy Storage System (BESS) to a wind farm to alleviate the wind forecast error penalty costs in SA. The hypothesis investigated in this study is that for a wind farm, the integration and operation of a BESS behind the meter can sufficiently alleviate the wind energy forecast errors and associated penalties to make such an integration financially feasible. An Excel-based simulation model that considers revenue, forecast penalties and the technical and financial performance of a li-ion BESS is developed. In evaluating the feasibility of the BESS integration, the net present value and internal rate of return metrics are employed. The model was tested through a case study using the Sere wind farm in SA. Feasibility was tested as a function of a number of parameters: BESS optimal size and efficiency; forecast error magnitude; BESS charging strategy; project discount rate; BESS replacement costs and wind farm size. For the case study, it was found that it is currently not financially feasible to install a li-ion BESS next to a wind farm for the sole purpose of wind energy forecast error alleviation in SA. The results of the sensitivity analysis indicate at what point such a BESS integration might become feasible given changes to input parameters. The outcome of this study is anticipated to be beneficial to wind farm owners and investors in the energy storage and wind energy domains seeking to alleviate costs associated with forecast errors.

Keywords: wind energy, forecast error, penalty cost, BESS.

#52

REVIEW OF ELECTRIFICATION MODELING APPROACHES FOR RURAL AREAS OF SUB-SAHARAN AFRICA

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Abstract

Energy is a major driver of social and economic development, but energy should also be provided at the right time and place and in the right amount. Thus, advance planning is required, and this planning demands accurate energy data. Energy system modeling has proven valuable for rationalizing resources and simulating and analysing energy systems prior to implementation for optimal design and during operation for improved operational decisions to be made. Due to lack of data, in particular in developing countries, energy systems studies often use aggregated statistical and/or survey data as well as data from geographic information systems (GIS). Yet, the accuracy of available statistical and survey data is debatable and may lead to over or underestimation of electricity demand and/or supply. This is particularly the case for rural areas. This calls for new modeling methods for electrification planning. Thus, this article reviews trends in modeling approaches used in studies of rural electrification in developing countries, particularly in sub-Saharan Africa, between 2012 and 2022. The majority of studies tend to optimize power generation systems based on the lowest-cost technologies and with a high degree of disaggregation of technologies. Results indicate that geospatial tools such as GIS help divide rural and urban zones, which is important for energy planning because of the different features of these different zones. Modeling electrification at the subnational level (especially in rural areas) requires higher resolution, in spatial and time variables. The models should include local variations in energy resources such as wind, biomass, and small hydro, to allow for good prediction of potential generation at different time scales and better planning of the alternatives that need to be considered for power system reliability. Besides, high-resolution population and resource data as well as high-time computational resolution would enhance the models result.

Keywords: electricity; modeling approach; sub-national, rural.

A REVIEW OF ELECTROLYSER MODELLING FOR HYDROGEN PRODUCTION COUPLED WITH RENEWABLE ENERGY SOURCES

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Abstract

Hydrogen production through water electrolysis, coupled with renewable energy sources presents a promising solution to significantly reduce carbon emissions. A substantial body of research has been conducted in the integration and modelling of these two domains, resulting in numerous models and simulation approaches being presented in the literature. However, selecting an appropriate model that accurately characterises an electrolyser is unclear, especially when renewable energy sources are integrated.

In this paper, the methodology used to review existing literature is outlined, followed by a discussion of the relevant electrolyser theory needed in order to model such a process. This work reviews various electrolyser models for both Alkaline Electrolysers and Proton Exchange Membrane Electrolysers. The models vary in complexity, ranging from simplified linear approximations to highly intricate ones that utilise experimental data.

The research focuses on evaluating the advantages and drawbacks of these models, along with identifying scenarios where the implementation of each model would be appropriate. The paper places special emphasis on essential variables including electrolyser efficiency, hydrogen production, power input, temperature affect, load range, operating states and ramp up and ramp down rates. These parameters play a crucial role in developing an accurate electrolyser model when integrated with variable renewable energy sources.

Keywords: Electrolyser; model; green hydrogen; renewable energy; review

A COMPARISON OF HEAT DISSIPATION FACTORS FOR OPEN-RACK, BUILDING-ATTACHED AND FLOATING SOLAR PHOTOVOLTAIC INSTALLATIONS

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Abstract

Estimation of solar photovoltaic (PV) module operating temperature is an important component of accurate PV system simulation and design. Faiman's module temperature model provides a simple method of estimating PV module operating temperature using empirical heat dissipation factors (HDFs) and is widely used in PV simulation. This paper presents HDFs for open-rack and floating solar PV (FPV) configurations based on measurements collected on installations around Stellenbosch, South Africa. The paper allows for direct comparison of the HDFs for these different PV configurations under similar solar and ambient conditions. Differences in the thermal characteristics of the configurations are thus highlighted and the need for specific factors to enable accurate prediction of module temperatures is motivated.

Keywords: module temperature; open-rack PV; floating photovoltaic (FPV); Faiman model; heat dissipation factors

#21

AGRIVOLTAIC SYSTEMS: TECHNO-ECONOMIC ANALYSES OF POTENTIAL PV CONFIGURATIONS FOR SOUTH AFRICA

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Abstract

Agrivoltaic systems can effectively tap into South Africa's solar resources while maintaining agricultural productivity. A prior GIS analysis identified that utilising less than 2% of viable agricultural land (about 400,000 hectares) could potentially double the country's annual electricity generation. With most the potential in central provinces with livestock and maize farming, followed by the Western Cape Province with orchards and vineyards [1]. This study presents techno-economic analyses for the most (technically) viable agrivoltaic systems across three farming types: grazing, maize, and orchards. The results yield Levelized Cost of Energy (LCOE) values ranging from R1.08 to R1.72 per kWh generated. Comparing to existing electricity tariff rates across provinces [2], suggests that agrivoltaic systems could be an economically viable choice for South African farmers.

