

DUT HIGH VOLTAGE DIRECT CURRENT RESEARCH

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF ELECTRICAL POWER ENGINEERING



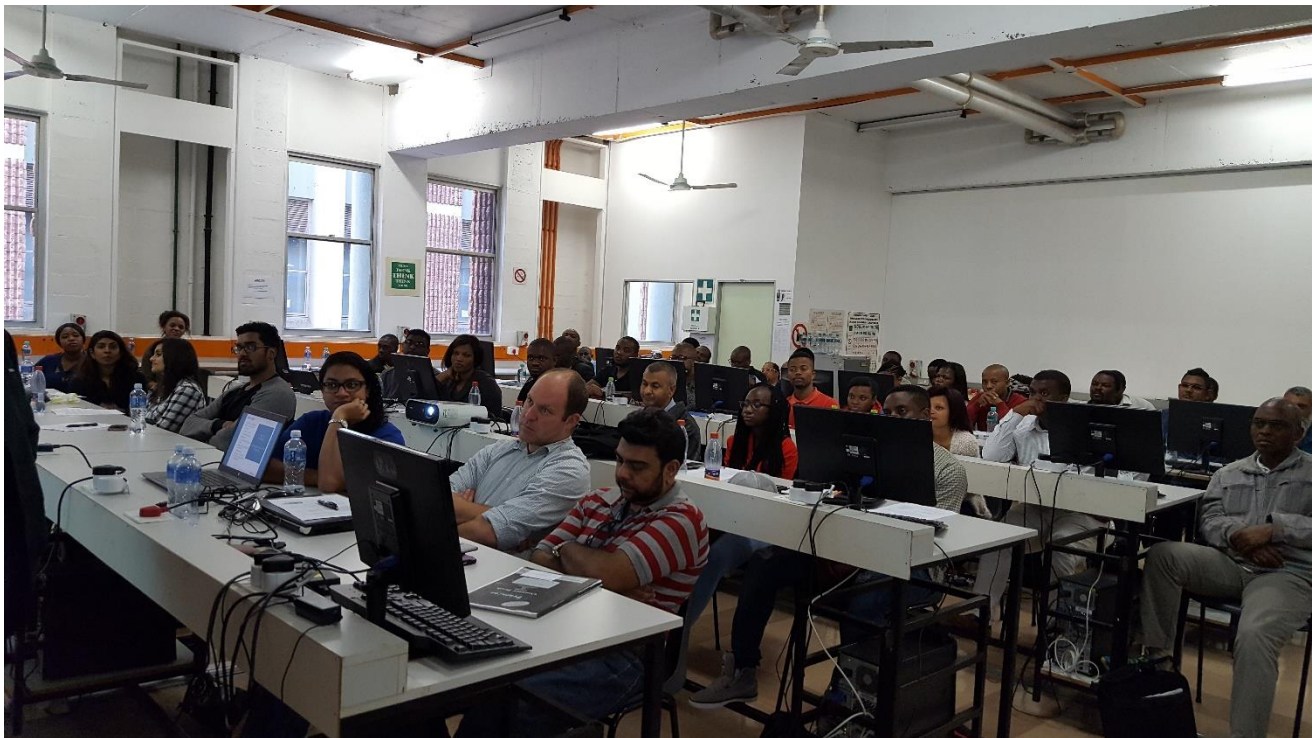
RESEARCH REPORT 2016 – 2017

By

Professor Inno Davidson

P Eng, C Eng, PhD, Fellow IET, Fellow SAIEE

Research Leader



Power Electronics Laboratory, Faculty of Engineering and the Built Environment,
Durban University of Technology, Steve Biko Campus, Durban, SOUTH AFRICA

EXECUTIVE SUMMARY – Capacity Building in HVDC Engineering at DUT

Electricity is the key driver of the economy. The availability of inexpensive and abundant energy is important to mechanized agriculture, mining and industrial manufacture, modern transportation and modern physical comforts. The organization of society, national and social security, are dependent on the availability of energy supplies. There is a strong correlation between: Per capita GNP and Per capita energy consumption and Standard of living. Energy security is critical to national security, hence the availability of electricity supplies is critical to national economic growth and development. Economists generally agree that there are five essential pillars of economic success for any nation in the 21st century, namely:

- Highly educated and sophisticated population
- Highly developed technology
- Rich modern and highly productive agricultural base
- Rich base of energy-bearing materials
- Abundant supply of non-energy bearing materials

For South Africa, Engineering Technology is most essential for economic success. It is therefore imperative to train more engineers, scientists, technologists, technicians and artisans in the lucrative and exciting fields of engineering, which is the backbone of our modern economy and the largest employer of labour in the country. Electricity is a prime energy resource for supplying customers, because of its transmissibility (easy to transport in bulk quantities over long distances), versatility (easy to convert to other forms of energy), and ease of control. The vision of modern electric power and energy systems engineering is to make electricity the preferred energy source for serving industrial, commercial and residential loads. Notably, every facet of our human development is woven around a sound and stable energy supply regime. We therefore have to develop human capacity and supply the local and global marketplace with highly motivated, marketable and competent professionals who understand the new and existing issues concerning electrical power and energy systems - the generation, transportation and distribution of electrical energy to serve consumers in an efficient, economic and reliable manner.

It is the strategic intention or objective of Eskom is to use High Voltage Direct Current Transmission (HVDC) technology extensively *at some point in the future*, hence HVDC research remains imperative. HVDC systems offer several operational and special technical advantages over HVAC transmission systems. HVDC power has no frequency, hence minimal problems of harmonics, oscillations or transients; they actually damp out transients. All angular stability problems disappear and even connection of systems at different frequency is feasible. The problems of cable charging current are eliminated. Thus cables can readily be used for underwater crossings. For weak AC grids, voltage source converter-based HVDC systems offer better controllability and grid flexibility for integrating intermittent renewable energy sources such as: wind and solar-power. Using power electronic switching devices or FACTS controllers, precise and fast power control in either direction is easier to achieve in HVDC than in HVAC systems as dc power is minimally affected by reactance. The ease of power flow control in HVDC lines makes it easy to achieve the maximum power and thermal capacity of transmission lines. It is also simple to control active power transfer at a predetermined level or even to modulate this to improve system damping.

Hitherto, HVDC transmission considered to be an alternative to overcome the limitations of HVAC transmission, but it is now the established technology of choice for long distance transmission, subsea electrical transmission systems and interconnection of asynchronous AC grids. HVDC technology is expected to grow beyond its traditional position as a complement to AC transmission and play a leading role in modernization of the electric

power system (Smart Grids); the emergence of medium and low voltage DC distribution networks and renewable energy integration into the grid. These emerging trends are important to Eskom and Municipalities, as they are posed to shape the local electricity industry in South Africa. As the Principal HVDC Investigator leading a high performance research team of postgraduate students and Collaborators, scenario studies have been conducted along various future transmission corridors to ascertain the performance of HVDC technology deployment along these corridors and the impact on Eskom's AC Grid infrastructure, with proven results, including significant improvements on rotor angle stability.

The HVDC Research Group at DUT strives to be a multi-disciplinary research centre focused on applied scientific research, technology development and contributing to the African Engineering and Scientific Expertise through its own fundamental and applied research, and through collaborative work with relevant groups at DUT and beyond. As the Research Leader, my role includes: leading the research team, writing funding proposals, providing direction, coordinating research, postgraduate programme, excel in community engagement in High Voltage Direct Current (HVDC) while strengthening capacity in the Department of Electrical Power Engineering for postgraduate research and industrial/design projects; focused on inter-disciplinary approaches to the resolution of real-world engineering problems, which will strengthen the position and influence of our communities in the wider arena.

