PROGRAM

2019 7th International Conference on Smart Energy Grid Engineering

SEGE 2019

August 12-14, 2019

Oshawa, Canada

Organized by

Sponsored by

WELCOME MESSAGE

It is our great pleasure to welcome you to Oshawa for attending the 2019 7th International Conference on Smart Energy Grid Engineering (SEGE 2019). This event will provide a unique opportunity for international scholars, researchers and practitioners who are working in the field of smart energy grid infrastructures, technologies, engineering design methods to get together and share their latest research findings and results.

We're confident that over the three days you'll get the theoretical grounding, practical knowledge, and personal contacts that will help you build long-term, profitable and sustainable communication among researchers and practitioners working in a wide variety of scientific areas with a common interest in energy generation, transmission and distribution infrastructures, energy storage, electrification, information and communications, and security.

On behalf of all the conference committees, we would like to thank all the authors for your contribution as well as the technical program committee members and external reviewers. Their high competence, enthusiasm, valuable time and expertise knowledge, enabled us to prepare the high-quality final program and helped to make the conference become a successful event.

The SEGE conference aims at providing an opportunity to discuss various engineering challenges of smart energy grid design and operation by focusing on advanced methods and practices for designing different components and their integration within the grid. It also provides a forum for researchers from academia and professionals from industry, as well as government regulators to tackle these challenges, and discuss and exchange knowledge and best practices about design and implementation of smart energy grids.

I truly hope you'll enjoy the conference and get what you expect from the conference.

General Chair

Dr. Hossam A. Gabbar

July 22, 2019

VENUE INFORMATION

Ontario Technology University

Address: 2000 Simcoe St N, Oshawa, ON L1H 7K4

Map of Ontario Technology University:

Conference rooms are located in the science building.

How to get there from Toronto Pearson International Airport:

1. By taxi: Take the taxi directly from the airport, which will take about 50 minutes and cost 112 CAD.

2. By bus: Take bus 40 from the airport till Richmond Hill Center. Then, from Richmond Hill Center take bus 52 to Durham College (Ontario Technology University).

Parking Information:

Founder Lot 2 beside ERC building (Paid parking).

TABLE OF CONTENTS

CONFERENCE COMMITTEES

General Chair

Hossam A. Gabbar, Ontario Technology University (UOIT), Canada

Technical Program Chairs

Ehab El-Saadany, University of Waterloo, Canada

Prasanta Ghosh, Syracuse Univ., USA

Mohammed Safiuddin, University at Buffalo, USA

Local Organization Chairs

Martin Agelin-Chaab, UOIT, Canada

Dr. Ahmed Othman, UOIT, Canada

Dr. Onur Elma, UOIT, Canada

Award Chair

Prof. Miguel F. Anjos, Polytechnique Montréal, Canada

Women in Engineering Chair

Ruth Milman, UOIT, Canada

Treasurer

Manir U. Isham, Loyalist College, Canada

Technical Program Committees

Michael Fowler, University of Waterloo, Canada

Claudio Canizares, University of Waterloo, Canada

Peter Lund, Aalto University, Finland

Felipe Rosa, University of Seville, Spain

Marc Rosen, UOIT, Canada

Maike Luiken, IEEE Canada President, Lambton College, Canada

Toshihisa Funabashi, Nagoya University, Japan

Hadis Karimipour, University of Guelph, Canada

Wang Qian, Jiangsu University, China

Veit Hagenmeyer, Karlsruhe Institute of Technology, Germany

Shamsodin Taheri, Université du Québec en Outaouais, Canada

Amr Ahmed A. Radwan, Western Washington University, Bellingham, USA

Alexander Sauer, Institute for Energy Efficiency in Production (EEP), University of Stuttgart, Germany

Sara Walker, Newcastle University, Newcastle, UK

Mahdi Ghamkhari, University of Louisiana at Lafayette, Lafayette, LA, USA

Mansoureh Zangiabadi, Newcastle University, UK

LOCAL INFORMATION

Time: UTC/GMT-8

Weather

Average high (C/F): 24℃/76℉ | Average low (C/F): 16℃/60℉.

August is a very favourable month and also the peak tourist season to visit right across Canada. For the most popular attractions and locations, you may need to book 6 to 9 months in advance to be sure of availability.

Banks and Foreign Exchange

The currency in Canada is Canadian Dollar (C$ or CAD). Canadian bills or bank notes are commonly available in $5, $10, $20, $50, and $100 dollar denominations. The $1 and $2 bills have been replaced with coins.

Foreign currencies are easily changed into Canadian dollars at currency exchange kiosks at airports, border crossings, large shopping malls, and banks. Credit cards and debit cards are widely accepted across Canada and ATMs are easy to find in urban areas.

Transportation

Public transit service – Go Transit

Check out the Go Transit bus information through the link below: https://www.gotransit.com/schedules

The Oshawa Visitor Information Centre

Address: 2 Bloor St. E., Oshawa, Ontario L1H 8S9 (Bloor & Simcoe)
Tel: 905.725.4523
Hours of Operation: 9:00 a.m. – 6:00 p.m.

Emergency Number

Fire/Medical/Police: 911
Emergency Management Office: 905-668-7711/ Toll-Free: 1-800-372-1102
Ontario 24 Hour Crisis Line: 416-364-4144/ Toll-Free 1-888-364-1210

INSTRUCTIONS FOR PRESENTATIONS

Oral Presentations

- Time: a maximum of 15 minutes in total, including 12 minutes' speaking time and 3 minutes' for discussion. Please make sure your presentation is well timed. Please keep in mind that the program is full and that the speaker after you would like their allocated time available to them.
- You can use USB flash drive (memory stick), make sure you scanned viruses in your own computer. Each speaker is required to meet her / his session chair in the corresponding session rooms 10 minutes before the session starts and copy the slide file (PPT or PDF) to the computer.
- It is suggested that you email a copy of your presentation to your personal inbox as a backup. If for some reason the files can't be accessed from your flash drive, you will be able to download them to the computer from your email.
- Please note that each session room will be equipped with a LCD projector, screen, point device, microphone, and a laptop with general presentation software such as Microsoft Power Point and Adobe Reader. Please make sure that your files are compatible and readable with our operation system by using commonly used fronts and symbols. If you plan to use your own computer, please try the connection and make sure it works before your presentation.
- Movies: If your Power Point files contain movies please make sure that they are well formatted and connected to the main files.

Poster Presentations

- Maximum poster size is 36 inches wide by 48 inches high (3ft.x4ft.)
- Posters are required to be condensed and attractive. The characters should be large enough so that they are visible from 1 meter apart.
- Please note that during your poster session, the author should stay by your poster paper to explain and discuss your paper with visiting delegates.

Dress Code

- Please wear formal clothes or national characteristics of clothing.

PROGRAM AT A GLANCE

August 12, 2019 (Monday)	02:00pm-06:00pm	**Registration**	Room UA2140
	02:00pm-04:00pm	**Tutorial 1**	Room UA2120
		Tutorial 2	Room UA2130
	04:00pm-04:30pm	**Invited Speech I:** The Innovation Roadmap: Exploring Evolution in Ontario's Electricity Sector Dr. Brennan Louw Independent Electricity System Operator	Room UA1120
	04:30pm-06:00pm	**Welcome Reception**	Room UA2140
August 13, 2019 (Tuesday)	08:30am-04:00pm	**Registration**	Room UA2140
	08:30am-08:45am	**SEGE Opening, Welcome Message**	Room UA1120
	08:45am-09:30am	**Keynote Speech I:** Fast Charging Infrastructures for Autonomous Transportation and Smart Cities Dr. Hossam A. Gabbar UOIT, Oshawa, Canada	Room UA1120
	09:30am-10:15am	**Keynote Speech II:** Bio-inspired Design to Improve Power Grid Resiliency Dr. Prasanta Ghosh Syracuse University, USA	Room UA1120
	10:15am-10:45am	**Coffee Break**	Room UA2140
	10:45am-11:30am	**Keynote Speech III:** Development of Photovoltaic Inverter Technologies Dr. Carl Ngai Man Ho University of Manitoba, Canada	Room UA1120
	11:30am-12:15pm	**Panel Discussion I**	Room UA1120
	12:15pm-01:30pm	**Lunch**	South Village Dining Hall
	01:30pm-03:30pm	**Session 1: Transmission & Distribution, Smart Infrastructures** **Chair:** Dr. Ahmed Abdelmaksoud	Room UA2120
		Session 2: Materials and Energy Engineering **Chair:** Dr. Prasanta Ghosh	Room UA2130
	03:30pm-04:00pm	**Coffee Break**	Room UA2140

	04:00pm-06:00pm	**Session 3: Smart Grid Design and Operations I** **Chair:** Dr. Yasser Hegazy	Room UA2120
		Session 4: Power Electronics Technology and Applications I **Chair:** Dr. Carl Ngai Man Ho	Room UA2130
	06:15pm-06:30pm	**Take Bus to Mandarin Restaursnt**	
	06:30pm-08:30pm	**Dinner**	Mandarin Restaursnt
August 14, 2019 (Wednesday)	08:30am-04:00pm	**Registration**	Room UA2140
	08:30am-09:00am	**Invited Speech II:** Application of AI in Smart Grid Cyber Security Analysis Dr. Hadis Karimipour University of Guelph, Canada	Room UA1120
	09:00am-10:00am	**Panel Discussion II**	Room UA1120
	10:00am-10:30am	**Coffee Break**	Room UA2140
	10:30am-12:30am	**Session 5: Power Electronics Technology and Applications II** **Chair:** Dr. Prasanta Ghosh	Room UA2120
		Session 6: Smart Grid Design and Operations II **Chair:** Dr. Onur Elma	Room UA2130
	12:30am-01:30pm	**Lunch**	South Village Dining Hall
	01:30pm-03:30pm	**Session 7: Safety and Security of Smart Energy & Grids** **Chair:** Dr. Farnaz Derakhshan	Room UA2120
		Session 8: Micro Energy Grids **Chair:** Dr. Hadis Karimipour	Room UA2130
	03:30pm-04:00pm	**Coffee Break**	Room UA2140
	04:00pm-05:00pm	**UOIT/ACE Tour**	Room UA1120
	05:00pm-06:00pm	**Closing Ceremony**	Room UA1120