For beef and dairy farming, a minimum installation height of 2.8 meters is necessary to protect against livestock damage. Smaller livestock, like sheep, can use standard ground-mounting heights without impacting pasture growth. Agrivoltaic systems can maximize electricity generation with an optimal panel density, as shading has minimal effects.

Maize farming requires taller installations of at least 4 meters for harvester clearance when using overhead racks. An alternative option is vertical bi-facial panels, eliminating the need for costly infrastructure. Overhead panels reduce water loss, which is beneficial for dryland maize farming. A shading density of 15% or less is recommended to minimize yield losses due to shade intolerance [5, 6].

Orchard agrivoltaic systems often place panels between tree rows to minimize shading. Overhead panels offer frost protection and create a beneficial micro-climate. Literature reports installation heights of up to 5 meters [7, 8]. Orchards tolerate higher panel densities (30%) and may require structures to support nets, reducing rack mounting costs.

Solar tracking systems are preferred in all cases to maximize solar irradiation interception, evenly distribute sunlight, and offer operational flexibility. They can be oriented to adapt to different conditions, causing rapid vegetation drying after heavy rain or frost prevention during winter [1][7].

A techno-economic analysis was conducted for three 1P solar tracking configurations at a 5-meter height. Optimal panel densities of 30% (beef and dairy farming), 15% (maize farming), and 30% (orchard farming) were considered.

Initial CAPEX and operational costs per hectare were calculated, including hardware and labour, then compared to similar agrivoltaic systems in other countries and utility-scale PV projects in South Africa. The LCOE for each system was determined and compared to local South African import and export tariffs across provinces, with ROI and payback periods estimated assuming electricity is either used on-site or exported to the municipality for payment, highlighting the economic potential of agrivoltaic systems for South African farmers.

Notes

#13

MODELLING THE INFLUENCE OF REFLECTED LIGHT ON THE REAR SIDE OF A BIFACIAL PV MODULE

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Abstract

This paper focuses on modelling the influence that the reflected light spectrum has on the rear side of a bifacial PV module. The front and rear-facing spectrums as well as current-voltage (I-V) curves for the front and rear side are measured for a bifacial PV module on two different surfaces (white gravel and grass). The five parameters of a single diode model are then extracted from the measured I-V curves and two new factors are proposed that can be used with the conventional way of modelling the rear side to improve yield forecasting. The results demonstrate that the photocurrent (I_{ph}) is the most influenced factor with varying reflected spectrums. Notably, on white gravel and grass surfaces, there is an improvement in modelling the Iph parameter by 61.7% and 87.4%, respectively, compared to conventional methods. These results contribute significantly to the accurate modelling of the rear side of bifacial PV modules.

#38

CURRENT-VOLTAGE CHARACTERIZATION OF BIFACIAL MODULE WITH A SINGLE LIGHT SOURCE SOLAR SIMULATOR

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Abstract

Bifacial photovoltaic (bPV) modules are designed to absorb light on both the front and rear surfaces to generate electricity, and as a result bPV modules have a better yield and can improve the Levelized Cost of Electricity (LCOE) of photovoltaic (PV) installations. The factor by which the output of the bifacial module is increased compared with a monofacial PV module is called the rear irradiance driven Power Gain. The two surfaces of a bPV module differ in collection efficiency and this difference depends on the cell technology used in the module. The electrical parameters of each surface of a bPV module are measured at standard testing conditions (STC) as explained in the technical standard IEC TS 60904-1-2: 2019. These parameters included Maximum Power (P_max), Short-circuit Current (I_SC) Open circuit voltage (V_OC) and the ratios of these parameters give the bifaciality coefficients (φ_(P_max), φ_(I_SC), φ_(V_OC)) of a bPV module. These measurements are made indoors using an indoor solar simulator and outdoors using a portable I-V curve tracer. The results are comparable given the associated measurement uncertainty of each method. This paper outlines the advantages and disadvantages of each method and critically examines the limits and challenge of each method.

Keywords: Bifacial photovoltaic module; bifacial module characterisation; rear irradiance driven power gain yield

#32

BIOGAS CONVERSION TO ELECTRICITY FROM FOOD WASTE AND WASTE-ACTIVATED SLUDGE DIGESTION

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Abstract

An enormous amount of waste-activated sludge (WAS) and food waste (FW) is generated worldwide. Most of this waste is discarded in landfills, where it undergoes uncontrolled anaerobic digestion (AD), which emits excessive amounts of greenhouse gases, (methane and carbon dioxide), thereby contributing to global warming. Controlled digestion of WAS and FW is key for organic waste management with a positive impact on the environment and economy. In South Africa (SA) there is little uptake of biogas technology for WAS and FW management due to little research on biogas potential at small to large scale. In the current study WAS and FW was treated in both mono-digestion and co-digestion at mesophilic temperatures on a pilot scale, aided by a solar system. A complete-mix biogas pilot plant (VUT-1000C) was designed, constructed and commissioned. The materials used for constructing the pilot plant were sourced locally, including the solar geyser, to prove the applicability of the AD technology in South Africa. The biogas produced was converted to electricity using a generator. A power balance was then performed over the biogas plant for each treated feedstock. Up to 2.3 kWh power output was from 1 400 L of biogas produced during FW mono-digestion and co-digestion with WAS at an organic loading rate (OLR) of 1.6 kgVS/m_3/day. Up to 0.6 kWh of power was produced from 150 L of biogas during WAS mono-digestion indicating that the plant required 68% of the output for input. In the co-digestion of WAS with FW and mono-digestion of FW, the power output to input ratio was higher compared to WAS-only digestion. Great volumes of biogas as renewable energy are being lost in South Africa due to the lack of anaerobic technology uptake. Furthermore, the study has shown that biogas technology is readily available for South Africans as the designed biogas plant was very effective in waste-to-energy conversion.

Keywords: Anaerobic co-digestion; Biogas; Electricity; Food waste; Waste-activated sludge.