The focus areas of HVDC Research at DUT are:

- Modelling, testing and evaluation of **HVDC equipment and components** – DC Breakers, DC Transformers, and insulation coordination in HVDC systems.
- **Power System Simulation studies** on the impact of **HVDC links on Eskom Network** – stability studies, contingency analysis.
- Conducting the modelling and performance evaluation of **HVDC converters designs** using the powerful Real-Time Digital Simulator at DUT and engaging Hardware-in-the-loop tools and methodologies.
- Developing **optimal HVDC system design and analysis of DC protection schemes** for interior and exterior faults in power electronic converters located on power networks including low voltage DC networks.

These focus areas are derived from the broad theme of Eskom Power Plant Engineering Institute (EPPEI) HVDC Research Project. DUT HVDC Research will focus on developing both academic staff and postgraduate students in these focus areas in HVDC research, and will be foremost in providing **training and development of South Africa's HVDC Technologist, Technicians and Artisans**.

In this 2016-2017 report of the DUT HVDC Research, several postgraduate students in Electrical and Mechanical Engineering completed their studies leading to the award of PhD and MSc degrees; high-quality journal papers were published and peer-reviewed local/international conference papers were presented at local and international conferences and workshops in Canada, United Kingdom and Ghana.

Professor Inno Davidson
Research Leader

1. RESEARCH FOCUS – HVDC Grid Reliability

In this era of opportunity and tremendous technological advances, the electric power system is facing major ongoing changes. The main drivers include system reliability, climate, environmental, regulatory and economic challenges, as well as the fundamental goal of reducing transmission/distribution losses. A long recognized technology solution to this development involves using HVDC for long distance transmission of bulk electric power, and how to effectively integrate HVDC systems into existing HVAC electric power grids. Around the world, there are several projects and research initiatives investigating these developments using HVDC technology and the effect of HVDC transmission on the grid reliability and performance of electric power systems in this emerging SMART Utility environment.

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2. RESEARCH TEAM AND COLLABORATORS

Name / Designation	Areas of Expertise	Email Address	Discipline / Institution
Davidson, IE (Prof) Research Leader EPPEI Supervisor	HVDC / HVAC Delivery Systems Electric Power System Analysis Smart Grids and Smart Cities Renewable Energy Technologies Grid Energy Storage Special Machines – LIMs, LSMs.	innocentD@dut.ac.za	Durban University of Technology Electrical Power Engineering
Bussy, E R	High Voltage Engineering Power Electronics	eamonb@dut.ac.za	Durban University of Technology Electrical Power Engineering
Akindeji, K T	Distributed Energy Resources Smart Grids & Micro-Grids	TimothyA@dut.ac.za	Durban University of Technology Electrical Power Engineering
Ojo, J O (Prof) UKZN Honorary Professor	Multi-Port Power Converters FACTS Controllers: UPFC STATCOM; Renewable Energy and Micro-Grid Systems Electric Vehicles and Fuel Cell Energy Storage Technologies	jojo@tntech.edu	Tennessee Tech. University Electrical and Computer Engineering Cookeville, TN, USA
Naidoo, P (Prof)	Green economy and innovation. Micro Grids & Energy Efficiency Renewable-energy resources	pat@patnaidoo.co.za	University of Johannesburg Electrical Power Engineering
Tiako, R (Dr) EPPEI Co-Supervisor	Power Systems Engineering Stability and control; On-line Dynamic Security Assessment	Taiko@ukzn.ac.za	University of KwaZulu-Natal Electrical Engineering
Gitau, M N (Prof) EPPEI Supervisor	Power Engineering Power Electronics Electric Motor Drives	Njoroge.Gitau@up.ac.za	University of Pretoria Electrical Engineering
Adam, G P (Dr)	Power Electronics & Applications in Power Systems Drives & Energy Conversion HVDC Power Converters	grain.adam@strath.ac.uk	University of Strathclyde Electronic & Electrical Engineering Glasgow, Scotland, UK
Adewumi, A (Prof) Specialist Consultant	Optimization: Modelling, Heuristics and Meta-heuristics Computational Intelligence: AI, Swarm Intelligence	adewumia@ukzn.ac.za	University of KwaZulu-Natal Mathematics, Statistics & Computer Science
Subramoney, J	P1. P2 Industrial Training Technician / Artisan Specialist		TEMATRON Pty Jacobs, Durban
Venayagamoorthy, G K (Prof) UKZN Honorary Professor	Smart Grids Computational Intelligence Real-Time Power & Intelligent Systems	gvenaya@clemson.edu	Clemson University Electrical & Computer Engineering Clemson, SC, USA
Sewchurran, S (Dr) Chief Engineer RE Industrial Specialist	Grid Integration of Small Scale Embedded Generation Renewable Energy Projects Utility Scale Projects - Landfill gas to electricity	SewchurranSan@elec.durban.gov.za	eThekweni Electricity eThekweni Municipality, Durban
Chidzonga, R	Distributed Energy Control Smart Micro-Grid Optimization	rfchidzonga@gmail.com	Durban University of Technology Electrical Power Engineering
Tapamo, Jules (Prof) EPPEI Co-Supervisor	Computer Vision; Pattern Recognition, Machine Learning; Algorithms; Image Processing	tapamoj@ukzn.ac.za	University of KwaZulu-Natal Computer Engineering
Agee, J T (Prof) UKZN Co-Supervisor	Control Systems Engineering Instrumentation and Smart Grids	ajej@ukzn.ac.za	University of KwaZulu-Natal Electrical Engineering
Matsumoto, Takao (Prof)	High Voltage Engineering Plasma Research		Fukuoka University Electrical Engineering Fukuoka-shi, Japan

3. HIGHER DEGREES SUPERVISION

The following postgraduate students completed their dissertations under my supervision / co-supervision:

Doctor of Philosophy (2016)

Chetty, Nevendra Krishniah, *BSc, BScHons, MSc* *Electrical Engineering*
 Dissertation: DC Corona Electroporation
 Supervisors: Dr IE Davidson and Professor T Govender

Nyete, Abraham Mutunga, *BEng (UNairobi), MScEng*.....*Electronic Engineering*
 Dissertation: A Flexible Statistical Framework for the Characterization and Modelling of Noise in Powerline Communication Channels.
 Supervisors: Professor TJO Afullo and Dr IE Davidson [**Non-Eskom EPPEI**]

Master of Science in Engineering (2016)

Botha, Larry Chama Chidza, *BEng (CopperbeltU)* *Mechanical Engineering*
 Dissertation: Effect of Fretting Marks Introduced During Strand Winding on the Fatigue Performance of Transmission Line Conductors
 Supervisors: Dr RC Loubser and Dr IE Davidson

Dumakude, Gugulethu Carol, *BTech (DUT)*..... *Electrical Engineering*
 Dissertation: Evaluation of a Smart Technology for the Improvement of Reliability in a Power Distribution System.
 Supervisors: Dr AG Swanson and Dr IE Davidson [**Eskom EPPEI**]

Ilunga, Kayumba Grace, *BScEng (ULubumbashi)*..... *Electrical Engineering*
 Dissertation: Influence of Fire on DC Corona Current
 Supervisors: Dr IE Davidson and Dr L Chetty

Khan, Shiraz Yusuf, *BTech (DUT)*.....*Electric Power and Energy Systems*
 Dissertation: A Comparative Study and Analysis of PHES and UGPHES Systems.
 Supervisor: Dr IE Davidson