KEYNOTE SPEAKERS

Dr. Hossam A. Gabbar

UOIT, Oshawa, Canada

Biography: Dr. Gabbar is a full Professor in the University of Ontario Institute of Technology (UOIT) in the Faculty of Energy Systems and Nuclear Science, and cross appointed in the Faculty of Engineering and Applied Science, where he has established both the Energy Safety and Control Lab (ESCL) and Advanced Plasma Engineering Lab. He is the recipient of the Senior Research Excellence Aware for 2016, UOIT. He is leading national and international research in the areas of smart energy grids, smart and autonomous transportation, intelligent safety and control systems, advanced plasma systems and their applications on nuclear and clean energy systems. Dr. Gabbar obtained his B.Sc. degree in 1988 with first class of honor from the Faculty of Engineering, Alexandria University (Egypt). In 2001, he obtained his Ph.D. degree from Okayama University (Japan) in the area of Safety Engineering. From 2001 till 2004, he joined Tokyo Institute of Technology (Japan). From 2004 till 2008, he joined Okayama University (Japan) as a tenured Associate Professor, in the Division of Industrial Innovation Sciences. From 2007 till 2008, he was a Visiting Professor at the University of Toronto. He has more than 220 publications, including patents, books / chapters, journal and conference papers. He been invited and participated in world-known conferences and delivered plenary talks on number of scientific events and invitations to international universities. He has supervised and hosted undergraduate, graduate, postdocs, visiting researchers and scholars from different countries including: Japan, India, Qatar, Egypt, Mexico, Malaysia, China, Brazil, Chile, UAE, and Colombia.

He participated and led several large scale national and international projects, in Japan, China, Middle East, and Canada, related to connected autonomous vehicles, fast charging infrastructures for smart transportation, smart energy grids, intelligent control systems and safety design and operation synthesis and optimization of energy systems, micro energy grids, and integrated gas-power grids, plasma-based waste-to-energy. He proposed new integrated energy storage system based on hybrid energy storage including flywheel and battery technologies, and applied on power substations, transportation electrification, and urban infrastructures. He is the founding general chair of the annual IEEE Smart Energy Grid Engineering Conference, SEGE.

Speech Title: “Fast Charging Infrastructures for Autonomous Transportation and Smart Cities”

Abstract: This talk will discuss design of fast charging infrastructures and their planning in smart cities and communities to support autonomous transportation. Recent development of fast charging infrastructures using hybrid energy systems will be presented. The talk will discuss aspects of connected and autonomous vehicles (CAV) and their integration within transportation networks and city infrastructures. The talk will elaborate on challenges and opportunities for autonomous transportation including connected and autonomous vehicles, shuttles, and their technology development and deployment within smart communities. Intelligent control strategies, architectures, and systems will be presented along with intelligent data center to ensure effective transportation networks in normal and emergencies. Planning strategies will be presented to demonstrate the resilient transportation infrastructures. Optimized performance will be discussed in view of performance indicators and requirements specifications, as well as regulations and standards.

Dr. Prasanta Ghosh

Syracuse University, USA

Biography: Professor Prasanta Ghosh is a faculty member in the Department of Electrical Engineering and Computer Science at Syracuse University. He has been conducting research in the area of microelectronics and power engineering. He has authored and co-authored many journal articles and conference papers in the area of thin films, solid-state devices, and power engineering. As a Fulbright Scholar, he has traveled internationally to teach engineering students and delivered lectures on his research. His current research focus includes microgrid, sensors, cloud computing and bio-inspired control for power system. He is a senior member of IEEE.

Speech Title: "Bio-inspired Design to Improve Power Grid Resiliency"

Abstract: The electric power delivery system must have few outages to meet the electrical energy needs of our everyday life. Therefore, future investment focus should be on the power system reliability. Modern power system has been undergoing considerable changes in technology and planning. Technological advancements on smart grid includes improved sensing, communication, automation and advance metering. Thus, the modern electric power system becomes a complex cyber-physical system with many components spread around the network. It is understandable that despite all efforts there is potential for occasional large-scale outages especially due to natural disasters. Major outages will have huge negative impact on human lives and the economy. Therefore, there is an

urgent need to increase power system resiliency, decrease outages and at the same time reduce impacts on the society. It is also important to lower the power network restoring time.

Strategies to enhance electric power resilience must accommodate both a diverse set of technical arrangements and a wide variety of hazards. There are many publications focusing on the different aspects of the power system with the intention of improving system resiliency. Among them, some recent publications discuss about the bio-inspired design to enhance sustainability and performance of systems such as power network. Bio-inspired design draw analogies between human and natural systems to identify biological principles that are useful for solving engineering problems.

Biological food webs have evolved over millions of years to manage and survive extreme events. These networks have already inspired the redesign of several organizational analogous human networks. Results indicate reduced environmental impacts and cost when design mimic food web characteristic structure. Power grid, in many ways, resembles food webs; both are made of components that exchange, use, and transform energy to meet the needs of the participants.

In this presentation, I will review work done in this area which demonstrate improved robustness of the electric power network through the understanding and application of the knowledge gained from biological food webs. Results points to increased system flexibility and redundancy, which lead to more resilient power grid.

Dr. Carl Ngai Man Ho

University of Manitoba, Canada

Biography: Dr. Carl Ho received the BEng and MEng double degrees, in 2002, and the PhD degree, in 2007, in electronic engineering from the City University of Hong Kong. He was involved in research on the development of dynamic power quality conditioning technology during his Ph.D degree. In 2007, he joined ABB Switzerland. He has been appointed as Scientist, Principal Scientist, and R&D Principal Engineer. He has led a research project team at ABB Switzerland to develop Solar Inverter technologies for three years. In October 2014, he joined the University of Manitoba in Canada, currently, he is Associate Professor and Canada Research Chair in Efficient Utilization of Electric Power. He established the Renewable-energy Interface and Grid Automation (RIGA) Lab at the University of Manitoba and takes up the challenge of research into Microgrid technologies, Photovoltaic Inverters, Power-Hardware-in-the-loop, Power Quality Conditioning and Wide Bandgap semiconductors. Dr. Ho is currently an IEEE Senior Member and an Associate Editor of the IEEE Transactions on Power Electronics (TPEL) and the IEEE Journal of Emerging and Selected Topics in Power Electronics (JESTPE). He received the Best JESTPE Associate Editor Award in 2018 and His student project team received “Best

Student Team Regional Award" of the IEEE Empower a Billion Lives 2019 competition in the Americas region.

Speech Title: "Development of Photovoltaic Inverter Technologies"

Abstract: Decentralisation of power generation is generally acknowledged one of characteristics of future smart grids. Different conventional and renewable energy sources will be installed in different locations but supporting the common grid network. Currently, solar energy is the most commonly used among the renewable energy sources, since PV panel installation is very flexible, it can be down to few kilowatts or up to tens Magawatt. However, solar energy harvesting is not operating all the time, it only operates during day time and amount of extracting energy highly depends on the weather condition. It creates power quality issues in the future smart grids due to this unpredictable power generation. Besides, some new regulations of PV inverters are issued in various countries, it further limits the design of PV inverters. On the other hand, emerging semiconductors is getting close to be in application level. The design of PV inverters will be in a new era to achieve high efficiency. This seminar will discuss the technologies of PV inverter in the future based on the grid-environment, the regulations and the market environment. Moreover, the technology trend of improving system performance of PV inverters including semiconductors, magnetic materials and converter topology will be reviewed and discussed.

INVITED SPEAKERS

Dr. Hadis Karimipour

University of Guelph, Canada

Biography: Dr. Hadis Karimipour received the Ph.D. degree in Energy System from the Department of Electrical and Computer Engineering in the University of Alberta in Feb. 2016. Before joining the University of Guelph, she was a postdoctoral fellow in University of Calgary working on cyber security of the smart power grids. She is currently an Assistant Professor at the School of Engineering, Engineering Systems and Computing Group at the University of Guelph, Guelph, Ontario. Her research mainly focuses on monitoring and security of critical infrastructure including large scale control systems and smart grids. The overall objective of her research is to investigate and overcome the challenges associated with the security, real-time monitoring and control of the large scale systems and smart grids using data analytic and machine learning techniques. She is the member of IEEE, IEEE Computer Society, and Cyber Science Lab - A community of cybersecurity researchers. She serves as the Chair of the IEEE Women in Engineering (WIE) and Chapter Chair of IEEE Information Theory in Kitchener-Waterloo section.