#35

ENHANCING ANAEROBIC DIGESTION OF ORGANIC WASTE THROUGH MICRO-AERATION

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Anaerobic digestion (AD) is a mature technology that can process several different types of organic feedstocks while simultaneously producing biogas. The process contributes to the reduction of greenhouse gas (GHG) emissions by effectively capturing the methane produced in the biogas instead of releasing it into the atmosphere. However, the process has several pitfalls, such as a slow hydrolysis rate for lignocellulosic feedstocks, instability at high organic loading rates, and production of hydrogen sulphide in the biogas. These issues can potentially be overcome through micro-aeration, which exposes facultative anaerobic bacteria to low levels of oxygen, leading to an increase in the growth rate, activity and diversity of these bacteria and the associated production of hydrolytic enzymes. Improved hydrolysis rates and biogas yields from this increased activity result in a more stable process through controlling volatile fatty acid concentration, and hydrogen sulphide gas scavenging. The project will aim to determine the role that micro-aeration plays in improving the hydrolysis of lignocellulosic biomass and recovering process stability after a volatile fatty acid accumulation occurs during AD of organic waste. This will be shown by developing an effective micro-aeration delivery system, assessing the most effective aeration rate, and determining the effectiveness of micro-aeration during co-digestion. The experiments will be conducted using inoculum from a cow manure digester with an average total solids and volatile solids percentage of 4.46 ± 1.41% and 3.47 ± 1.16%, respectively, and an average pH of 7.69 ± 0.05. Mono-digested corn stover will be compared to its co-digestion with food waste based on an optimised carbon-to-nitrogen ratio of 30:1. Three different aeration rates of 0.10, 0.60, and 0.90 L-O_2/L-reactor/day for corn stover and three different aeration rates of 0.02, 0.03, and 0.10 L-O_2/L-reactor/day for corn stover with food waste co-digestion will be assessed. Improving biogas production using low levels of air further enhances the appeal of anaerobic digestion as an approach to waste diversion and renewable energy production.

Keywords: Anaerobic digestion; micro-aeration; corn stover; food waste; hydrolysis; process stability.

#54

INDUSTRIAL WASTE VALORISATION FOR MANAGING THE FOOD-ENERGY-WATER NEXUS TOWARDS A CIRCULAR BIOECONOMY

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Abstract

The impact of the increasingly growing population together with the energy crises and dwindling resources on the food-energy-water (FEW) nexus has exacerbated the global mandate to accelerate progress towards achieving sustainable development goals. The complex linkages between the FEW domains require a suitable integrated approach to optimally manage the water, energy and food triad. From a biotechnology perspective, microbial factories generate an array of biofuels and biochemicals with the potential to revolutionize the bioeconomy and address key global challenges in line with the FEW nexus. For instance, the utilisation of renewable sources for energy production such as biogas and bioethanol that can be used to supplement current energy sources has seen tremendous growth over recent years worldwide. Nevertheless, biofuel production faces several challenges such as the low yields and high cost that is associated with suitable substrates and nutrients for microorganisms coupled with the lack of knowledge on the microbial kinetics and key influential parameters. Therefore, the search and development for waste-based processes to reduce costs and use of valuable resources is imperative and will contribute towards achieving a "waste to wealth" approach. This research aims to explore industrial waste valorisation for managing the food-energy-water nexus towards a sustainable bioeconomy.

Keywords: biofuels; bioproducts; bioenergy; bioeconomy; waste valorisation

#61

DIRECT VALORISATION OF FRESH POTATO PEELS FOR PRETREATMENT, SIMULTANEOUS SACCHARIFICATION AND BIOETHANOL PRODUCTION: ELIMINATING DRYING PROCESSES, REDUCING FRESHWATER USAGE, AND ENHANCING HYDROLYSATE PROCESSABILITY

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Abstract

The depletion of fossil fuel reserves, increasing world population and global energy demand have increased the need for alternative energy sources. These have forced the world in search of an alternate, abundant, cost effective, renewable, sustainable, and environmentally friendly energy source such as plant-based energy source [1]. About 50% of the global biomass is plant lignocellulosic with total annual estimated of over 50 billion tons been release to the environment. These lignocellulosic agricultural wastes include starch-based lignocellulosic biomasses such as potato peels [2].

The study directly pretreated fresh waste potato peels (FWPP), eliminating drying processes, reducing freshwater usage, and assessing hydrolysate processability for bioethanol production. The FWPP pretreatment was optimised for the released of reducing sugar. Freshwater usage was conserved up to 80% during FPPW pretreatment. FPPW lignocellulosic contents showed significant differences in the hemicelluloses (1.32-fold), cellulose (1.67-fold), and lignin (1.10-fold) solubilization. The concentration of phenol, furfural and HMF process inhibitors were lower in the FWPP hydrolysate. Moreover, lower viscosity (1.75-fold), CO2 production (1.02-fold) and higher glucose concentration (2.24-fold) were obtained with FPPW hydrolysate. In addition, the FPPW hydrolysate produced ethanol concentration of 70.27 g/L compared to control experiment (32.79 g/L). These findings demonstrate the direct utilization of fresh potato peel to circumvent the need for drying as well as reduces the use of fresh water during biorefinery upstream processes.