Malapermal, Sanjian, *BScEng*.....*Electric Power and Energy Systems*
 Dissertation: A Methodology for Optimal Placement of Distributed Generation on Meshed Networks to Reduce Power Losses for Time Variant Loads.
 Supervisors: Dr IE Davidson and Mr. MM Bello [**Eskom Non-EPPEI**]

* **Mbangula**, Kamati Nghilifavali, *BScHons (UNamibia)*..... *Electrical Engineering*
 Dissertation: Investigating the effects of HVDC Transmission Schemes on Eskom's Network Transient Rotor Angle and Voltage Stability
 Supervisors: Dr IE Davidson and Dr R Tiako [**Non-Eskom EPPEI**]

Mtolo, Patrick Dumsani, *BScEng*.....*Electric Power and Energy Systems*
 Dissertation: The Safety Risk Assessment and Mitigation of the LV Networks with Embedded Generators.
 Supervisor: Dr IE Davidson [**Eskom Non-EPPEI**]

Mwale, Stacey Juliana Tombozi, *BSc (UNamibia)*..... *Electrical Engineering*
 Dissertation: The Southern African Power Pool (SAPP) Steady State Security Assessment Using Contingency Analysis.
 Supervisor: Dr IE Davidson [**Non-Eskom EPPEI**]

Williamson, Andrew Robert Faure, *BScEng (Wits)*.....*Electric Power and Energy Systems*
 Dissertation: Field-effect Limits and Design Parameters for Hybrid HVDC/HVAC Transmission Lines
 Supervisor: Dr IE Davidson

Doctor of Philosophy (2017)

Sewchurran, Sanjeeth *BScEng, MScEng (UKZN)* *Electrical Engineering*
Dissertation: Modeling and Performance Analysis of the EThekweni Electricity Distribution Grid with Increased Embedded Generation Sources
Supervisors: Professor IE Davidson and Professor Olorunfemi Ojo

Master of Science in Engineering (2017)

Bodlingwe, Bridgete Afrodite, *BTech (Pret Tech)* *Electrical Engineering*
Dissertation: Practical Evaluation of Weak In-Feed Tripping Effectiveness on Eskom Network.
Supervisors: Prof NM Ijumba and Prof IE Davidson [**Eskom Non-EPPEI**]

Boodraj, Dinesh, *BTech (MLS Tech)*..... *Electrical Engineering*
Dissertation: Design and Prototype Development of a Remote Intelligent Electronic Devices Verification Platform
Supervisor: Prof IE Davidson and Dr Remy Tiako

Chetty, Dayahalen, *BScEng* *Electrical Engineering*
Dissertation: The Application of Volt/VAr Optimisation on South African Distribution Power Networks: Solutions for Smart Grid Distribution Automation Applications
Supervisor: Prof IE Davidson and Mr. M Bello [**Eskom Non-EPPEI**]

Chetty, Vasudevan, *BScEng* *Electrical Engineering*
Dissertation: Mitigating High Fault Current Levels in eThekweni HV Transmission System
Supervisor: Prof IE Davidson

De Lange, Gerald, *BTech (Natal Tech)*..... *Electrical Engineering*
Dissertation: Analyzing and Mitigating the Effects of Stray Currents on Underground Metal Pipelines
Supervisor: Prof IE Davidson and Prof JT Agee

Hamatwi, Ester, *BScEng (UNamibia)* *Electrical Engineering*
Dissertation: Control of a Permanent Magnet Synchronous Generator-based Wind Energy Conversion System.
Supervisors: Prof IE Davidson and Prof MN Gitau [**Non-Eskom EPPEI**]

Maharaj, Ashwin, *BTech (DUT)* *Electrical Engineering*
Dissertation: Technical Evaluation and Life Cycle Cost Analysis of Transmission and Distribution Assets
Supervisor: Prof IE Davidson

Mludi, Shaibu Adam Ibu, *BEng (UMalawi)*..... *Electrical Engineering*
Dissertation: Dynamic Analysis of the Southern African Power Pool (SAPP) Network
Supervisor: Prof IE Davidson [**Non-Eskom EPPEI**]

Oni, Oluwafemi Emmanuel, *BEng (UAdo-Ekiti)* *Electrical Engineering*
Dissertation: Technical Performance and Stability Analysis of Eskom Power Network Using 600kV, 800kV, and 1000kV HVDC
Supervisor: Prof IE Davidson [**Non-Eskom EPPEI**]

Rampersadh, Navin, *BTech (Natal Tech)*..... *Electrical Engineering*
Dissertation: Grid Energy Storage Devices
Supervisors: Prof IE Davidson and Dr Remy Tiako

Reuben, Rodney, *BTech (Natal Tech)*..... *Electrical Engineering*
Dissertation: An Engineering Study and Design of a Renewable Energy Solar Park
Supervisors: Prof IE Davidson and Dr Remy Tiako

4. HIGHER DEGREES UNDER EXAMINATION

The following postgraduate students completed their dissertations under my supervision/co-supervision and are currently under examination:

Doctor of Philosophy

Iruansi, Usiholo *BScEng, MScEng* *Electrical Engineering*
 Dissertation: Power line Defect Detection and Classification
 Supervisors: Professor Jules-Tapamo and Professor IE Davidson [**Non-Eskom EPPEI**]

Tefera, Getahun Aklilu, *BScEng, MScEng ()*..... *Mechanical Engineering*
 Dissertation: Design and Testing of a Composite Material for Modelling Wind Turbine Blade Structures in Tropical Region
 Supervisors: Professor Sarp Adali, Professor Glen Bright and Professor IE Davidson

5. HIGHER DEGREES UNDER SUPERVISION

The following postgraduate students are currently under my supervision/co-supervision:

Doctor of Philosophy

Singh, Hariram, *BScEng, MScEng (UKZN)* *Electrical Engineering*
 Dissertation: Utilisation of Line Surge Arrestors to Improve Overhead EHV AC and DC Line Performance under Lightning Conditions
 Supervisors: Professor IE Davidson [**Eskom Non-EPPEI**]

Akindeji, Kayode Timothy, *BScEng, MScEng ()*..... *Electrical Engineering*
 Dissertation: Analyzing the Impacts of Microgrid Operations and Control on the Eskom Distribution Networks
 Supervisors: Dr Remy Tiako and Professor IE Davidson

Chidzonga, Richard Foya, *BScEng, MScEng ()*..... *Electrical Engineering*
 Dissertation: Application of Smart Micro-Grid Optimization to a Hybrid Renewable Durban Distributed Power Network
 Supervisors: Professor IE Davidson and Prof John Agee

Sibilant, Gary, *BSc, BScEng, MScEng ()* *Electrical Engineering*
 Dissertation: An Analytical Mechanical Model for Predicting Sag in ACSR Conductor at High Temperatures in Overhead Transmission Lines
 Supervisors: Professor IE Davidson

Gizaw, Mengistu, *BScEng, MScEng ()*..... *Mechanical Engineering*
 Dissertation: Aeolian Vibration Analysis of Optical Ground Wire (OPGW)
 Supervisors: Dr Richard Loubser, Professor Glen Bright and Professor IE Davidson (**NOT REGISTERED**)

Ogunboyo, Patrick Ogunboyo, *BScEng, MScEng ()* *Electrical Engineering*
 Dissertation: Power Quality Evaluation in Low Voltage Smart Grid Distribution Networks
 Supervisors: Dr Remy Tiako and Professor IE Davidson [**Non-Eskom EPPEI**]