Speech Title: "Application of AI in Smart Grid Cyber Security Analysis"

Abstract: The deployment of smart technologies in communication layer brings new challenges for online monitoring and control of the Cyber-Physical Systems (CPS). In addition to failure of physical infrastructure, CPS is also sensitive to cyber-attacks on its communication layer. Such systems have the potential to have a major impact on all aspects of our lives. Examples of CPS include smart grid, autonomous transportation systems, medical monitoring, process control systems, robotics systems, and automatic pilot avionics. The evolution of power systems toward the smart grids era increase the size and complexity of the power grids which makes wide-area monitoring of the power system state a *challenging computational* problem. In addition, smart grid comes with many cyber *security concerns*. As far back as 2002, 70% of energy companies experienced some kind of cyber-attack. Cyber-attacks are intelligently designed to bypass existing fault identification approaches. In case of a successful attack, a domino effect may follow which will result in irreparable damage in different parts of the system. Looking at the big picture, a nationwide effort to completely automate the grid is under way. The key to the success of this goal is an underlying system of data acquisition and

data processing that will provide accurate and reliable data through dynamic state estimation (DSE) and proper control strategies. There are lots of discussions about the role of security-aware design and analysis in the development of modern CPS such as smart grid using advanced AI and machine learning techniques. Rapid advancement in AI technology enhances the scale, speed, and accuracy of the security in CPS. Various machine learning-based security assessment tools have been designed for CPS, which proves that AI is poised to revolutionize the way we monitor, control, manage, and respond to the emergency in critical CPS.

Dr. Brennan Louw

Independent Electricity System Operator

Biography: Brennan Louw is Senior Manager of System and Sector Development at the Independent Electricity System Operator. In his current role Brennan is focused on exploring and preparing for the impacts of longer term trends, like decentralization and decarbonisation, on Ontario's bulk electricity system. Previously, Brennan has held a number or positions at the IESO focused on the evolution of Ontario's electricity markets and has worked at Ontario's Ministry of Energy and as a consultant in the electricity sector. Brennan holds an MBA from the Schulich School of Business.

Speech Title: "The Innovation Roadmap: Exploring Evolution in Ontario's Electricity Sector"

Abstract: This presentation will introduce the IESO's Innovation Roadmap and will highlight several projects captured within the Roadmap that are helping to develop new solutions to important challenges within Ontario's electricity sector. In particular, the presentation will focus on what steps the IESO is taking today to ensure it is prepared to deliver reliability and cost-effectiveness in a high-distributed energy resource future.

CONTENTS OF SESSIONS

Note: Please find out which session your paper is included in and arrive at the session room at least 10 minutes before the session starts to copy your PPT or PDF presentation file into the laptop which has been set up in the room.

Session 1: Transmission & Distribution, Smart Infrastructures

Session 2: Materials and Energy Engineering

Session 3: Smart Grid Design and Operations I

Session 4: Power Electronics Technology and Applications I

Session 5: Power Electronics Technology and Applications II

Session 6: Smart Grid Design and Operations II

Session 7: Safety and Security of Smart Energy & Grids

Session 8: Micro Energy Grids

ORAL PRESENTATION ABSTRACTS

Note:
• Session photo will be taken at the end of each session.
• Upload your PPT or PDF to the laptop 10 minutes before each session starts.
• To show respect to other authors, especially to encourage the student authors, we strongly suggest you attend the whole session
• The certificate for oral presentations will be handed out by session chair at the end of each session.
• ***Important:*** The scheduled time for presentations might be changed due to unexpected situations, please come as early as you could.

August 13, 2019

SESSION 1

Transmission & Distribution, Smart Infrastructures

01:30pm-03:30pm

Venue: Room UA2120

Chair: Dr. Ahmed Abdelmaksoud
UOIT, Oshawa, Canada

GE013

01:30pm-01:45pm

Ensemble Machine Learning Forecaster for Day Ahead PV System Generation

Mahtab Kaffash, Geert Deconinck

KU Leuven, Belgium

Abstract: In this paper, the application of machine learning methods to predict the day ahead photovoltaic power generation in hourly intervals from the previous days, without using any exogenous data, have been studied. In order to select the relevant features, a random forest feature selection is used. This paper proposes a forecasting approach based on ensembles of artificial neural networks and support vector regression. The focus of this paper is on a single installed photovoltaic system, and in order to evaluate the performance of the proposed approaches, the measured data related to the photovoltaic installation on the roof of EnergyVille-1 is used. The results show that proposed approach can improve the accuracy of forecasting.

 GE015	01:45pm-02:00pm Smart Meter Load Profiling for e-Health Monitoring System **Amleset Kelati**, Juha Plosila, Hannu Tenhunen *Royal Institute of Technology (KTH), Sweden*

Abstract: A structural health-monitoring system needed to come out from the problem associated due to the rapidly growing population of elderly and the health care demand. The paper discussed the consumer's electricity usage data, from the smart meter, how to support the healthcare sector by load profiling the normal or abnormal energy consumption. For this work, the measured dataset is taken from 12 households and collected by the smart meter with an interval of an hour for one month. The dataset is grouped according to the features pattern, reduced by matrix-based analysis and classified with K-Means algorithm data mining clustering method. We showed how the clustering result of the Sum Square Error (SSE) has connection trend to indicate normal or abnormal behavior of electricity usage and leads to determine the assumption of the consumer's health status.

GE031	02:00pm-02:15pm A Comparison of Methods for Missing Data Treatment in Building Sensor Data **Mehdi Pazhoohesh**, Zoya Pourmirza, Sara Walker *Newcastle University, UK*

Abstract: Data collection is a fundamental component in the study of energy and buildings. Errors and inconsistencies in the data collected from test environment can negatively influence the energy consumption modelling of a building and other control and management applications. This paper addresses the gap in the current study of missing data treatment. It presents a comparative study of eight methods for imputing missing values in building sensor data. The data set used in this study, are real data collected from our test bed, which is a living lab in the Newcastle University. When the data imputation process is completed, we used Mean Absolute Error, and Root Mean Squared Error methods to evaluate the difference between the imputed values and real values. In order to achieve more accurate and robust results, this process has been repeated 1000, and the average of 1000 simulation is demonstrated in this paper. Finally, it is concluded that it is necessary to identify the percentage of missing data before selecting the proper imputation method, in order to achieve the best result.

GE045	02:15pm-02:30pm Smart Grid Cyber Attacks Detection Using Supervised Learning and Heuristic Feature Selection **Jacob Sakhnini**, Hadis Karimipour, Ali Dehghantanha *University of Guelph, Canada*

Abstract: False Data Injection (FDI) attacks are a common form of Cyber-attack targetting smart grids. Detection of stealthy FDI attacks is impossible by the current bad data detection systems. Machine learning is one of the alternative methods proposed to detect FDI attacks. This paper analyzes three various supervised learning techniques, each to be used with three different feature selection (FS) techniques. These methods are tested on the IEEE 14-bus, 57-bus, and 118-bus systems for evaluation of versatility. Accuracy of the classification is used as the main evaluation method for each detection technique. Simulation study clarify the supervised learning combined with heuristic FS methods result in an improved performance of the classification algorithms for FDI attack detection.

GE0103

02:30pm-02:45pm

Modeling Network Intrusion Detection System Using Feed-Forward Neural Network Using UNSW-NB15 Dataset

Liu Zhiqiang, **Ghulam Mohi-ud-din**, Li Bing, Luo Jianchao, Zhu Ye, **Lin Zhijun**

Northwestern Polytechnic University, China

Abstract: Ordinary machine learning algorithms are not very efficient in solving the classification problem of Network Intrusion because of the huge amount of data. Deep Learning is proven to be more effective in this scenario. Deep Learning can effectively classify with high dimensionality and complex features. In this paper, a deep learning IDS is proposed using state of the art UNSW-NB15 dataset. An experiment conducted to select the optimal activation function and features and then testing on unseen data demonstrates high accuracy and lower false alarm rate. The evaluation results show that proposed classifier outperforms other machine learning models, thus opening new dimensions in research in Network Intrusion Detection.

GE0104

02:45pm-03:00pm

A Smart Switch Control System Using ESP8266 Wi-Fi Module Integrated with an Android Application

S. P. Makhanya, E. M. Dogo, N. I. Nwulu, **U. Damisa**

University of Johannesburg, South Africa

Abstract: There is an increase in demand for low-cost Smart Switch Control Systems (SSCS) that can remotely control home switches or devices in residential environments using mobile applications or websites. In this paper, an SSCS which uses open source software, and can be configured without any physical adjustment to the environment, is developed to automatically minimize energy consumption. The device comprises two parts: An Android application and a unit made up of a programmable Arduino board,

ESP8266 Wi-Fi module, wall socket and an SD card. In the SSCS, the Android application is used to remotely control switches using the Wi-Fi technology. Tests carried out on the system proved its effectiveness and quick response to signals.

GE061	03:00pm-03:15pm Development of Active Gate Driver to Reduce Switching Loss for Inverter System **Jun-Hyuk Choi**, Yong-Su Noh, Jin-Hong Kim *Korea Electronics Technology Institute, Korea*

Abstract: This paper proposes the active gate driver which controls gate resistance for reducing switching loss. The proposed active gate driver is suited for various type of inverter. In the case of passive gate driver, the switching transient time can be reduced by reducing gate resistance. However, lower gate resistance causes higher switch peak current, and it may increase EMI and device stress. Using the active gate driver, the gate current is controlled to reduce switching transient time with low switch peak current. Therefore, switching loss can be decreased. To verify proposed active gate driver, a laboratory prototype has built and tested.

GE075	03:15pm-03:30pm A Layered Intrusion Detection System for Critical Infrastructure Using Machine Learning MohammadReza Begli, Farnaz Derakhshan, **Hadis Karimipour** *University of Guelph, Canada*

Abstract: Security of critical infrastructures is very important and remote healthcare systems are of those critical infrastructures which need more attention regarding security issues. Remote healthcare systems collect data of patients continuously and react appropriately. Although personal medical data needs to be protected, security issues are ignored in most of the remote healthcare systems. Therefore, in this paper, our research goal is to propose an architecture that performs secure remote healthcare system. We aim to offer a secure framework for remote healthcare systems that preserve the data of the system as safe as possible against common network attacks including Denial of Service (DoS) and User to Root (U2R) attacks. To do so, we designed an intrusion detection system (IDS) using one of the machine learning algorithm, Support Vector Machine (SVM). After implementing our method, the evaluation parameters of the layered architecture of IDS prove the efficiency of our proposed framework.