#5

THERMAL CHARACTERISTICS OF AN INDIRECT SOLAR DRYER FOR DRYING BANANAS

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Abstract

Post-harvesting losses are predominant in developing countries due to inadequate food preservation methods. Open sun drying usually used by small-scale subsistence farmers in the developing world is inefficient since the quality of the product is reduced due to under or over-drying in the sun. Additionally, environmental factors such as rain, wind, and dust have a negative impact on the quality of the dried products. To cater to the drawbacks of open sun drying, an indirect solar dryer is designed and experimentally evaluated for drying bananas. The dryer is evaluated under two experimental conditions. The first drying condition involves drying bananas during two 8 h periods of good solar radiation on two consecutive days. Secondly, the solar dryer is tested for a continuous 24 h period to study the overnight characteristics of the dryer. To evaluate the thermal characteristics, the thermal profiles in six drying trays are measured with K-type thermocouples during the drying process. The six trays are in three levels (top, middle, and bottom), and there are two trays per level (left and right). Each tray has two thermocouples making a total of twelve measurement positions in the dryer. The moisture ratio is also used to evaluate the thermal characteristics in the drying chamber. The maximum temperatures attained for both days in the 8 h sunny period tests in the top trays are around 48 oC. For the 24 h test, the maximum temperature at the top trays is around 50 oC. The drying process continues even when the drying tray temperatures drop drastically overnight to minimum values between 6-8 oC for the 24 h test. The final average moisture ratios for the 16 h and 24 h tests are comparable showing values of around 26 % and 32 %, respectively. This indicates that the solar drying process can be continuously done for 24 hrs without much moisture rebuild. A storage system can effectively improve the drying process overnight.

Keywords: Bananas; Indirect solar dryer; Thermal characteristics

#34

DEVELOPMENT OF A PILOT LOW TEMPERATURE SOLAR THERMAL CO-GENERATION SYSTEM FOR WATER DISTILLATION AND ENERGY GENERATION

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Abstract

A solar-thermal system for co-generation of distilled water and energy was investigated in a collaborative study by the University of Southampton and Stellenbosch University. The system utilises a condensing engine, using solar-generated steam at ~1 atm (abs) and a vacuum generated by condensation. The study entailed the design, manufacture, commissioning and testing of a 6.5 kW_{th} prototype system. From on-sun testing, the average daily specific energy consumption (SEC) for water distillate production was 2125 kWh_{GTI}/m^3; and the average daily theoretical solar-to-mechanical energy conversion efficiency was 0.79 %. The SEC was determined to be significantly higher than existing alternatives such as solar PV reverse osmosis, and the energy generation significantly lower compared to commercial solar power technology (e.g. solar PV). As such, the performance and experience gained with the prototype suggest this system is not feasible.

Keywords: co-generation; compound parabolic collector; desalination; solar thermal energy; steam expansion

#48

UPGRADING THE COMPRESSOR STAGE OF A SOLARISED MICRO GAS TURBINE

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Abstract

A solar-hybrid gas turbine combines the environmental advantages of concentrating solar power (CSP) with the capabilities of a micro gas turbine's (MGT) continuous high-power output. A variety of options are available to improve MGT's performance and efficiency, with the primary focus being on its compression stage. An upgraded compressor stage for an existing solar-hybrid application MGT testbench is presented. MGT engines commonly feature a centrifugal compressor stage due to higher per stage pressure ratios being achieved compared to single stage axial configurations. The existing operational solar-hybrid MGT testbench, operates at low efficiency. The impeller of the MGT is redesigned by first simulating the existing impeller in a computational fluid dynamics (CFD) simulation and comparing the results to its existing performance charts. It is then redesigned with a one-dimensional (1D) mean line code and simulated in CFD to evaluate performance improvement. The new design is further improved by increasing the geometrical tolerances of the impeller stage's tip gaps to the finest achievable manufacturing tolerance of 0.3 mm. This improvement increases the simulated pressure ratio and efficiency of the MGT compressor from 1.482 to 1.55 and 78.3% to 84.2%, respectively. The MGT testbench predicted overall output power improves by 22.7%, from 18.078 kW to 22.186 kW. Due to a redesigned impeller and finer impeller clearance tolerance requirements, both the impeller and shroud cover need to be re-manufactured. This enables the centrifugal compressor to provide its optimal performance based on geometrical limitations.

Keywords: Centrifugal compressor design; Micro gas turbine; Solar-hybrid gas turbine.

#69

FEASIBILITY STUDY ON THE USE OF A WATER-COOLED SHELL AND TUBE HEAT EXCHANGER FOR A SCO2 BRAYTON RECOMPRESSION CYCLE IN CSP APPLICATIONS

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Abstract

The Rankine cycle has been a leading power generation cycle for years. Recently however, the Brayton cycle, specifically the recompression configuration, has proven to be more efficient when using sCO2. Studies have demonstrated that if the compressor inlet temperature and pressure of sCO2 are maintained near the critical values, the cycle's efficiency can be improved. For this project, the goal was to design a water-cooled shell and tube heat exchanger (STHE) that can cool sCO2 to within a range of 30°C to 33°C for a Brayton recompression cycle and evaluate its performance when used with CSP. The STHE was designed iteratively using the Bell Delaware method and TEMA standards. With FLOWNEX, a simulation of the Brayton recompression cycle with an inventory control system was conducted using DNI collected in the Upington area on the hottest day of the year. For this simulation, it was found that a minimum heat input of 35MW was required for accurate results. It was shown that even when the dew point temperature varies, the heat exchanger can maintain the required outlet temperature. However, it transpired that this could not result in the predicted 51.5% efficiency, but cycle temperatures revealed to be stable even during transient operation. To achieve the above efficiency, a combination of pressure ratio, split ratio, and main compressor inlet temperature (CIT) to the recommended range is required to ensure efficiency increase. Keywords: Supercritical carbon dioxide Brayton cycle; Compact heat exchangers; Recompression cycles; Concentrated Solar Power.

#10

TESTING BASIC SOLAR IRRADIANCE MODELS ON MEASUREMENTS AT SOUTHERN AFRICAN LOCALITIES

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Abstract

Five clear-sky models have been investigated to determine the accuracy of the model to fit the calculated solar irradiance measured over an eight-year period (2014-2021). The main forms of solar irradiance that were investigated were: Direct normal irradiance (DNI), which is used in solar PV and CSP, Diffuse horizontal irradiance (DHI) and Global horizontal irradiance (GHI), which are important for solar PV systems. The Haurwitz, Chràcicki, Meinel, Power law, and Logarithmic (newly proposed) models were used to investigate GHI, the Archer, Sharma, Meinel, Power law, and Logarithmic models for DNI; and the ASHRAE, Power law, Fritz, Daneshyar, and Logarithmic (newly proposed) models for DHI. All models are regarded as simple clear-sky models due to only depending on the zenith angle and having two scaling parameters used for linear regression analysis. The minutely measured data was taken from the five stations (Richtersveld, Vanrhynsdorp, Graaff-Reinet, Gaborone, and Windhoek) found in South Africa, Namibia and Botswana which were supplied by the SAURAN network. The influence of station elevation will also be evaluated.