Doctor of Business Administration

Ramprith, Viren, *BScEng, MScEng (UKZN)*..... *Electrical Engineering*
 Dissertation: Managing and Communicating Behaviour Change from a Smart Electricity Grid Perspective at the eThekweni Municipality
 Supervisors: GSB Professor and Professor IE Davidson (**SUSPENDED REGISTRATION**)

Master of Engineering

Tshikomba, Salome Busisiwe Jiyane, *BTech BSc (Hons)* *Electrical Engineering*
Dissertation: Technical Analysis and Mitigation Measures for Illegal Electricity Theft for Domestic and Commercial End Users
Supervisor: Prof IE Davidson and Mr. Evans Ojo

Madonsela, Bhhekinkosi, *BTech* *Electrical Engineering*
Dissertation: Integrating Power Transformer Protection scheme and Telecontrol RTU
Supervisor: Prof IE Davidson [**Eskom Non-EPPEI**]

Loji, Nomhle, *BTech* *Electrical Engineering*
Dissertation: Evaluation of grid-scale battery energy storage system as an enabler of large-scale renewable energy integration
Supervisor: Prof IE Davidson and Mr. Timothy Akindeji

Gwatidzo, Ngoni, *BTech* *Electrical Engineering*
Dissertation: Modelling, Testing and Evaluation of HVDC Equipment and components – DC Breaker, DC Transformers and Insulation Coordination in HVDC Systems.
Supervisor: Prof IE Davidson

Khoza, N S E *BTech* *Electrical Engineering*
Dissertation: Investigation of Air Breakdown Initiated by Extreme Heat Under HVDC Conditions..
Supervisor: Prof IE Davidson

Master of Science in Engineering

Sithole, Zenzinkosi Sibusiso Brook, *BSc* *Electrical Engineering*
Dissertation: The reliability analysis of eThekweni Electricity Medium voltage/Low voltage network
Supervisor: Prof IE Davidson

Chamane, Mbalenhle Nokwanda, *BScEng (UKZN)* *Electrical Engineering*
Dissertation: Design of Protection Scheme for a Voltage Source Converter-based HVDC Systems
Supervisor: Prof D Dorrell, Prof IE Davidson and Prof MN Gitau [**Eskom EPPEI**]

Goqo, Zama, *BScEng (UCT)* *Electrical Engineering*
Dissertation: Design of a Micro-converter for Rooftop PV Application in a Low-Voltage Distribution Network
Supervisor: Prof D Dorrell, Prof IE Davidson and Prof Olorunfemi Ojo

Lasabi, Olarewaju, *BScEng ()* *Electrical Engineering*
Dissertation: An Evaluation and Performance Analysis of Insulator Breakdown under Negative HVDC Polarity
Supervisor: Dr Andrew Swanson and Prof IE Davidson

Mukwekwe, Leonard Kwamuchaguma, *BScEng (UNamibia)* *Electrical Engineering*
Dissertation: Development of a Micro-Grid Based on Distributed Small Scale Rooftop PV Arrays
Supervisor: Dr Rudy Capernum and Prof IE Davidson

Moodley, Denzil, *BScEng (UKZN)* *Electrical Engineering*
Dissertation: A Study of the Viability and Economics of Optimal Utilisation of Excess Refinery Fuel Gas for Electricity Generation Via High Pressure Steam Turbine
Supervisor: Mr. K. Moodley and Prof IE Davidson

6. HONOURS, AWARDS AND RECOGNITIONS

- **2017: Published News Articles:**

"DUT Professor Elected to Fellow of the Institution of Engineering and Technology, London, UK" 11th May 2017.
<http://www.dut.ac.za/dut-professor-elected-to-fellow-of-the-institution-of-engineering-and-technology-london-uk>

- **2017: Published News Articles:**

"UKZN Student Wins Best Paper Award at International Conference", UKZNdabaOnline: 23 March 2017, Volume: 5, Issue 7. Available at: <http://ndaba-online.ukzn.ac.za/UkzndabaStory/1176/ukzn-student-wins-best-paper-award-at-international-conference->

- **2016: BEST Paper Award Recipient** - For the paper titled: "Harmonic Distortion of LCC-HVDC and VSC-HVDC Link in Eskom's Cahora Bassa HVDC Scheme by Oluwafemi Oni, Innocent Davidson. *5th International Conference on Renewable Energy Research and Applications*, (ICRERA 2016), Birmingham, United Kingdom, 20-22 November 2016. Paper nominated by the ICRERA 2016 Technical Committee for publication in the *IEEE Transactions on Power Electronics*, January 2017.

BEST PAPER Award for DUT Professor and Student at ICRERA 2016 International Conference, Birmingham, UK. Durban University of Technology News, 3rd January 2017. Available at: <http://www.dut.ac.za/best-paper-award-for-dut-professor-and-student/>

MEDIA Press Release: Eskom Power Plant Engineering Institute student receives international award for best paper in renewable energy research. Saturday, 10 December 2016: <http://www.eskom.co.za/news/Pages/Dec10.aspx>

- **2016: First Place for the Outstanding Student Paper** - Received the *Best Student Paper Award* for the technical paper: 'S. Sewchurran, I.E. Davidson and J.O Ojo', "*Intelligent Disbursement and Impact Analysis of DG on Distribution Networks to Mitigate SA Energy Shortages*", Clemson University Power Systems Conference, March 8 - 11, Clemson, SC, USA, 2016 (\$300 prize money)
- **2016: CIGRE Best Paper Award** - Received the *CIGRE Best Paper Award* for the technical paper: S Sewchurran, J Kalichurran and S Maphumulo, "Drivers and Application of Small Scale DG on Municipal Distribution Networks in South Africa: An eThekweni Electricity Case Study", at the 65th *Association of Municipal Electricity Utilities Conference*, Vereeniging, South Africa, 1 - 5 October 2016 (R6000 00 prize money). *PhD Student* - Sanjeeth Sewchurran
- **2016: COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE (CAES) DOCTORAL BURSARY AWARD Recipient** *PhD Student* - Timothy Akindeji, August 2016. (R50 000.00 prize money)
- **2016: COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE (CAES) FIRST PRIZE Award Recipient** in recognition for best presentation at the University of KwaZulu-Natal Postgraduate Research Day, Howard College, Durban, South Africa, 1 November 2016. (R15000 prize money). *PhD Student* - Sanjeeth Sewchurran
- **2016 JW NESON FUND RESEARCH AWARD Recipient** *PhD Student* - Sanjeeth Sewchurran. (R20 000.00 prize money).
- **2016 UKZN Research Productivity Unit: 269.70**
Achieved and compliant with Senate approved research productivity norms at the University of KwaZulu-Natal with a score of 269.70 research productivity units (PU) earned for 2016 as against 120 Pus for Full Professors.
- **2016: CAES CONFERENCE TRAVEL GRANT Recipient** *PhD Student* - Sanjeeth Sewchurran. (R15 000.00)
- **2016: Published News Articles:**
"Presentation by Engineering Lecturer Focuses on Smart Grids Research", UKZNdabaOnline: 10th February 2016, Volume 4, Issue 1. Available at: <http://ndabaonline.ukzn.ac.za/UkzndabaStory/Vol4-Issue1/Presentation%20by%20Engineering%20Lecturer%20Focuses%20on%20Smart%20Grid%20Research/>

7. RESEARCH PUBLICATIONS

Keynote Address and Invited Presentations

- [1] I E Davidson, "Environmental Sustainability with a focus on Renewable Energy", Panelist Address at the 2nd Mangosuthu University of Technology Research Innovation and Engagement Week, July 10 – 14, 2017, International Convention Centre, Durban, South Africa.