SESSION 2

Materials and Energy Engineering

01:30pm-03:30pm

Venue: Room UA2130

Chair: Dr. Prasanta Ghosh
Syracuse University, USA

GE001	01:30pm-01:45pm Harmonics from Today's Emergent Technology **Michael D.N. Dang, Mohammad Waleed** *McMaster University, Canada*

Abstract: The IEEE STD 519 was first introduced in 1981, revised in 1992, and most recently updated in 2014 to provide direction on dealing with harmonics introduced by static power converters and other nonlinear loads so that power quality problems could be averted. However, it is time to update and reflect today's growing technology because harmonic emissions emanating from renewable energy generation such as wind turbines, solar photovoltaic panel, energy cost-saving products such as LED lighting, home appliances, and electric vehicle chargers fail to adhere to the IEEE STD 519. This was based on real-time measurements and analyses. Without a very strong standard, backed up by rigid enforcement measures, it is likely that harmonic pollution will continue to increase. Power quality would trigger "power quality" problems under certain operating conditions.

 GE201-A	01:45pm-02:00pm The Use of Renewable Energy to Solve Energy Crisis in Ghana **Fosu Rockson** *China Three Gorges University, China*

Abstract: Recent years, Ghana has been experiencing shortages of electricity, which have led to "dumsor" in the local language (persistent, irregular and unpredictable electric power outages). Industries are laying-off workers, domestic power consumers are complaining of the destruction of household appliances, while cold store operators are grumpy over their rotten fish and meat products due to an inconsistent supply of electricity. The transmission system has inadequate available transfer capacity to meet the requirements of the major load centers (Accra, Kumasi, Tarkwa, etc.), particularly at peak.

The energy supply crisis can be attributed to inadequate gas supply to various thermal plants and the limited usage of renewable energy to generate electricity.

Solving Ghana's electricity crisis would require measures including, but not limited to, diversifying the electricity generation mix through the development of microgrid and renewable energy sources for which the country has large potential, promote renewable energy research, development, commercialization, training and supporting local experts.

 GE018	02:00pm-02:15pm Impact of Hysteresis Control and Internal Thermal Mass on the Energy Efficiency of IoT-Controlled Domestic Refrigerators **M. R. Zavvar Sabegh**, C M Bingham *The University of Lincoln, UK*

Abstract: The paper considers the impact of various temperature hysteresis bands on the projected annual energy consumption of a domestic refrigerator when operating empty of product and with an internal product (comprising of 10L of water). Measurements from an IoT system employing a NodeMCU-based Generalized Predictive Control scheme, are used to support the study. A ThingSpeak platform and Smart Wi-Fi plug is used to realize the different temperature hysteresis bands whilst maintaining a given mean nominal internal temperature. Experimental measurements are taken from an IGENIX IG 3920 refrigerator. Results show that by judicious choice of hysteresis band, which is shown to be dependent on the internal product characteristics, annual energy savings of up to 20% can be obtained compared to worst case fixed hysteresis band scenarios.

GE020	02:15pm-02:30pm Hybrid System of Geothermal Power Generation Using Abandoned Oil/Gas Bores Assisted by The Power of Solar Plates Zia Hameed, Adnan Yousaf, **Faiza Ahmad**, Muhammad Rafay Khan Sial, Hina Maqbool *Superior University, Pakistan*

Abstract: Fossil fuels are more efficient and low cost as compared to Renewable Energy resources. Numerous methods have been proposed to decrease the initial cost and to increase the efficiency of Renewable energy resources (RES). The proposed method is the combination of solar and geothermal power. In this research paper binary power plant is designed combining geothermal heat, extraction from abandoned gas/oil bores and energy from photovoltaic system (PV). The cost of drilling and casing has been ignored in designing of proposed method. Two photovoltaic scenarios have been used in combination with geothermal power. In first one PV system is used to work with hybrid geothermal and photovoltaic power cycle. In second one hybrid geothermal and concentrated solar thermal system is used to generate heat for super heating geothermal binary cycle. This concentrated solar thermal cycle (CSTC) needs more periodic

maintenance depending upon the area of system. Using the proposed system, the efficiency of the system has increased by 35% as compared to the traditional PV systems.

GE024

02:30pm-02:45pm

Application of Dual Axis Solar Tracking System in Qurghonteppa, Tajikistan

Adven Masih, Ismoil Odinaev, Murodbek Safaraliev, Bukhtiyor Ghoziev, Karomatullo Mukhmudov, Akbarsho Toshtemurov

Ural Federal University, Russian Federation

Abstract: Development of solar power all around the world has gained momentum recently. Like other renewable energy recourses such as hydro and wind, fortunately, Tajikistan is equally endowed with the solar energy resources. The study is based on "Bokhtar, Qurghonteppa" a region located in Tajikistan. The experiment was conducted to explore the solar potential of the region by using daily average solar irradiance data recorded for a period of 1 year. For this study the performance of Dual Axis Solar Tracker (DAST) and Static Solar System (SSS) was assessed and compared. Apart from measuring daily and monthly average solar intensity records by using DAST and SSS, additionally, seasonal and yearly energy gain and efficiencies were also calculated. Results obtained suggest that, having an overall efficiency advantage of 44.02% during one year period, DAST can achieve an efficiency as high as 80.57% during autumn season only.

GE040

02:45pm-03:00pm

Operational Optimization of a Remote Off-Grid Hybrid Renewable Energy System in Northern Canada

Roshani Kaluthanthrige, Athula D. Rajapakse

University of Manitoba, Canada

Abstract: An optimal energy management strategy for a remote, off-grid Hybrid Renewable Energy System (HRES) in Northern Canada is presented. The proposed control strategy aims at optimizing the day-ahead operational plan to achieve minimized costs and emissions. Particle Swarm Optimization (PSO) is deployed to solve the underlying optimization problem. Special attention is given to enhance the operational efficacy of the oversized diesel generators. Two dispatching strategies are evaluated under the proposed operational optimization platform. Several case studies considering different seasons are presented. The results confirm the robust performance of the proposed method in achieving the intended objectives of day-ahead energy management.

GE055	03:00pm-03:15pm Nonlinear Control of a Boost DC/DC Converter for Photovoltaic MPPT Systems Using a TMS320F28379D Microcontroller Patricia Vázquez Aguilar, Diego R. Espinoza-Trejo, José Luis Saavedra, Cristian H. De Angelo, **Shamsodin Taheri** *Univ. du Québec en Outaouais, Canada*

Abstract: This work presents a nonlinear controller of a boost dc/dc power converter for photovoltaic (PV) maximum power point tracking (MPPT) systems. The scheme of the proposed controller consists of the design of a nonlinear controller for the duty cycle generation. For this purpose, a simple and low-cost voltage-oriented controller is proposed in this study. In fact, this control algorithm is suitable to efficiently track fast irradiance changes. Consequently, the efficiency of the overall MPPT system is improved by avoiding loss of PV power caused by i) oscillatory responses due to varying irradiance conditions and ii) load disturbances. In addition, by assuming passivity properties of the constitutive relationship of the load element, internal stability of the closed-loop system is guaranteed for different load conditions, which are applicable for most PV applications. Besides, the internal stability allows to consider load scenarios affected by bounded disturbances. Finally, the proposed MPPT control system is implemented by using a proportional-integral-derivative controller, thereby providing a low-cost solution, which is programmed in the TMS320F28379D DSC Board. Experimental results by considering several scenarios, i.e., i) irradiance changes, ii) changes of setpoint and iii) load disturbances are illustrated to validate the effectiveness of the proposal.

GE0109	03:15pm-03:30pm Shunt Capacitors Optimal Placement in Distribution Networks Using Artificial Electric Field Algorithm **Abdelazeem A. Abdelsalam**, Hossam A. Gabbar *University of Ontario Institute of Technology, Canada*

Abstract: This paper presents a novel artificial electric field algorithm (AEFA) to solve the problem of optimal locations and sizes of capacitor banks (C-Bs) in various configurations of radial distribution systems. Two strategies are considered in this study; first, using combined loss sensitivity factor and AEFA and second, using AEFA only. The objective function is to maximize the annual net saving of loss reduction. The proposed algorithm is tested on 69-bus and 118-bus radial distribution systems with different scenarios of single and multi-C-Bs installation. The simulation results using Matlab programming environment show that the proposed method is able to maximize the annual net saving with a small capacity of C-Bs. Moreover, the obtained results via the proposed algorithm are compared with other optimization methods such as genetic algorithm, particle swarm optimization, plant growth simulation algorithm, cuckoo search algorithm, flower pollination algorithm, fuzzy-genetic algorithm, and evolutionary algorithm to highlight the benefits of the presented algorithm.

03:30pm-04:00pm

SESSION 3

Smart Grid Design and Operations I

04:00pm-06:00pm

Venue: Room UA2120

Chair: Dr. Yasser Hegazy
UOIT, Oshawa, Canada

GE002

04:00pm-04:15pm

Challenges of the Existing Security Measures Deployed in the Smart Grid Framework

Pallab Ganguly, Mita Nasipuri, Sourav Dutta

CESC VENTURES Ltd, India

Abstract: Due to the rise of huge population in mankind and the large variety of upcoming utilization of power, the energy requirement has substantially increased. Smart Grid is a very important part of the Smart Cities initiative and is one of the crucial components in distribution and reconciliation of energy. Security of the smart grid infrastructure, which is an integral part of the smart grid framework, intended at transitioning the conventional power grid system into a robust, reliable, adaptable and intelligent energy utility, is an impending problem that needs to be arrested quickly. With the increasingly intensifying integration of smart devices in the smart grid infrastructure with other interconnected applications and the communication backbone is compelling both the energy users and the energy utilities to thoroughly look into the privacy and security issues of the smart grid. In this paper, we present challenges of the existing security mechanisms deployed in the smart grid framework and we tried to bring forward the unresolved problems that would highlight the security aspects of Smart Grid as a challenging area of research and development in the future.