#18

COMPARISON AND VALIDATION AGAINST IN-SITU MEASUREMENTS OF THE SARAH-3 SOLAR IRRADIANCE SATELLITE ESTIMATES OVER THE SOUTH WEST INDIAN OCEAN

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Abstract

The solar resource has by far the highest energy potential on Earth leading to an increased attention to climate data sets of surface solar radiation (SSR) as an important source of information for solar energy assessment. Such an assessment is essential for solar energy projects policy and planning. The present work aims at evaluating the skill of satellite-based estimates of solar global horizontal irradiance (GHI) from the new "Surface Solar Radiation Data Set-Heliosat edition 3" SARAH-3 at 0.05° spatial resolution and 30min temporal resolution over the South West Indian Ocean, using 1-min pyranometer GHI measurements (in-situ) recorded at different stations of the Indian Ocean Station network (IOS-net) during the year 2020. Both data have been arithmetically averaged to different time scales from the annual means to hourly means for comparison. The data have also been classified into 4 clusters by the use of an unsupervised method of machine learning "K-means clustering" to depict the 4 types of solar regimes. Validation results show that SARAH-3 reproduces fairly the shapes of seasonal cycles and diurnal cycles with different amplitude compared to the in-situ measurements. Stations with higher GHI estimates in SARAH-3 also depict more clear days and fewer overcast days than the in-situ measurements.

#19

DNI ESTIMATION FROM SPN1 PYRANOMETER AND SATELLITE FOR THE ASSESSMENT OF SOLAR RADIATION AVAILABILITY FOR CONCENTRATING SOLAR SYSTEMS IN REUNION ISLAND

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Abstract

The DNI (Direct Normal Irradiance) is the resource utilized by solar concentrators such as in CSP (Concentrated Solar Power) and CPV (Concentrated Photovoltaic) applications for electricity production or in solar bakery applications in off-grid remote communities. The main goal of the SoCooMa (Solar Concentration for Cooking in Mafate) project is to provide a detailed assessment of Surface Solar Radiation (SSR) availability for concentrating solar bakeries in Reunion Island with a focus on the isolated area of Mafate. The accurate instrument that can be used for DNI measurements is the pyrheliometer. However, this instrument is expensive and requires high maintenance efforts, as it must be mounted on an expensive automatic two-axis sun tracker to point precisely at the sun all day. Since the measurements of GHI (Global Horizontal Irradiance) and DHI (Diffuse Horizontal Irradiance) from the cost-effective SPN1 pyranometers at the Indian Ocean Solar network (IOS-net, https://galilee.univ-reunion.fr/) stations have good accessibility and availability over Reunion Island, the present paper aims at clarifying to what extent these measurements can be used for deriving the DNI time series for the SoCooMa project. It also explores the possibilities provided by satellite-based DNI databases for places where no pyranometer measurements exist. Additionally, the paper presents a study of the estimation procedure for DNI from 1-minute experimental data of GHI and DHI from IOS-net in Saint-Denis (Réunion Island University, Moufia campus site), as well as the evaluation of satellite-based DNI at the same site. As the DNI in this study is indirectly derived, an error analysis is then performed for both DNI values (SPN1 and satellite) using the reference measurements of the Kipp&Zonen CHP1 pyrheliometer from Reunion BSRN station at Saint-Denis. Finally, correction procedures are applied to the DNI raw data of the SPN1 and satellite in order to reduce their deviation from the reference DNI determined by the CHP1 (pyrheliometer).

#20

INTERCOMPARISON AND VALIDATION OF ERA5, ERA5-LAND AND AROME AGAINST IN-SITU MEASUREMENTS FOR WIND ENERGY APPLICATIONS OVER REUNION ISLAND

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Abstract

To ensure energy autonomy, initiatives aiming at mitigating emissions of greenhouse gases in the energy sector rely on the development of renewable energy sources (RES). However, integrating electric RES into the energy mix represents an important challenge due to the variations they undergo, which induce variations in electricity production that are not always in phase with demand. The key goal of the present study is to provide a wind resource assessment over Reunion, a small island located in the South West Indian Ocean (SWIO) aiming to become self-sufficient for its electricity with RES by 2030. Currently, wind energy comes from two farms. An increased reliance on wind energy could help reach the 100% RES target, including new offshore and onshore wind turbine capacity installations. In this study, the wind data from a variety of gridded datasets, including climate reanalysis ERA5 at ~25 km spatial resolution and ERA5-Land at ~9 km spatial resolution, along with Météo-France AROME model at ~2.5 km spatial resolution are compared and validated against in-situ measurements from different Météo-France sites across Reunion over the period 2017-2020. All datasets are recorded at 10 m height with an hourly temporal resolution. The validation was performed over different time scales, from annual means to diurnal cycles, and statistical metrics such as correlation, bias, and root-mean square error were computed to measure errors. Logarithmic law is used to extrapolate wind speed at hub heights in order to obtain the wind power density at those heights. The results reveal that the AROME is highly accurate and reliable, especially in complex terrain where lower biases are obtained in comparison to the reanalysis datasets. The wind power potential is high at 50 m and 100 m, especially in the northeast parts of the island, which appear to be suitable for onshore wind farm installation.