Books and Book Reviews

- [1] S. Y. Khan and I E Davidson. "Underground Pumped Hydroelectric Energy Storage in South Africa using Aquifers and Existing Infrastructure", in Book: "NEIS Conference 2016", pp.119-122, Chapter · March 2017, DOI: 10.1007/978-3-658-15029-7_19. Springer. <http://www.springer.com/978-3-658-15028-0>. ISBN: 978-3-658-1028-0. Editor Prof (Dr) D Schulz.

Refereed Journal Papers

- [1] Ester Hamatwi, Innocent Davidson and Michael Gitau, "Rotor Speed Control of a Direct-driven Permanent Magnet Synchronous Generator-based Wind Turbine using Phase-lag Compensators to Optimize Wind-Power Extraction", *Journal of Control Science and Engineering*, Vol. 2017, Article ID 6375680. <https://doi.org/10.1155/2017/6375680>.
- [2] P. T Ogunboyo, R. Tiako, I.E Davidson, "Application of Dynamic Voltage Restorer for Power Quality Improvement in Low Voltage Electrical Power Distribution Network: An Overview", *International Journal of Engineering Research in Africa*, Vol. 28, pp. 142-156, 2017.
- [3] O.E. Oni, K.N.I. Mbangula and I.E. Davidson, "A Review of LCC-HVDC and VSC-HVDC Technologies and Applications". *Transactions on Environment and Electrical Engineering*, Vol. 1, No 3, Sept. 2016, pp 68-76. ISSN 2450-5730, a peer-reviewed, open access (OA) interdisciplinary journal.
- [4] E. Hamatwi, C. N. Nyirenda and I. E. Davidson, "Optimization of a Hybrid PV-Diesel System for Rural Application: The Case of Oluundje Village, Namibia" *International Science and Technology Journal of Namibia*, Vol 8, pp. 117-132, 2016.
- [5] O. E. Oni, K.N.I. Mbangula and I.E. Davidson, "Dynamic Voltage Stability Studies using a Modified IEEE 30-Bus System". *Transactions on Environment and Electrical Engineering*, Vol 1, No 3, 2016 Sept. 2016, pp. 41-49. ISSN 2450-5730, a peer-reviewed, open access (OA) interdisciplinary journal.
- [6] N. K. Chetty, L. Chonco, L. Chetty, T. Govender, R. Parboosing and I. E. Davidson, "Analysis of Corona Discharge Current Pulses in HeLa-Cell Permeabilization due to High Voltage DC Corona". *IEEE Transactions on Nano Bioscience*, Vol. 15, No. 6, September 2016, pp. 526-532. DOI: 10.1109/TNB.2016.2585624
- [7] K. N. I. Mbangula, I. E. Davidson and R. Tiako, "Improving Power System Stability of South Africa's HVAC Network Using Strategic Placement of HVDC Links", *CIGRE Science & Engineering Journal (CSE)*, Vol. 5, June 2016, pp. 71-78.
- [8] G. P. Adam and I. E. Davidson, "Robust and Generic Control of Full-Bridge Modular Multilevel Converter High-Voltage DC Transmission Systems", *IEEE Transactions on Power Delivery*, Vol. 30, No. 6, pp.2468-2476, December 2015. ISSN: 0885-8977. DOI: 10.1109/TPWRD.2015.2394387

Journal Papers (Under Review)

- [9] Shiraz Khan and Innocent E Davidson, "Underground Pumped Hydroelectric Energy Storage in South Africa using Aquifers and Existing Infrastructure". A manuscript resubmitted to the *Journal of Energy Storage*, 2nd February 2017. Manuscript Ref. No.: EST_2016_10
- [10] P. T Ogunboyo, R. Tiako, I.E Davidson, "Application of Dynamic Voltage Restorer for Voltage Unbalance Improvement in Low Voltage 11/0.4kV Electrical Power Distribution Network under 3-phase Balance Load State", A manuscript resubmitted to the *IEEE Power Generation*, 31st January 2017. Manuscript Ref. No.: GTD-2017-0110.
- [11] E. Hamatwi, I. E. Davidson, G. K. Venayagamoorthy, and J. Agee, "Cost Optimization and Design of a Hybrid Distributed Generation System for a DC Microgrid". Paper nominated by Clemson Power Systems Conference for publication in the *IEEE Transactions on Industry Applications*, January 2017.
- [12] O.E. Oni, and I E Davidson, "Harmonic Distortion of LCC-HVDC and VSC-HVDC Link in Eskom's Cahora-Bassa HVDC Scheme', Best Paper Award and nominated by the 5th *IEEE International Conference on Renewable Energy*

Research and Application, Birmingham, United Kingdom for publication in the *IEEE Transactions on Power Electronics*, January 2017.

- [13] E. Hamatwi, I. E. Davidson and M.N. Gitau, "Control of a Wind Energy System Integrated into the Grid through a 3-Level Voltage Source Converter-Based HVDC Transmission System" Paper submitted to the *Transactions of the South African Institute of Electrical Engineers*, January 2017.
- [14] D Chetty, M.M. Bello and I.E. Davidson, "Performance Evaluation of Traction and Utility Network Interface: Fault Location, Protection Coordination and Management of Transient and Temporary Overvoltage". A manuscript resubmitted to the *Electric Power Systems Research*, 7th March 2017. Manuscript Ref. No.: EPSR-D-16-01735
- [15] D Chetty, M.M. Bello and I.E. Davidson, "The Application of Volt/VAr Optimization on Eskom South Africa Distribution Feeders". A manuscript resubmitted to the *Electric Power Systems Research*, 7th March 2017. Manuscript Ref. No.: EPSR-D-16-01734
- [16] P. T Ogunboyo, R. Tiako, I.E Davidson, "Application of Dynamic Voltage Restorer for Voltage Unbalance Improvement in Low Voltage 11/0.4kV Electrical Power Distribution Network under 3-phase Balance Load State", A manuscript resubmitted to the *IET Power Generation*, 31st January 2017. Manuscript Ref. No.: GTD-2017-0110. [Under Review]
- [17] P. T Ogunboyo, R. Taiko and I. E. Davidson, "Investigation of Voltage Unbalance Profile in Low Voltage Electrical Distribution Network with Normal Mode Operation Using MATLAB" Manuscript [Under Review] in *International Journal of Engineering Research in Africa*
- [18] P. T Ogunboyo, R. Taiko and I. E. Davidson, "Enhancement of Voltage Profile in Low Voltage 11/0.4 kV Electric Power Distribution Network under 3-Phase Unbalance Load Using Dynamic Voltage Restorer". Manuscript submitted to *Journal of Electrical and Electronic Engineering*, 18th April 2017. Manuscript Ref. No.: J-17-04-166 [Under Review].
- [19] Usiholo Iruansi, Jules-Raymond Tapamo and Innocent E. Davidson, "Hydrophobicity Classification of Insulators Based on Geometric Parameters". Manuscript submitted to the *Journal of Computers*, Taiwan. May 2017. (Under Review)
- [20] U Iruansi, J R Tapamo and I E Davidson, "Classification of Insulator Condition using Scale Invariant Feature Transform with K-Nearest Neighbour". Manuscript submitted to *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, July 2017. (Under Review)
- [21] U Iruansi, J R Tapamo and I E Davidson, "Classification of Power-line Insulator Condition using Local Binary Patterns with Support Vector Machines". Manuscript submitted to *IAENG International Journal of Computer Science*, 28th July 2017. Manuscript Ref. No.: IJCS_2017_07_18c. (Under Review)