 GE022	04:15pm-04:30pm Power System Protection Evolutions from Traditional to Smart Grid Protection **Bright Tetteh**, Kehinde Awodele *University of Cape Town (UCT), South Africa*

Abstract: The power system that we have today has gone through several transformations over the years. These changes are due to either advancement in science and technology or changes in customer demands. Today we have the vision for a future electrical power system known as the 'Smart Grid'. This power system has several functional and operational capabilities which are envisioned to solve the reliability, generation deficit and cost issues in the power system. Majority of the power systems in the world are still being operated as the traditional power system with one-way communication and one-way power flow. Transitioning to a Smart Grid (SG) influences the protection schemes and principles of the power system as the smart grid is to incorporate Distributed Generation (DG) units and other Distributed Energy Resources (DERs) hence there is going to be a bi-directional flow of power and information. Therefore, there is also a need for development and advancement in the protection schemes. Over the years there have been a lot of transformational stages in the protection schemes for power system operation. Understanding the protection needs is important for power system operators to know the reason why certain protection schemes cannot work on new and modern power systems as they seek to transform their utilities to the future electrical grid known as the smart grid. This paper presents the transitional stages that power system protection has gone through and the requirements needed for smart grid protection.

GE041	04:30pm-04:45pm Joint State Estimation and Cyber-Attack Detection Based on Feature Grouping Sandra Geris, **Hadis Karimipour** *University of Guelph, Canada*

Abstract: Inspite of the significant development in network security, the existing solutions are unable to completely defend Smart grid against the malicious threats. Smart grid technology increases the reliability, security and efficiency of the electrical grid. However, its strong dependencies on digital communication technology brings up new vulnerabilities that need to be considered for efficient and reliable power distribution. This paper proposes an anomaly detection techniques based on feature grouping combined with linear correlation coefficient (FGLCC) algorithm. Decision tree is used as the classifier in the proposed method. For performance verification, the proposed method was applied on IEEE 39-bus system. The results verified a high accuracy (96%) and detection rate (97%) with a low false positive rate (1.65%) compared to the existing methods in the literature.

GE043-A

04:45pm-05:00pm

Smart Metering Infrastructure for Energy Security and Management through Advance Communication Networks in Azad Jammu and Kashmir

Khursheed Sabeel, Shahbaz Baig, Anzar Mahmood

Mirpur University of Science and Technology (MUST), Pakistan

Abstract: With the rapid advance in information and communication technology (ICT), the standard of life has raised to a high level. Worldwide concern about the smart use of electricity is becoming high and automation in every field is becoming necessary. Therefore the need of hour is to increase our generation capacity and improve the transmission, distribution and utilization system in order to maintain the continuous supply of power. Our power system in Azad Kashmir is facing different challenges gradually due to many threats about the scarce and limited resources and power theft which results in the blackout. This not only creates problem for human beings but also making the economy weak. In Pakistan, the service provider still uses traditional methods for billing of the energy consumed by individual customer. There should be some intelligent system such as Smart Grid system for meter reading and load management on consumers' side. This research proposes a smart and intelligent model for prepaid billing and load management in Smart Grid Engineering System. The proposed model automatically reads the energy usage from conventional meter, compares it with the available balance, disconnects the supply on zero balance, allows consumer to recharge their electricity bills to reconnect the supply and load control by using the existing short messaging services (SMS), through GSM (Global system for mobile communication) technology.

GE047

05:00pm-05:15pm

Sizing Electric Storage Devices for Power Smoothing Applications in DC Microgrids

Darian Andreas Schaab, Raoul Laribi, Alexander Sauer

University Stuttgart, Germany

Abstract: Converter technologies powering drive systems established direct current technology in industrial applications. Recent developments expand the regular Direct Current (DC) link from a multi-axis-drive-systems to an interlinked multiple machine supply system. The extended DC-link allows for the exchange of recuperated energy between different processes and increases the overall system efficiency. The comparison of the extended DC link and the DC microgrids shows that the integration of multiple supply systems, like distributed generation and storage systems, allows for further optimization with respect to reliability, efficiency and robustness. One possible

optimization strategy is to reduce dynamic load peaks with a storage system and downsize the grid infeed converter. Several applications for power smoothing can be found in literature, however there is no approach for sizing storage capacity and power for these applications. This paper introduces a systematic approach, which aims for storage sizing based on a load profile of industrial machines.

GE049	05:15pm-05:30pm Semantic CIM2Matpower: Ontology-Based Network Topology Processor and Converter for CIM Node-Breaker Models **Artem Schumilin**, Hüseyin Kemal Çakmak, Karl-Uwe Stucky, Clemens Duepmeier, Veit Hagenmeyer *Karlsruhe Institute of Technology, Germany*

Abstract: Smart electricity grids are key to a successful transition towards a future sustainable energy system. Network topology processing (NTP) is an important and frequently reoccurring task in most power grid analysis and simulation applications, including power flow calculations, short circuit and contingency analysis. NTP is applied to a detailed node-breaker representation of the power grid, as provided by the IEC Common Information Model (CIM). It is performed in order to obtain a reduced bus-branch representation, which serves as input to downstream analysis and simulation applications. The present paper introduces a novel approach to NTP that utilizes a semantic knowledge base for network model management and exploits semantic reasoning over the formal CIM ontology and instance data. The proposed system is tested on publicly available ENTSO-E data, validated by converting the generated bus-branch model to Matpower and running power flow calculations in a power grid modelling and simulation framework.

 GE078	05:30pm-05:45pm Hosting Capacity Improvement Using Reactive Power Control Strategy of Rooftop PV Inverters Wijaya Yudha Atmaja, **Sarjiya**, Lesnanto M. P., Eko Yudo Pramono *Universitas Gadjah Mada, Indonesia*

Abstract: Since on-grid rooftop photovoltaic (PV) installation is rapidly growing, and the interconnection requests of a new rooftop PV installation are still increasing, the improvement of PV hosting capacity of large-scale rooftop PV penetration needs to be studied. In this paper, the strategy to improve PV hosting capacity using reactive power control of PV inverters is provided. Since the load demand and PV output vary with the time, the results are provided in time-series. Monte Carlo based method is constructed to model the random nature of PV penetration concerning PV size and location. Furthermore, an evaluation study is provided to obtain the appropriate PV power factor setting of which

the PV hosting capacities are the highest. Firstly, several possible settings of PV power factor are constructed to conduct an evaluation study of reactive power control scenarios. Secondly, the best setting is chosen concerning the ability for generating the highest PV hosting capacity. In addition, a case study is provided to assess the best setting presented by the evaluation study. The results show that rooftop PV penetration with lagging power factor setting of PV inverters generates higher PV hosting capacity compared to rooftop PV penetration with unity power factor setting, with an improvement rate of 96%.

GE052	05:45pm-06:00pm Employing Composite Demand Response Model in Microgrid Energy Management Shahrzad Hadayeghparast, Alireza SoltaniNejad Farsangi, Heidarali Shayanfar, **Hadis Karimipour** *University of Guelph, Canada*

Abstract: Microgrids bring in various benefits to power systems such as improvement in reliability, security, efficiency and cost reduction. They are also capable of integrating Demand Response (DR). Therefore, precise modeling of DR is an important issue. In this paper, a composite DR model, based on price elasticity of demand and customer benefit function, is employed in the microgrid energy management. This model helps with more realistic and accurate modeling of DR by considering different groups of customers having different load profiles and energy use habituates. Regarding the energy management, two-stage stochastic programming is used for modeling the optimization problem. Various distributed energy resources along with uncertainties are also taken into account. Simulation results demonstrate that the proposed method helps with more accurate modeling of DR. It is also shown that the implementation of Time of Use (TOU) program resulted in about 10% decrease in peak demand, around 3% reduction in energy consumption and about 5% decrease in the total operational cost of the microgrid.

SESSION 4

Power Electronics Technology and Applications I

04:00pm-06:00pm

Venue: Room UA2130

Chair: Dr. Carl Ngai Man Ho
University of Manitoba, Canada

GE030	04:00pm-04:15pm State Feedback Sliding Mode Control Law Design for Grid-Connected Wind Turbine Model **Mudhafar L. Shanoob**, Kamran Iqbal *University of Arkansas at Little Rock, United States*

Abstract: A grid-connected wind turbine system is considered for power system studies. The wind turbine with doubly fed induction generator (DFIG) is modeled in MATLAB/Simulink. The fifth-order system is divided into two third-order systems representing in direct and quadrature components. Sliding mode controllers are designed for the nominal system to output rotor voltages. The Super-twisting scheme is adopted to eliminate the chattering in the switching relay. A three-phase fault on the grid side with 150 msec. duration time is applied to test the reliability of the closed-loop system. Computer simulation results show that the control system effectively clears the fault and maintains the stability of the system.