#25

AN ASSESSMENT OF AVAILABLE RENEWABLE ENERGY RESOURCES AND MODELS INTEGRATING TECHNICAL AND ECONOMIC STRUCTURES IN LIMPOPO PROVINCE (TECHNOLOGY ANALYSIS)

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Abstract

In South Africa, energy transition from fossil fuels to renewable energy is advancing. The advancement is essential to meet affordable, reliable, and sustainable energy. Replacing fossil fuels with renewable energy has been unfolding at an average rate due to gradual improvements in renewable energy technologies and insufficient awareness towards those technologies. Improvements of renewable energy technologies will protect the environment, improve socio-economic lives of people and promoting clean economic growth in rural areas. This paper presents an assessment of available and potential renewable energy resources in Limpopo province to evaluate their technologies with regard to availability of energy source, technological criteria and environmental aspects. Renewable energy resources assessed were solar PV, biomass, hydropower, geothermal and wind energy. Two renewable energy resources (solar PV and biomass) are top utilized energy resources in the province and the remaining resources are potential resources. Favorable geographic location and affordability are the drivers behind solar PV demand biomass waste availability and waste treatment plants availability drive the utilization of biogas technology. Satisfying renewable energy performance consequence economical reliable energy supply, lower harmful gas emissions, and reduced energy poverty.

Keywords: Techno-Economic analysis; solar PV; Biomass; Biogas; renewable energy; Micro-grids

#51

INITIAL EXPERIMENTAL TESTING OF A SOLAR SALT THERMAL ENERGY STORAGE UNIT COUPLED TO A SOLAR DISH

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Abstract

Ongoing efforts in the development of thermal energy storage (TES) systems coupled with concentrating solar power systems show potential for matching increasing energy demand. A solar dish and tubular receiver coupled to a short-term TES unit are currently being investigated at the University of Pretoria (UP) over a full range of mass flow rates and using concentrated solar energy as the source of heat input. This paper reports the findings from initial experimental results evaluated in lower-range mass flow rates using a blower with air as the heat transfer fluid (HTF). During the experimental evaluation, 151 kg of solar salts was charged and discharged in a TES unit. The full cycle of charging the system was achieved over three sunny days (which included two unavoidable overnight heat loss processes) whereafter one overnight discharging process was performed. A maximum average temperature of 222.6 ℃ was achieved in the TES unit. During the charging process, an average uncontrolled air mass flow rate of 0.0132 kg/s was supplied. Results show that 17.51 kWh of energy was stored during the 13-hour intermittent charging process and 9.81 kWh was recovered from the TES during the 17-hour discharge process. Lastly, the system displayed substantial parasitical energy losses - recommendations are suggested for the next round of mid-range and higher-range mass flow rate testing.

Keywords: Concentrating solar power (CSP); solar salts; solar dish; thermal energy storage.

#36

MAGNETITE THERMAL ENERGY STORAGE FOR CSP PLANTS

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Abstract

The Department of Mineral Resources and Energy estimates that the industrial sector is the largest consumer of energy in South Africa. Approximately 66% of energy end-use in industry is for heat generation during manufacturing. South African industry has been previously developed in the context of low energy prices for coal and electricity. This has resulted in a wide range of industrial processes that are inefficient and carbon intensive. With rising fuel prices, the prospect of fossil fuel depletion and the continuous global effort to minimise environmental impact, it is necessary to develop alternate energy sources for heat generation. A significant portion of thermal energy can be generated using solar technology. However, solar energy supply is variable in nature and does not always match demand. It is therefore necessary to integrate thermal energy storage systems into solar plants to ensure availability. Thermal energy can be stored in three main ways namely, sensible, latent and thermochemical heat form. Magnetite is a material that undergoes an antiferromagnetic phase change at ~570 °C. This causes a reversible spike in the heat capacity of the material. This is highly advantageous for thermal energy storage applications and allows it to store more heat than other typical sensible storage media. Magnetite is widely available in South Africa and is often a waste product of other production processes. A lab-scale prototype was developed to analyse the thermal storage characteristics of magnetite in an open (non-pressurised) system with air as the working fluid. The magnetite was heated using a gas burner in a packed bed reactor and discharged using ambient air. Magnetite has the ability to store heat up to 1000 oC which makes it suitable for CSP plants. The experimental results will be used to validate a CFD model to inform future CSP plant designs and for industrial process heating applications.

#9

OPTIMIZING ENERGY MIX FOR ECO-INDUSTRIAL PARKS IN SOUTH AFRICA: A TECHNO-ECONOMIC ANALYSIS STUDY USING PYPSA

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Abstract

The energy security situation in South Africa remains bleak, with load shedding persisting since 2008. As a result, numerous industries have increased their efforts to adopt alternative energy technologies to lessen their reliance on the national grid. Industrial parks are no exception, particularly with the emergence of eco-industrial parks (EIPs). An EIP can be described as a group of manufacturing and service businesses situated on a shared property. Member companies strive for improved environmental, economic, and social performance through cooperation in handling environmental and resource concerns. Fundamentally, EIPs aim to create more efficient and cost-effective industrial parks that are more competitive, attractive for investment, and resilient to risks. Amid ongoing load shedding and efforts to employ more environmentally sustainable energy sources, questions arise regarding how much an industrial park can decrease its reliance on the national grid and how much emissions can be reduced by utilizing an optimal combination of available energy technologies. This study endeavours to answer these questions as well as supplementary inquiries such as what the capital and operational expenses of such an optimal mix of technologies would be and when investments in such technologies should be made. This work will address the above questions by conducting a techno-economic analysis study using a general medium-sized eco-industrial park as a case study. The techno-economic analysis study will be conducted using a custom capacity expansion planning tool built on Python for Power System Analysis (PyPSA).