Refereed Conference Papers

2016

- [1] E Hamatwi and I E Davidson, "Optimised Model of a Solar/Wind/Diesel Hybrid Generation System for Rural Application". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 366 – 371, ISBN 978-1-77012-386.
- [2] G C Dumakude, A G Swanson, R Stephen and I. E. Davidson, "Power Distribution Systems Reliability Improvement through the Application of Smart Technology". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 623 – 630, ISBN 978-1-77012-386.
- [3] G Ininahazwe and I E Davidson, "A Study of the Distribution of Voltage and Electric Field on Glass Insulators using Charge Simulation Method". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 43 – 45, ISBN 978-1-77012-386.
- [4] J. Schutte, A.C. Britten, J. van Coller, R. Hubbard and I. E. Davidson, "Towards an Explanation of the Abnormal Attenuation of the Power Line Carrier Signals on an HVDC Monopolar Transmission Line". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 138 – 141, ISBN 978-1-77012-386.
- [5] K N I Mbangula, O E Oni and I. E. Davidson, "The Impact of HVDC Schemes on Network Transient Rotor Angle Stability". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 461 – 466, ISBN 978-1-77012-386.
- [6] M Gizaw, R Loubser, I E Davidson, G Bright and R Stephen, "Assessment of the Vibration Level at the Catenary value of 2100m for an OPGW using Endurance Limit Approach". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 616 – 622, ISBN 978-1-77012-386.
- [7] S Y Khan and I E Davidson, "Aquifer Underground Pumped Hydroelectric Energy Storage in South Africa". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 581 – 586, ISBN 978-1-77012-386.
- [8] Stacey J T Mwale and Innocent E Davidson, "The Southern African Power Pool (SAPP) steady state security assessment using contingency analysis". In *Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 631 – 636, ISBN 978-1-77012-386.

- [9] S Sewchurran and I E Davidson, "Guiding Principles for Grid Code Compliance of Medium-High Voltage Renewable Power Plant Distributed Generation Integration onto South Africa's Transmission and Distribution Networks". *In Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 220 – 227, ISBN 978-1-77012-386.
- [10] S Sewchurran and I E Davidson, "Drivers and Application of Small Scale DG on Municipal Distribution Networks in South Africa". *In Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 105 – 114, ISBN 978-1-77012-386.
- [11] S Malapermal, M Bello and I E Davidson, "A Methodology for Optimal Placement of Distributed Generation on Meshed Networks to Reduce Power Losses for Time Variant Loads". *In Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 207 – 213, ISBN 978-1-77012-386.
- [12] K T Akindeji and I E Davidson, "Microgrid and Active Management of Distribution Networks with Renewable Energy Sources". *In Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 171 – 175, ISBN 978-1-77012-386.
- [13] V Ramprith and I E Davidson, "Smart Grid Penetration at the eThekweni Municipality". *In Proceedings of the 24th South African Universities Power Engineering Conference*, 26-28 January 2016, Vereeniging, South Africa, pp. 498 – 503, ISBN 978-1-77012-386.
- [14] S. Sewchurran, I.E. Davidson and J.O Ojo, "Intelligent Disbursement and Impact Analysis of DG on Distribution Networks to Mitigate SA Energy Shortages," *Proceedings of the Clemson University Power Systems Conference (PSC)*, March 8-11, 2016, Clemson University, Clemson, SC, USA.
- [15] E. Hamatwi, I.E. Davidson, J Agee and G.K. Venayagamoorthy, "Model of a Hybrid Distributed Generation System for a DC Nano-Grid," *Proceedings of the Clemson University Power Systems Conference (PSC)*, March 8-11, 2016, Clemson University, Clemson, SC, USA.
- [16] O. E. Oni, K.N.I. Mbangula and I.E. Davidson, "Voltage Stability Improvement of a Multi-Machine System using HVDC," *Proceedings of the Clemson University Power Systems Conference (PSC)*, March 8-11, 2016, Clemson University, Clemson, SC, USA.
- [17] J Agee, I.E. Davidson and L. T. Kombani, "Intelligent Proportional Integral Control of a Polar Axis Solar Tracker," *Proceedings of the Clemson University Power Systems Conference (PSC)*, March 8-11, 2016, Clemson University, Clemson, SC, USA.
- [18] U Iruansi, J R Tapamo and I.E. Davidson, "An Active Contour Approach to Water Droplets Segmentation from Insulators," *Proceedings of the IEEE International Conference on Industrial Technology (ICIT2016)*, March 14-17, 2016, Taipei, Taiwan, pp.737-741.
- [19] G.C. Sibilant, I.E. Davidson, R.G. Stephen and D.A. Douglass, "An Introduction to ACSR Conductor Sag at High Temperatures", 2016 CIGRE-IEC Colloquium, May 9-11, 2016, Montréal, QC, Canada.
- [20] E. Hamatwi, I.E. Davidson and M.N. Gitau, "Modeling and Control of Voltage Source Converters for Grid Integration of a Wind Turbine System". *Proceedings of the IEEE PES Power Africa Conference*, Livingstone, Zambia, 28 June - 2 July 2016, pages 98-106.
- [21] M. Gebremeskel, R. Loubser, I.E. Davidson, G. Bright and R. Stephen, "Assessment of the Damped Vibration Level of an OPGW at the Catenary value of 2100m". *Proceedings of the IEEE PES Power Africa Conference*, Livingstone, Zambia, 28 June - 2 July 2016, pages 107-111.
- [22] C. Subramani, A. A. Jimoh, M. Sudheesh and Innocent E. Davidson, "Fault Investigation Methods on Power Transmission Line: A Comparative Study". *Proceedings of the IEEE PES Power Africa Conference*, Livingstone, Zambia, 28 June - 2 July 2016, pages 93-97.
- [23] Jonathan O. Okoronkwo, Olorunfemi Ojo and Innocent Davidson, "Design Considerations for the Katsina Wind Farm in Nigeria". *Proceedings of the IEEE PES Power Africa Conference*, Livingstone, Zambia, 28 June - 2 July 2016, pages 251-253.
- [24] E. Hamatwi, I.E. Davidson, M.N. Gitau, R. Vajeth and K. Pickster, "Power Control Techniques in Voltage Source Converters for Grid Integration of Wind Energy". *Proceedings of the 3rd Eskom Power Plant Engineering Institute Student Workshop*, Eskom Academy of Learning, Midrand, South Africa, 11-12 July 2016.
- [25] U. Iruansi, J.R. Tapamo, I.E. Davidson and M. Khan, "Polymeric Insulator Condition Analysis Based on Hydrophobicity". *Proceedings of the 3rd Eskom Power Plant Engineering Institute Student Workshop*, Eskom Academy of Learning, Midrand, South Africa, 11-12 July 2016.
- [26] S Khan and IE Davidson, "Underground Pumped Hydroelectric Energy Storage in South Africa using Aquifers and Existing Infrastructure". *Proceedings of the NEIS Conference 2016 on Sustainable Energy Supply and Energy Storage Systems*, Hamburg, Germany, 15-16 September 2016.**
- [27] D Chetty, M.M. Bello and I.E. Davidson, "The Application of Volt/VAr Optimization on Eskom South Africa Distribution Feeders" *Proceedings of the 2016 CIGRE Canada Conference*, Vancouver, BC, Oct 17-19, 2016.
- [28] D Chetty, A. Perera, M.M. Bello and I.E. Davidson, "Performance Evaluation of Traction and Utility Network Interface: Fault Location, Protection Coordination and Management of Transient and Temporary Overvoltage" *Proceedings of the 2016 CIGRE Canada Conference*, Vancouver, BC, Oct 17-19, 2016.