GE074	04:15pm-04:30pm Bifurcation Analysis of Weak Electrical Grids Considering Different Load Representations Jonathan Devadason, Paul Moses, **Wanghao Fei** *University of Oklahoma, USA*

Abstract: The mathematical modeling, bifurcation analysis and simulation of a weak electrical network supplying an isolated load represented by a constant power and constant impedance model is presented in this paper. The features that characterize a weak grid namely the R/X ratio and the inertia are considered as bifurcation parameters. It has been observed that a Hopf bifurcation occurs when the R/X ratio exceeds a particular value in the system with constant power load. Also, a Hopf bifurcation occurred when the inertia of the system goes below a particular value in the system consisting of constant power and constant impedance loads. Time domain simulation results reveal the existence of a limit cycle at the bifurcation point confirming the occurrence of Hopf bifurcation.

 GE083	04:30pm-04:45pm A Copula-Based Uncertainty Modeling of Wind Power Generation for Probabilistic Power Flow Study **Wolf Peter Jean Philippe**, Sara Eftekharnejad, Prasanta K. Ghosh *Syracuse University, USA*

Abstract: In this paper, a probabilistic power flow (PPF) modeling of the uncertainty of wind power generation is proposed. The developed PPF is based on the theories of point estimate method (PEM) and regular vine (R-vine) copula. For a large number of wind power resources, the computational burden related to construction of an R-vine copula increases significantly. Therefore, an algorithm based on Kullback-Leibler (KL) distance is introduced to tackle the computational burden to form an R-vine. The proposed PPF is tested on two different testbeds: IEEE 57-bus and Illinois 200-bus systems. The obtained results show that the proposed method is effective and accurate when compared to PPF results obtained by either a Monte Carlo simulation (MCS) or a multivariate Gaussian copula.

GE095

04:45pm-05:00pm

An Internet-of-Things Design Approach to Real-Time Monitoring and Protection of a Residential Power System

Moses O. Onibonoje, Nnamdi I. Nwulu, **Pitshou N. Bokoro**

University of Johannesburg, South Africa

Abstract: The need for fault detection and isolation of power supply from appliances is a vital component of safety in homes and residential facilities. There is a growing trend and motivation to optimize energy domestically and minimize the down time of power availability due to faults in homes and offices. This paper presents a study on the development of an Internet-of-Things (IoT) based residential power monitoring and protection system (RPMPS). The continuous power monitoring system was designed and hardware-implemented as a GPRS-enabled device, with Short Message Service (SMS) capabilities, and access to the internet for effective remote monitoring and real-time protection in the different sections of the dwelling. The system is capable of providing protection over electrical hazards, voltage surges, over loading, high temperatures and other faults on the residential distribution lines. Also, the system can detect electrical smoke, shuts down the system, and relay the message of the event remotely. The system combines the role of an energy meter and the traditional distribution fused board, with the inter-operability, scalability and advanced remote real time monitoring and control functionalities. The high-tech system serves as an easy-to-install upgrade to the basic electrical distribution board for fault detection of electrical wiring faults and protection. The meter in the device has the capacity to adequately measure and indicate the parameters of power supply to appliances, leading to more efficient utilization of electricity.

GE069

05:00pm-05:15pm

Comparative Study of Grid-Connected Multilevel Inverters for High Power Phtovoltaic Systems

Xueyang Jiang, Mamadou Lamine Doumbia

Université du Québec à Trois-Rivières, Canada

Abstract: Photovoltaic (PV) energy conversion becomes main focus of many researches due to its promising potential as energy source for clean electricity production. One of the important aspects that should be considered in PV application is the use of grid connected multilevel inverter. The Neutral Point Clamped Multilevel Inverter (NPC-MLI), the Flying Capacitor Multilevel Inverter (FC-MLI), and the Cascaded H-Bridge Multilevel Inverter (CHB-MLI) are the three widely used configurations of multilevel inverters. This paper presents the simulation and comparative analysis of the three topologies of three phase 3-level inverter. The multi-carrier sinusoidal pulse width modulation (SPWM) technology is used to realize the closed-loop control model of the photovoltaic grid-connected system. The output waveforms of multilevel inverters are presented and their comparison is based on the total harmonic distortion (THD) present in the output voltage. All topologies are simulated using MATLAB/Simulink in the same operating conditions.

GE072	05:15pm-05:30pm Modeling Power Distribution Grids through Current Tracing Method **Wanghao Fei**, Paul Moses *The University of Oklahoma, USA*

Abstract: Nowadays, the growing amount of intermittent re-newable energy sources in distribution grids is raising some new challenges. One major problem is the bidirectional power flows that complicate grid modeling methods including practical problems of state estimation, protection, transmission line allocation and others. To solve this problem, we propose a current tracing method to model the distribution grid. Unlike traditional methods which the currents are congested on a single transmission line, we developed an equivalent circuit that has several parallel connected virtual lines which can clearly trace the current flowing from different current sources to different loads. The developed method can trace the current regardless of the bidirectional power flow on the transmission line and it is completely equivalent to the traditional method in regard to the physical principles. The equivalence is validated with a single transmission line example.

 GE067	05:30pm-05:45pm LQR Based STATCOM Voltage Controller Using Genetic Algorithm and Invasive Weed Optimization Siddig M. Elkhider, **Aalim M. Mustafa**, Abdul-Wahid A. Saif *Prince Mohammad bin Fahd University, KSA*

Abstract: Static synchronous Compensator (STATCOM) defined as shunt-converter connection, with which the transmission line AC voltage can be fast controlled by its influence in reactive flow. The purpose of STATCOM is to control the voltage very fast and improve damping of inter-area oscillations. In this paper, an LQR (Linear Quadratic Regulator) controller was designed for STATCOM-power system damping. Matrix coefficients for Q and R were selected in two different ways: The first technique was based on Genetic Algorithm (GA), while the second technique was based on Invasive

Weed Optimization (IWO). Genetic Algorithm and Invasive Weed Optimization based LQR controllers results were compared with each other, and with a classic LQR controller results.

GE076	05:45pm-06:00pm Simulated Testing Algorithm for μPMU Full Observation of Balanced Radial Distribution Grid **Wael Ahmed**, Ibrahem M. Hassan, M. Nayel, Hossam Gaber *Assiut University, Egypt*

Abstract: Today's electric power distribution systems with development of distributed energy resources introduce variability, uncertainty, and opportunities to recruit diverse resources for grid services. Multiple resources on each feeder have more complex impacts on the circuit behavior that can be observed with voltage and current phase angle variations. Micro Phasor Measurement Units (μPMUs) take time-synchronized measurements of voltage, current and frequency that can tell grid operators what is happening, where, and when. This paper presents a new μPMUs power flow algorithm for complete observation of balanced radial distribution grid. This algorithm calculates all voltages in both high and low voltage buses, currents in all branches, line active and reactive power flow in all branches and total active and reactive power losses in the grid. This algorithm provides high quality data for distribution planners and operators, which will translate into better model accuracy and thus better results from distribution analysis tools. To test the validity of proposed algorithm, backward / forward sweep power flow program is developed and tested by ETAP software.

August 14, 2019

SESSION 5

Power Electronics Technology and Applications II

10:30am-12:30am

Venue: Room UA2120

Chair: Dr. Prasanta Ghosh
Syracuse University, USA

GE101

10:30am-10:45am

A Hybrid Wind-Photovoltaic Generation System—Modeling and Performance Evaluation

Amr Ahmed A. Radwan, Yasser A.-R. I. Mohamed, Xichen Jiang

Western Washington University, USA

Abstract: This paper presents a novel power electronic converter topology for interconnecting a full-scale wind turbine and solar photovoltaic (PV) arrays to the utility-grid. Back-to-back voltage source converters are used as an energy processing interface, and since no dc-dc converters are used, the system efficiency is maximized. The machine-side converter is used to achieve the maximum power point tracking of the wind turbine, whereas the grid-side converter is used to maximize the PV power, and to inject the captured wind and PV-generated power into the utility-grid. The regulation of the power converters is achieved using a vector control strategy. The system performance is evaluated using a Matlab/Simulink platform, where time-domain simulations illustrate the effectiveness of the proposed system.

GE017-A

10:45am-11:00am

The Smart and Robust Operation of Flexible Power Distribution System

Pradeep kumar

Electrical Research and Development Association, India

Abstract: This paper summarizes the concept of smart and robust operation of flexible power distribution system. The main objectives are to maintain smart control network which offer optimum control function switching during distribution of power between

mode transition from grid connected and islanded modes which maximize the disturbance rejection performance. In particular internal model control based voltage controller and a power flow controller is proposed to reject the disturbance and improve the performance within the power distribution system. These operational control actions are dynamic in nature as they depend on the load/generation profile, demand-side management control and overall network optimization controllers. To achieve this vision, the distributed generation interface should offer high flexibility and robustness operating in both grid-connected and islanded modes. Smooth transfer between these modes robustness against islanding detection delays. The impact of electronic control and effectiveness of the proposed control scheme is evaluated via simulation results for different operating modes.

GE026

11:00am-11:15am

Single-Phase Shunt Active Power Filter Using Parabolic PWM for Current Control

Abul Hasan Fahad, Md. Shamim Reza

United International University, Bangladesh

Abstract: Shunt active power filter (SAPF) is the best solution to minimize the problem of harmonics in the power systems, but its effectiveness is strictly dependent on how quickly and accurately its control algorithms can perform. In this paper, parabolic carrier-based pulse-width modulation (PWM) method is applied for current control in a voltage-source converter (VSC) based single phase Shunt Active Power Filter. This technique employs a pair of parabolic PWM carriers (a positive one and a negative one) to determine the switching states of the two switches in a converter phase leg while limiting the current tracking error within nonlinear parabolic band. In addition, PI controller with self-charging technique to regulate the dc-bus voltage of the SAPF. The proposed single phase SAPF can compensate harmonic currents and improve power factor. In this paper, the design concept of the proposed SAPF is verified through Matlab-Simulink simulation study and the results obtained are discussed.