#11

OPTIMAL BATTERY STORAGE AND DC/AC RATIO SIZING OF HYBRID PV POWER PLANTS IN SOUTH AFRICA

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Abstract

This paper considers how to optimally size a solar photovoltaic power plant with battery storage, for nonintermittent energy supply. The optimal DC/AC ratio of grid-constrained solar PV systems, across different climatic regions of South Africa was evaluated. Battery storage was then introduced to increase the plant's energy output and AC capacity factor. Software simulation of the solar photovoltaic systems was done using a readily available simulation program and open-source weather data, while the battery storage system simulation was done in-house. The DC/AC ratio, AC Capacity Factor and Levelized Cost of Energy for the lowest cost optimisation are presented for South Africa. Both the DC/AC ratio and Levelized Cost of Energy have their lowest points in the Northern Cape, and their highest points along the East Coast, while both being insensitive to the storage duration. Heatmaps and multi-hour storage-duration colour bands are presented that could be used to determine an optimal DC/AC ratio which meets a plant's dispatch requirements. A simulated location in the Northern Cape having DC/AC ratios of 1.20, 1.42 and 1.58, while a location in the Eastern Cape having ratios of 1.31, 1.68, and 1.87 for a power plant with a storage duration of 0-hours, 2-hours and 4-hours respectively.

Keywords: South African Solar PV; Economic Analysis; Technical Analysis; Software Simulation; Battery Storage; Optimal Sizing

#39

INVESTIGATION OF SODIUM ACETATE TRIHYDRATE AS A LOW-GRADE HEAT STORAGE MATERIAL IN SOUTH AFRICAN DOMESTIC WATER HEATING

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Abstract

With South Africa amidst an energy crisis, there is a need to re-evaluate current domestic water heating technology by implementing more efficient water heating systems, not only to help relieve excess pressure on the national power grid but to reduce consumer costs. Thermal energy storage (TES), more specifically the use of latent heat storage systems, provides a unique solution with the ability to take advantage of excess renewable energy, off-peak electricity tariffs and waste heat from industry which can be stored for later use. Latent heat storage is achieved using phase change materials (PCMs), specifically solid-liquid PCMs. These are classified into organic and inorganic substances that store and release energy when needed. Inorganic salt hydrates, specifically sodium acetate trihydrate (SAT) and its mixtures are presented in the following study. The high energy density, melting temperature of 58°C and relative stability in a supercooled state make SAT an ideal PCM candidate for TES and domestic water heating applications. Through small-scale experiments, including a Modified T-History method and simple heat loss method, the thermophysical and behavioural properties of SAT and its mixtures with excess water and Xanthan Gum were analysed. The T-History method confirmed that the latent heat of fusion of the SAT supplied was 248.7 kJ.kg. The simple heat loss method determined that the heat content of SAT with excess water decreased with an increasing percentage of additional water. It was also observed that the addition of Xanthan Gum of between 0.4-0.5 wt.% increased the heat content although not as significantly as in the comparative literature. However, a decrease in phase separation and spontaneous nucleation was observed with the Xanthan Gum stabilizing the solution. The results indicated that SAT shows potential as a viable alternative for on-demand domestic hot water applications in South Africa.

#17

TOWARDS IMPROVED SOLAR PV MODULE CHARACTERISATION: CORRELATING ELECTROLUMINESCENCE IMAGE DEFECTS WITH I-V CURVE CHARACTERISTICS USING A SEMANTIC SEGMENTATION-BASED MULTI-DEFECT DETECTION ALGORITHM

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Abstract

There has been significant research on the relationship between current-voltage (I-V) curve characteristics and electroluminescence (EL) module defects. Current methods use EL image pixels to develop features, which are then correlated with module I-V curve characteristics. In most cases, image thresholding is used to gather pixel information. These approaches have two major limitations. First, they lack generalisability, as imaging conditions may vary from module to module, and thresholding algorithms are often developed for specific types of defects or imaging conditions. Second, the correlation between specific types of defects and I-V features cannot be studied because all defects are grouped into one high-level defect detected by a sharp change in pixel intensity. In this paper, we conduct a correlation study between EL defects and I-V curve characteristics of photovoltaic (PV) modules that were exposed to accelerated stress testing. We correlate power loss and two common EL defects. The defects are detected and quantified using a prediction model based on semantic segmentation in which each pixel is assigned to one of multiple classes. Results obtained indicate that the defect detection tool can be used to correlate power loss with dark cells and cell cracks. A significant amount of variability in output power delta can be explained by defects detected by the prediction model (r_2 = 72%).

#41

Photovoltaic Module Fault Classification Using Optical and Thermal Imagery

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Abstract

Faults arising in photovoltaic (PV) systems can result in major energy loss, system shutdown and safety breaches. It is thus crucial to detect such faults to improve the efficiency, reliability and safety of such PV systems (Garoudja et al., 2017). This study seeks to identify the best type of image data for use in classification of faults in large PV installations. This study extends on past published research (Westraadt et al., 2023), as well as the published work of Dunderdale et al. (2020) at Nelson Mandela University, in an effort to find the most efficient technique and methodology for classifying these types of PV faults. This study compares the results of both optical and thermal image data, as well as a layered version of both optical and thermal images, for module-based fault classification. This classification is done according to a framework of twelve, IEC-aligned (IEC, 1906) fault categories. These categories are based on the size, shape, intensity and pattern of faults, as seen in thermal images. The results are obtained for all three types of image data (optical, thermal, and layered) using five pre-coded CNN architectures, namely: InceptionV3, ResNet50, Xception, MobileNet and VGG16.

By comparing these three types of image data as input for classification analysis, results can be used to determine the best overall image data type for this task. It will also outline and emphasize the advantages to using each type of image data on its own, versus using them together as a layered input. Made up of aspects from both the mathematical statistics and physical sciences fields, this study could yield useful tools for larger scale PV installations and their classification methods going forward.