- [29] E. Hamatwi, I E Davidson and M N Gitau, "Control of Multi-Level Voltage Source Converters Integrating a Wind Turbine System into the Grid". Proceedings of the *5th International Conference on Renewable Energy Research and Applications*, Birmingham, United Kingdom, 20-22 November 2016.
- [30] OE Oni and IE Davidson, "Harmonic Distortion of LCC-HVDC and VSC-HVDC Link in Eskom's Cahora Bassa HVDC Scheme". Proceedings of the *5th International Conference on Renewable Energy Research and Applications*, Birmingham, United Kingdom, 20-22 November 2016.
- [31] OE Oni, N Parus and IE Davidson, "Static Voltage Stability Analysis of Eskom Eastern Grid". Proceedings of the *5th International Conference on Renewable Energy Research and Applications*, Birmingham, United Kingdom, 20-22 November 2016.
- [32] S Sewchurran and IE Davidson, "Optimisation and Financial Viability of Landfill Gas to Electricity Projects in South Africa". Proceedings of the *5th International Conference on Renewable Energy Research and Applications*, Birmingham, United Kingdom, 20-22 November 2016.
- [33] S Sewchurran and IE Davidson, "Guiding Principles for Grid Code Compliance of Large Utility Scale Renewable Power Plant Integration onto South Africa's Transmission/Distribution Networks". Proceedings of the *5th International Conference on Renewable Energy Research and Applications*, Birmingham, United Kingdom, 20-22 November 2016.
- [34] P. T Ogunboyo, R. Taiko and I. E. Davidson, "Evaluation of Power Quality in Smart Electrical Power Distribution Networks" College of Agriculture, Engineering and Science, *Postgraduate Research and Innovation Day 2016*, University of KwaZulu-Natal, 29 November 2016, Shepstone Lecture Theatre Complex, Howard College, pp. 188.

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- [35] M. Chamane, M.N. Gitau and I.E. Davidson, "A Study of the Performance of VSC-HVDC Transmission System during DC Faults". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 20-25, ISBN 978-0-620-74503-1.
- [36] O. Lasabi, A. Swanson and I.E. Davidson, "Surface Charge Accumulation on DC Insulators: An Overview". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 38-43, ISBN 978-0-620-74503-1.
- [37] G. Ininahazwe and I.E. Davidson, "A Numerical Investigation of the Effects of External Field on Electric Field Distribution around Glass Insulator". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 125-130, ISBN 978-0-620-74503-1.
- [38] E. Hamatwi, I. E. Davidson and M.N. Gitau, "Pitch-Angle Control of a Wind Turbine Equipped with a Permanent Magnet Synchronous Generator". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 200-205, ISBN 978-0-620-74503-1.
- [39] E. Hamatwi, I. E. Davidson and M.N. Gitau, "Control of a Wind Turbine Equipped with a Permanent Magnet Synchronous Generator for Maximum Power Point Tracking". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 206-214, ISBN 978-0-620-74503-1.
- [40] E. Singh, I.E. Davidson and G.K. Venayagamoorthy, "Methodology for Measuring and Enhancing Tower Footing Resistance for Lightning Protection in an 88KV Line". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 655-659, ISBN 978-0-620-74503-1.
- [41] O.E. Oni, N. Parus and I. E. Davidson, "Dynamic Analysis of Eskom Eastern Power Grid". In *Proceedings of the 25th South African Universities Power Engineering Conference*, 30 January – 1st February 2017, Stellenbosch, South Africa, pp. 824-830, ISBN 978-0-620-74503-1.
- [42] Innocent Davidson, Timothy Akindeji, Eamon Bussy and Navin Rampersadh, "Application of Cost-Effective Grid-Scale Battery Storage as an Enabler of Network Integration of Renewable Energy", Paper S1-5 presented at the 17th IERE General meeting and Canada Forum, Vancouver BC, Canada, 16-19 May 2017.
- [43] Rodney Reuben, Innocent Davidson and Sizwe Dhlamini, "Renewable Energy Zones in Queensland: A means to Integrate Transmission and Generation Infrastructure Development", Paper S4-7 presented at the 17th IERE General meeting and Canada Forum, Vancouver BC, Canada, 16-19 May 2017.
- [44] Mbalenhle Chamane, David Dorrell, Innocent Davidson, Njoroge Gitau and R. Vajeth, "A protection scheme for voltage source converter (VSC) based HVDC systems". *Proceedings of the 4th Eskom Power Plant Engineering Institute Student Workshop*, Eskom Academy of Learning, Midrand, South Africa, 29 - 30 May 2017, pp. 34-35.
- [45] P. T Ogunboyo, R. Taiko and I. E. Davidson, "Enhancing Voltage Profile of Low Voltage 11/0.4 kV Electric Power Distribution Network using Dynamic Voltage Restorer". *Proceedings of the 4th Eskom Power Plant Engineering Institute Student Workshop*, Eskom Academy of Learning, Midrand, South Africa, 29 - 30 May 2017, pp. 56-57.
- [46] O.P. Taiwo, R. Taiko and I. E. Davidson, "An investigation of voltage unbalance quality in low voltage electrical power distribution network under normal operation mode". In Proceedings of the *EAI International Conference for Research, Innovation and Development for Africa (ACRID 2017)*, Victoria Falls, Zimbabwe, June 20–21, 2017.
- [47] Zama Goqo, Sanjeeth Sewchurran, Innocent Davidson and Olorunfemi Ojo, "An Assessment of Voltage Rise Phenomenon on Existing Low-Voltage Distribution Network in Durban, South Africa". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 231 - 235. ISBN: 978-1-5090-4746-8/17.

- [48] E. Hamatwi, M.N. Gitau and I. E. Davidson, "Control of a Direct-driven Permanent Magnet Synchronous Generator-based Wind Turbine to Achieve Maximum Wind-Power Extraction". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 65 - 74. ISBN: 978-1-5090-4746-8/17.
- [49] O.E. Oni and I. E. Davidson, "Technical Performance and Cost Analysis of a 600kV HVDC Link on South Africa's EHV Network". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 88 - 94. ISBN: 978-1-5090-4746-8/17.
- [50] A. Maharaj and I. E. Davidson, "Lifecycle Cost Optimization of Electric Utility Transmission and Distribution Assets". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 65 - 74. ISBN: 978-1-5090-4746-8/17.
- [51] S. Mludi and I. E. Davidson, "Dynamic Analysis of Southern Africa Power Pool (SAPP) Network". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 65 - 74. ISBN: 978-1-5090-4746-8/17.
- [52] O.P. Taiwo, R. Tiako and I. E. Davidson, "An Improvement of Voltage Unbalance in a Low Voltage 11/0.4 kV Electrical Power Distribution Network under 3-phase Unbalance Load Condition using Dynamic Voltage Restorer". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 126 - 131. ISBN: 978-1-5090-4746-8/17.
- [53] Enyo Agbodo, Babatunde Adeyemo, Ashwin Maharaj and Innocent Davidson, "Transforming the West African Regional Electricity Market – Lessons and Experiences". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 128 - 131. ISBN: 978-1-5090-4746-8/17.
- [54] Sanjeeth Sewchurran, Innocent Davidson and Olorunfemi Ojo, "Drivers, Barriers and a Method for Evaluating the Feasibility of Residential Rooftop Solar PV in Durban - Part 1". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 208 - 213. ISBN: 978-1-5090-4746-8/17.
- [55] Sanjeeth Sewchurran, Innocent Davidson and Olorunfemi Ojo, "Drivers, Barriers and a Method for Evaluating the Feasibility of Residential Rooftop Solar PV in Durban - Part 2". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 214 - 219. ISBN: 978-1-5090-4746-8/17.
- [56] Sanjeeth Sewchurran and Innocent Davidson, "Study of Renewable Energy Resources Found within Local Municipalities - An eThekweni Electricity Case Study". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 220- 226. ISBN: 978-1-5090-4746-8/17.
- [57] Nsofwa Kangwa, Chitra Venugopal and Innocent Davidson, "A Review of the Performance Analysis of VSC-HVDC and MTDC Systems". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 267 - 273. ISBN: 978-1-5090-4746-8/17.
- [58] Leonard Mukwekwe, Chitra Venugopal and Innocent Davidson, "A Review of the Impacts and Mitigation Strategies of High PV Penetration in Low Voltage Networks". Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 274 - 279. ISBN: 978-1-5090-4746-8/17.
- [59] Navin Rampersadh and Innocent Davidson, "Grid Energy Storage Devices", Proceedings of the *IEEE PES-IAS PowerAfrica Conference*, Accra, Ghana, 27-30 June 2017, pp. 121 – 125. ISBN: 978-1-5090-4746-8/17.
- [60] Sizwe Dhlamini, Innocent Davidson and Andrew Fisher, "Promoting access to grid electricity for communities by using energy efficient transformer components within the clean development mechanism", Paper accepted for presentation at the 3rd IEEE Canada International Humanitarian Technology Conference (IHTC 2017), Toronto, Canada, July 20-21, 2017.