GE028

11:15am-11:30am

Fractional Order PID Control of Hybrid Power System with Renewable Generation Using Genetic Algorithm

M. Regad, M. Helaimi, R. Taleb, Hossam A. Gabbar, Ahmed M.Othman

Hassiba Benbouali University, Algeria

Abstract: This paper presents the frequency control of the microgrid system using Fractional Order PID controller (FOPID). This microgrid is composed of wind and SPG

generators, Diesel Engine Generator (DEG), Aqua Electrolyse (AE), Fuel Cell (FC) and Energy Storage Systems (Battery Energy Storage Systems (BESS) and Flywheel Energy Storage Systems (FESS)). Genetic Algorithm is used to optimize the parameters of the Fractional Order PID controller. The main of this study is to reduce the frequency and power deviation. The results give that the Fractional Order PID controller based on GA gives better performance in comparing with PID controller using GA.

GE044	11:30am-11:45am Contribution of Coordinated Charging of Plug-in Electric Vehicles to Urban Medium Voltage Distribution Grid Behzad Hashemi, Payam Teimourzadeh Baboli, **Shamsodin Taheri**, René Wamkeue *Université du Québec en Outaouais, Canada*

Abstract: To facilitate the integration of Plug-in Electric Vehicles (PEVs) into distribution networks, this paper proposes a coordinated charging approach. This approach consists of several stages. At first, a stochastic model of PEV charging demand is developed. Then, the constraints introduced into the power system are integrated into the mathematical model. Finally, optimal coordinated charging decisions are made through an improved optimization technique. The approach aims to minimize the total losses of the grid without violating system constraints and PEV owners' satisfaction. This strategy enables active and reactive power support to achieve peak load shaving and voltage regulation. The capability of the proposed coordinated charging approach of PEVs in mitigating the negative impacts of the recharging load is investigated on a typical power system by solving a mixed-integer linear programming problem. The study is carried out for different penetration levels of PEVs by modeling the stochastic temporal and spatial natures of the driving patterns. The proposed model considers charging at both residential and public charging stations. The findings of the study on a real distribution system using real local driving patterns and vehicle fleet data prove that not only the technical challenges of the high-penetrated PEVs to the grid is managed, but also the grid operation indices are improved significantly.

GE060	11:45am-12:00am An Analysis of Faults Diagnosis Method for Powre Conversion System ByongJo Hyon, Dongmyoung Joo, **Yong-Su Noh**, Joon-Sung Park *Korea Electronics Technology Institute, Korea*

Abstract: In this paper, fault diagnosis method of power conversion system was presented. The factors that can be measured in the motor drive system are motor output current, voltage and DC link voltage and current. This paper presents a method for diagnosing faults by analyzing various faults through comparison of faults with threshold values by normalizing the sampled voltage and current values for a certain period of time.

GE066

12:00am-12:15am

Transactive Energy to Guard against a Zero-Day Load Altering Attack on Power Distribution Systems

Samuel Yankson, **Mahdi Ghamkhari**

University of Louisiana at Lafayette, USA

Abstract: Zero-day cyber attacks against a system are novel attacks that exploit vulnerabilities in the system not known to the developers of the system. Accordingly, zero-day attacks can cause severe damages to the target system since they are not defended against. In this paper a zero-day load altering attack against power distribution systems is introduced. The zero-day attack exploits the mutual dependency of the price of electricity and the power consumption of the flexible loads in demand response programs. Through numerical simulations, it is shown that the zero-day attack amplifies the negative impact of the compromised electric loads on the power distribution systems by a factor of 86, making a much more devastating impact on the distribution systems. The extreme danger of the zero-day attack is demonstrated by bolding the shortcomings of the conventional attack prevention technique in forestalling the zero-day attack. To avert such dangers, a novel approach is proposed to guard against the zero-day attack in a transactive energy framework. Numerical Simulations on IEEE 33-bus standard system validate the effectiveness of the transactive energy framework in safeguarding power distribution systems.

GE077-A

12:15am-12:30am

A Distributed Algorithm to Manage Flexible Loads in Buildings with Demand Response Participation

Emrah Biyik

Yasar University, Turkey

Abstract: Recent advancements in communication and control capabilities of the power grid enabled demand side provide high-quality ancillary services at various time scales. In this paper, we present an iterative distributed algorithm to compute optimal demand response behavior for buildings participating in the ancillary services market. In our distributed framework, each building iterates its local optimization problem as a response to the actuation signal from the aggregator in a decentralized fashion, while ensuring the quality of service is within acceptable limits. The proposed approach is validated on simulation tests with a fleet of 1000 buildings. Results show that the fleet can reduce the overall load on the grid effectively, without significant degradation in the building thermal comfort.

SESSION 6

Smart Grid Design and Operations II

10:30am-12:30am

Venue: Room UA2130

Chair: Dr. Onur Elma
UOIT, Oshawa, Canada

GE073

10:30am-10:45am

Achieving Guaranteed Performance for Protection Traffic in Smart Grid Wide-Area Networks

Charles M. Adrah, Aditya K. Kamath, Steinar Bjørnstad, Mohit P. Tahiliani

Norwegian University of Science and Technology, Norway

Abstract: Recent years, tele-protection applications in utility grids have been deployed using Ethernet. However, Ethernet without Time Sensitive Network (TSN) mechanisms is nondeterministic. Hence, challenges of the queuing delays occurring on multi-hop paths result in Packet Delay Variations (PDV) and may even result in packet losses due to buffer overflows. There have been recommendations to use Priority Scheduling (PS) to lower the latency of tele-protection messages. However, for PS, maximum PDV occurs on higher priority packets when contending with lower priority packets, needing to wait until a lower priority packet with maximum length have exited a switch. In this paper, we explore through a performance simulation study the suitability of applying FUSION in smart grid teleprotection applications. FUSION is a packet switched principle applying Ethernet, offering circuit-switched quality of service with deterministic latency, zero packet loss and ultra-low PDV for high priority packets. We demonstrate FUSION performance in tele-protection for power system networks, and compare it with Strict Priority Queuing (SPQ), which is recommended for real-time industrial applications. Our results show that by applying FUSION, we are able to guarantee a fixed delay, zero PDV and packet loss through the network. Furthermore, we show that through proper network dimensioning, lower priority traffic can additionally be added with delays within acceptable limits.

GE090

10:45am-11:00am

Systematic Study of Data Requirements and AMI Capabilities for Smart Meter Analytics

Kavya Ashok, Matthew J. Reno, Logan Blakely, Deepak Divan

Georgia Institute of Technology, USA

Abstract: Timeseries power and voltage data recorded by electricity smart meters in the US have been shown to provide immense value to utilities when coupled with advanced analytics. However, Advanced Metering Infrastructure (AMI) has diverse characteristics depending on the utility implementing the meters. Currently, there are no specific guidelines for the parameters of data collection, such as measurement interval, that are considered optimal, and this continues to be an active area of research. This paper aims to review different grid edge, delay tolerant algorithms using AMI data and to identify the minimum granularity and type of data required to apply these algorithms to improve distribution system models. The primary focus of this report is on distribution system secondary circuit topology and parameter estimation (DSPE).

GE092

11:00am-11:15am

Communication Architecture for Automatic Faults Detection and Clearance in Secondary Distribution Power Grid—The Case of TANESCO

Godfrey Chugulu, Fatuma Simba

University of Dar Es Salaam, Tanzania

Abstract: A significant work has been done by electric power utility companies, in Tanzania and worldwide, to implement automated protection and control in their electric power grids. The automation is mainly implemented in generation, transmission and primary distribution parts of the grid, in order to guarantee quality of service to customers. However, for secondary distribution part of the grid in Tanzania, there is no much automation that has been put in place, as a result, defects and faults in the secondary distribution power grid are reported mainly by customers or through visual inspection (physical visits) by utility company personnel. This makes the entire process from faults occurrence, reporting and faults clearance be time consuming and costly. Automation in fault detection and clearance can be addressed by implementing a smart grid. The smart grid is facilitated by the presence of a well dimensioned communication architecture that can allow inputs from sensors to be conveyed to control elements in the control center, which will generate control messages for transmission to various points in the smart grid for appropriate actions. In the current setup, Tanzania's electric grid does not have a communication architecture to support two-way communication between secondary distribution network and control center for automation. In this paper, secondary distribution network architectures and communication technologies are surveyed. Thereafter, through Challenge Driven Education (CDE), a hybrid communication architecture with appropriate technologies convenient for Tanzania Electric Power Utility (TANESCO) to facilitate automatic faults detection and clearance is proposed. A prototype of the architecture was piloted and results obtained show that the communication architecture made up of distributed processing and hybrid communication technologies was capable to facilitate automatic faults detection and clearance in the scattered secondary distribution network.

GE094

11:15am-11:30am

Research on V2G Participating in Power System Frequency Control

Leugoue Emilienne, Jianhua Zhang, Dibonji Ndjansse Stephane Rodrigue

North China Electric Power University, China

Abstract: The interaction between electric vehicles and the grid is an important part of building a smart grid. Electric vehicles as energy storage components help the grid to accept clean energy. This paper first analyzes the causes and principles of grid frequency fluctuations. On this basis, it analyzes the feasibility and economy of electric vehicles participating in grid auxiliary frequency modulation. It provides reference and reference for the large-scale access of electric vehicles in the future and its effective assistance to the safe and stable operation of the power grid.