#8

SENSITIVITY ANALYSIS OF AEROSOL OPTICAL DEPTH AND OZONE IN SPECTRAL MISMATCH ESTIMATIONS FOR THREE SOUTH AFRICAN LOCATIONS

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Abstract

This paper assesses the sensitivity of the spectral mismatch for three South African locations for two atmospheric conditions: aerosol optical depth at 500nm (AOD_{500}) and ozone (O_3). Spectral data remains scarce, and this paper aims to determine how to substitute the data when no spectral data is available, specifically in South Africa. The initial investigation identified that AOD_{500} has a more significant effect on spectral irradiance than O_3, which will also be more pronounced in spectral mismatch calculations. Three corresponding SAURAN and AERONet databases were combined to assess the spectral mismatch sensitivity. The investigation showed that an estimated ozone value with the measured O_3 had a negligible error in spectral mismatch calculations, which prompted the second part of this investigation: to identify a way of predicting AOD_{500} using a lookup table using air mass, the clearness index or a combination of the two for different intervals. The investigation showed that a lookup table did not improve the error of estimating spectral mismatch using a constant AOD_{500} of 0.123. Spectral irradiance and mismatch can be determined with reasonable accuracy using an estimated O_3 and constant AOD_{500} when no spectral irradiance measurements are available.

#43

METAL OXIDE NANOMATERIALS AND NANOCOMPOSITES FOR PHOTOCATALYTIC HYDROGEN PRODUCTION THROUGH WATER SPLITTING

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Abstract

In recent years, there has been a rapidly growing interest in renewable and clean energy sources to lessen the impact of the continuously growing energy demand on irreversible global climate change [1]. Direct harvesting of solar light and its conversion into electrical energy using photovoltaic cells or into chemical energy using photoelectrochemical reactions are relevant technologies to overcome this challenge [2]. In this respect, research in the production of green hydrogen in an economically viable way is gaining momentum. Among various green hydrogen production methods, photocatalytic water splitting is most significant, because it utilizes solar energy, a freely available energy source, particularly in Africa. Photocatalytic hydrogen production relies on the absorption of sunlight by semiconductor materials with appropriate band gaps that match the solar spectrum [2]. Because of their superior properties, such as high specific surface area, rich morphology, and high light absorption, nanomaterials have attracted attention for application in photocatalytic hydrogen production. In this study the growth, characterization and application of nanostructured titanium oxide (TiO2) and Al-Ga composites for hydrogen production through photocatalytic water splitting will be presented.

Key words: hydrogen, photocatalytic, nanostructures

#33

COMPARATIVE ASSESSMENT OF AUTOCLAVE AND MICROWAVE FACILITATED SEAWATER PRETREATMENTS FOR THE ENHANCEMENT OF SUGAR RECOVERY FROM BANANA PSEUDOSTEM

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Abstract

The bioconversion of lignocellulosic biomass to value-added products has become an emerging trend for a sustainable economy. Despite the advantages of lignocellulosic-based bioprocesses, the application of these feedstocks for value-added products necessitates expensive, energy- and resource intensive pretreatments, that typically result in low product yields. Seawater represents approximately 96.5% of the Earth, and its salinity as well as alkaline nature (pH ~8.16) confers excellent lignocellulosic pretreatment characteristics. This study optimized two novel seawater-based pretreatments, namely autoclave-assisted seawater (A-SW) and microwave-assisted seawater (M-SW) to improve sugar recovery from banana pseudostem. Biomass structural changes in addition to the concentration of inhibitory compounds under the optimized pretreatment conditions were determined. Both models exhibited high coefficient of determination (R^2) values >0.82. Optimization revealed a higher maximum reducing sugar (0.41 ± 0.01 g/g) and glucose yield (0.25 ± 0.00 g/g) for the A-SW pretreatment compared to 0.23 ± 0.00 g/g (reducing sugar yield) and 0.15 ± 00 g/g (glucose yield) for the M-SW regime. Structural changes and low concentration of inhibitory compounds further confirmed the higher efficiency of the A-SW pretreatment. The present study provided novel insights on the potential use of abundant and sustainable seawater resources facilitated by different heating mechanisms for lignocellulosic pretreatment. This could reduce the costs associated with the application of chemicals and scarce fresh water in lignocellulosic biorefineries.

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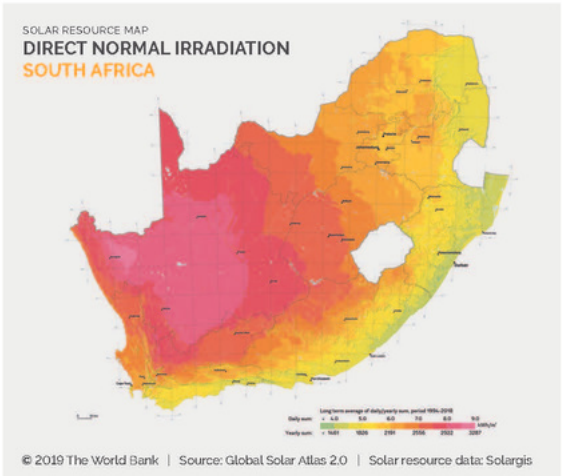

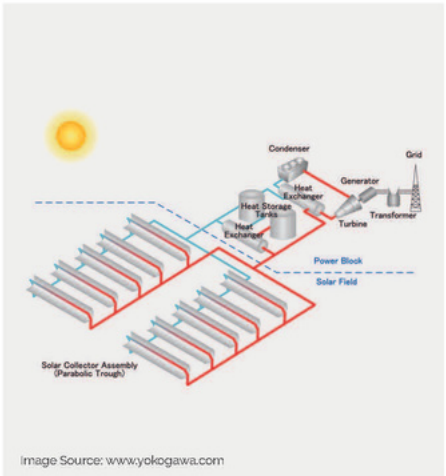

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STAFF AND RESEARCH INTERESTS

PROF AZEEM KHAN – Electrical Machines and Converters for Renewable and Energy Efficient systems, Grid Integration of Renewables.

PROF PAUL BARENDSE – Condition Monitoring of Energy Systems, Electric Drives and Converters for Energy Systems Grid Integration of Renewables, EVs, WPT.

DR SAMPATH JAYALATH – Grid Filter Design, Power Electronic Converter Topology and Control for Renewables Energy Systems, WPT, EVs.

PROF KOMLA FOLLY – Grid Integration of Renewables, Power System (PS) Stability, PS Resilience, PS Reliability, HVDC, Facts Devices.

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