Referred Conference Papers (Accepted for Presentation)

- [61] Rereloluwa O. Fatunmbi, Okezie O. Okoye, Olanrewaju A. Lasabi and Innocent E. Davidson, "FPGA Implementation of Open-Loop Controller for Five-Level Three Phase Multilevel Modular Converter". Paper accepted for presentation at the 13th *IEEE Africon Conference*, Cape Town, South Africa, 18 - 20 September 2017.
- [62] S. Sewchurran and I. E. Davidson, "Introduction to the South African Renewable Energy Grid Code Version 2.9 Requirements (Part I - Introduction)". Paper accepted for presentation at the 13th *IEEE Africon Conference*, Cape Town, South Africa, 18 - 20 September 2017.
- [63] S. Sewchurran and I. E. Davidson, "Introduction to the South African Renewable Energy Grid Code Version 2.9 Requirements (Part II – Grid Code Technical Requirements)". Paper accepted for presentation at the 13th *IEEE Africon Conference*, Cape Town, South Africa, 18 - 20 September 2017.
- [64] S. Sewchurran and I. E. Davidson, "Introduction to the South African Renewable Energy Grid Code Version 2.9 Requirements (Part III – Discussions and Conclusions)". Paper accepted for presentation at the 13th *IEEE Africon Conference*, Cape Town, South Africa, 18 - 20 September 2017.
- [65] Usiholo Iruansi, Jules-Raymond Tapamo and Innocent Davidson, "Insulator condition using local binary patterns combined with support vector machines". Paper accepted for presentation at the 13th *IEEE Africon Conference*, Cape Town, South Africa, 18 - 20 September 2017.
- [66] P. T Ogunboyo, R. Taiko and I. E. Davidson, "Voltage Profile Enhancement in Low Voltage 11/0.4 kV Electric Power Distribution Network Using Dynamic Voltage Restorer under Three Phase Balance Load" Paper accepted for presentation at the 13th *IEEE Africon Conference*, Cape Town, South Africa, 18 - 20 September 2017.

8. CAPACITY BUILDING AND COMMUNITY OUTREACH

Organized, hosted or participated in the following community activities:

- [1] **Royal Academy of Engineering Guest Lecture and Seminar**
Presenter: Dr Sanjeeth SEWCHURRAN
Chief Engineer
eThekweni Electricity
eThekweni Municipality, Durban
ROYAL ACADEMY OF ENGINEERING LECTURE: “The Changing Electrical Power System”
Time: 08.45 – 11.00 hours, Friday: 18th August 2017
Venue: S7-107, Power Electronics Lab, Dept. of Electrical Power Engineering, DUT, Steve Biko Campus
- [2] **2nd Mangosuthu University of Technology Research Innovation and Engagement Week**
Presenter: Innocent E. DAVIDSON
Durban University of Technology
SEMINAR WORKSHOP: “Environmental Sustainability with a focus on Renewable Energy”
Time: 10.30 – 12.30 hours, Wednesday: 12th July 2017
Venue: International Convention Centre, Durban, South Africa.
- [3] **Industry-Expert Workshop and Seminar**
Presenter: Mobolaji M. BELLO
Power System Studies, Power Delivery and Utilization sector
Electric Power Research Institute Inc. (EPRI), Knoxville, TN 37932, USA
SEMINAR WORKSHOP: “Advanced Modelling for Distribution Planning and Operations with Open DSS”
Time: 08.45 – 11.00 hours, Friday: 2nd June 2017
Venue: S7-107, Power Electronics Lab, Dept. of Electrical Power Engineering, DUT, Steve Biko Campus
- [4] **Durban University of Technology/University of KwaZulu-Natal
Special Seminar**
Presenter: Professor G. Kumar Venayagamoorthy
Duke Energy Distinguished Professor of Electrical and Computer Engineering
Clemson University, Clemson, USA
Topic: Frequency Control of Power Systems with Increasing Levels of Photovoltaic Plants
Date: 23rd June 2016
- [5] **Postgraduate Course Presentation**
Presenter: Dr. Grain Adam, University of Strathclyde, Glasgow
Topic: Power Electronics and High Voltage DC Delivery Systems
Date: 22-26th February 2016
- [6] **Industry Site Visit – Eskom Research Testing & Development
– Eskom Apollo Converter Station (LCC-HVDC Converter)**
Presenter(s): Nick Singh & Dr. Prathaban Moodley
Topic: Eskom Research Direction/ Smart Grid Research in Eskom
Date: 20th May 2016

9. RESEARCH FUNDING

The following funds and research grants were obtained by the Research Leader since 2016:

2017 Grants

Principal Investigator: Prof IE Davidson

Project: Postgraduate Training and Research in High Voltage Direct Current (HVDC) and High Voltage Direct Current Technology Applications

THRIP Grant: **R529 000.00**

Royal Academy of Engineering United Kingdom Award

Grant Amount: **£140 000.00**

Research Proposal: Quality Engineering Education through University-Industry Partnerships in Eastern & Southern Africa

Hub University (Lead University):

The University of Namibia, Namibia (Professor Frank Kavishe)

Spoke Universities:

The University of Nairobi, Kenya.

Professor George Rading

The University of Rwanda, Rwanda

Dr. Leopold Mbereyaho

Durban University of Technology, South Africa.

Professor Innocent E. Davidson

UK Partner: The University of Cambridge

Professor Catherine Rae

Principal Investigator: Prof IE Davidson

Eskom TESP Grant (Smart Grids)

R60 000.00

Eskom TESP Grant (HVDC)

R80 000.00

2016 Grants

Principal Investigator: Prof IE Davidson

Eskom TESP Grant (Smart Grids)

R60 000.00

Eskom TESP Grant (HVDC)

R80 000.00

Research Coordinator: Dr IE Davidson

Eskom EPPEI (UKZN SC in HVDC)

R2 200 000.00

JW Nelson Fund Research Award

R30 000.00

PhD Student: Sanjeeth Sewchurran

CAES College Bursary Grant

R50 000.00

PhD Student: Timothy Akindeji