GE100

11:30am-11:45am

Robustness and Reliability in Smart Grid Solutions

Reinaldo Burian, **Marcelo Gontijo**, Hugo Alvarez

ORBCOMM, Canada

Abstract: The Electric Power distribution systems should be integrated with the corporate solutions of power generators and distributors, so as to guarantee greater reliability, availability and speed in response to emergency moments, fault occurrence, the need to send maintenance teams and maneuvers in the system, aiming at reducing the SAIDI and SAIFI indices and ensuring an increase in quality of the electric power supply to the end users, at a well-balanced cost and adapted to the economic reality of Brazil and Latin America.

Satellite telemetry connectivity technology presents itself as a convenient and optimized solution for the monitoring and control of reclosers and other protection equipment installed in the electrical network, as well as measurement systems for large consumers such as industries, hospitals and stadiums integrated to a Smart Grid solution.

Many concessionaires and electric power cooperatives have had problems to achieve highly available and reliable communication channels between the devices installed in the field to the SCADA (Supervisory Control and Data Acquisition) installed in the DOC (Distribution Operation Center) of the Utilities, in regions with unstable telecommunication coverage or critical points that require redundancy or with no telecommunication coverage, which becomes a techno-financial market differential for large concessionaires and electric power cooperatives.

The satellite telemetry connectivity solution acts as a contingency for cellular networks and other relevant technologies, or as a main communication vector in electric distribution companies, since traditional solutions have presented failures at critical moments in the network, mainly due to inclement weather and periods of peak consumption or in case of overload of the electrical system.

This solution integrates the DOCs with a monitoring middleware in the cloud with protective and metering devices allocated in the field using the technology of satellite telemetry terminals as the main channel of communication or as a contingency solution.

During the last 5 years the solution has been installed in more than 1500 points around Latin America, including Brazil in their main electric companies with excellent results of improvement of SAIDI and SAIFI, allowing these companies to manage the devices deployed in the field and making strategic decisions in real time.

 GE0105-A	11:45am-12:00am Smart Water Microgrids to Enhance Cyber Security and Resiliency in Water Supply Systems **Mo'tamad H. Bata**, Rupp Carriveau, David S.-K. Ting *University of Windsor, Canada*

Abstract: Existing water and energy grids are aging. Conventional grids operate in a one-way supply process where minimal feedback is provided from the grid and the demand side. This makes theses grids more prone to disruptions, waste water and energy, and difficult to manage. Smart grids were introduced in the early 2000s as a potential solution to address these challenges. A smart grid is a two-way framework where suppliers and consumers can beneficially interact. This framework of communications, controls, computers, automation, and new technologies and tools are integrated to make the grid more efficient, more reliable, and greener. That being said, this evolutionary automated grid has brought new challenges, one of which is the grid physical and cyber security. Water and energy grids are complex, interconnected networks of generation, transmission, distribution, control, and communication technologies, that can be damaged by extreme natural events, and by malicious physical and cyber-attacks. This study investigates parallel components of water and energy microgrids to enhance cyber security and resiliency in water supply systems.

GE058	12:00am-12:15am Aggregation of BTM Battery Storages to Provide Ancillary Services in Wholesale Electricity Markets Ali Vafamehr, Ramin Moslemi, Ratnesh Sharma Presenter: **Chenrui Jin** *NEC Laboratories America, Inc., USA*

Abstract: The behind the meter battery energy storage systems (BTM-BESSs) have been deployed widely by industrial/commercial buildings to manage electricity transaction with utilities in order to reduce customers' electricity bills. Commercial BTM battery storages are mainly employed to cut the customers' monthly demand peaks, which is rewarded by significant decrease in the monthly demand charge. However, given complexity of demand charge management problems, the rates of return on investments for installation of BTM-BESSs are not appealing enough. In this paper, an aggregation model for BTMBESSs is proposed in order to provide the opportunity for the BTM-EMS units to participate in the multiple wholesale markets to provide ancillary services, in addition to the demand charge management, to maximize owners' payoff from installation of BTM-BESSs. Finally, the efficiency of the proposed aggregation model is validated through the simulation studies on the real value data.

GE085-A

12:15am-12:30am

Photovoltaic (PV) Power Generation Forecasting for Microgrid Energy Management

Aysegul Kahraman, Onder BULUT, Cuneyt GUZELIS, Gokhan DEMIRKIRAN

Yasar University, Turkey

Abstract: Energy management and control of microgrid is a very popular research field in these days. The inputs of microgrid such as renewable energy generation, energy consumption, and electric prices, etc. are stochastic parameters. To increase the capability of control, we need to eliminate uncertainties as much as possible. To reduce uncertainties, 24 h-ahead output power is forecasted by Artificial Neural Network (ANN) for Building Integrated Photovoltaic (BIPV) System at Yasar University, Turkey. The same training process is applied to forecast both sunny and cloudy day by using 2 different input selection approaches. In addition, their forecasting performance is evaluated by Mean Square Error (MSE), Mean Absolute Percentage Error (MAPE), and symmetric Mean Absolute Percentage Error (sMAPE). The results indicated that the historical data of temperature and power output based MLP forecaster causes worse forecast performance in the cloudy days. The proposed weather prediction based MLP approach has MAPE 0.8361% while the previous approach has MAPE 5.008% for a partly cloudy day.

Lunch

12:30am-1:30pm

SESSION 7

Safety and Security of Smart Energy & Grids

01:30pm-03:30pm

Venue: Room UA2120

Chair: Dr. Farnaz Derakhshan
University of Tabriz, Tabriz, Iran

 GE081	01:30pm-01:45pm The Masterplan for Developing Electricity Systems for Archipelagic Area by Considering Local Energy Resources: A Case Study of Maluku Islands **Tumiran**, Sarjiya, Lesnanto M. Putranto, Wahri Sunanday, Roni Irnawan, Adi Priyanto, Ira Savitri *Gadjah Mada University, Indonesia*

Abstract: Maluku Province have an electrification ratio of 79.62%, which is among the lowest in Indonesia. This number needs to be increased, such that the economic growth is encouraged and the energy demand can be met. However, there are several challenges hinder the expansion plan of the generation capacity in Maluku, e.g. uneven distribution of the population over a thousand islands. Currently, the main energy sources for Maluku is fossil fuel (diesel power plant). In this paper, the potential of alternative energy resources in Maluku is provided. Based on the statistics, the masterplan for developing electricity systems in Maluku is developed. This plan is initiated by holding a focus group discussion (FGD) with several stakeholders to gain knowledge on the potential energy resources location and size, also to determine the electricity demand growth in Maluku. In the end, the optimization of generation expansion planning can be performed by considering some constraints to retrieve the most suitable power plant resources for Maluku.

GE099	01:45pm-02:00pm Feasibility Analysis of Grid-Connected Nuclear-Renewable Micro Hybrid Energy System **Hossam A. Gabbar**, Muhammad R. Abdussami *University of Ontario Institute of Technology (UOIT), Canada*

Abstract: In recent time, researchers are aiming to integrate renewable energy with nuclear energy to utilize the energy infrastructure at its best or to meet the local energy

demand, especially for the remote places. In this paper, the feasibility analysis of the nuclear-renewable energy system is conducted by HOMER (Hybrid Optimization Models for Energy Resources) software. This paper considers three modes of power supply; only renewable energy, only Nuclear Power Plant (NPP), and integration of both nuclear – renewable energy; to meet the electric demand. The simulation results show that the grid-connected Nuclear-Renewable Micro Hybrid Energy System (N-R MHES) is the most feasible option to meet the sizeable electrical power demand. The paper also sets the analysis guidance and criteria for the three power supply mode depending on the annual load profile of a facility.

GE035

02:00pm-02:15pm

Peer-to-Peer and Real-Time Energy Exchanges with Data Centers in a Transactive Energy Framework

Md Atiqur Rahama, **Mahdi Ghamkhari**

University of Louisiana at Lafayette, USA

Abstract: Renewable generators can be installed behind-the-meters of the power consumers to offset a portion of the consumers' power loads. Although these generators help in lowering electricity cost of power consumers, they pose serious challenges to the operation of power distribution systems. Namely, the power consumers with behind-the-meter renewable generators compensate for their local generation shortages by adjusting their power draw from the power distribution systems. Consequently, the fluctuations in the local renewable generations are transmitted to the consumers' net loads, i.e. the actual power consumptions of the consumers minus the local renewable generations. The rapid fluctuations of the net loads may cause reliability issues in the operation of the power distribution systems, specially at higher levels of renewable energy penetration. To secure the reliable operation of the distribution systems under penetration of renewable generators, there is a need for a mechanism that can counterbalance the rapid fluctuations of the net loads. The transactive energy paradigm is emerging to fulfill this urgent need. This paper studies energy exchanges with data centers in a transactive energy framework. Through numerical simulations, it is shown that the fluctuations of the net loads are 53% more counterbalanced when the data centers' flexibilities are exploited in the transactive energy framework instead of a demand response framework.

GE091

02:15pm-02:30pm

Resource Management for Uninterrupted Microgrid Operation

P.K. Ghosh, M. Sahinoglu, V. V. Phoha

Syracuse University

Abstract: To meet the ever-increasing demand of electric power, microgrids are establishing themselves to be one of the most reliable power delivery systems. Microgrids

can deliver power efficiently, cost-effectively and environment-friendly way. To design a sustainable microgrid; several tasks including resource allocation, optimization, power flow analyses, load demand, etc., need to be performed for a reliable operation. The system control should be able to process periodically a plethora of data originating from various sensors and measurement units, and then deliver appropriate control signals in response to changes in the system. Cloud computing can be an efficient way to handle this huge data processing task to meet various operational needs. It also eliminates the need for a local macro server and thus reduces overall operational cost of the microgrid.

GE054-A	02:30pm-02:45pm Sorting of Spent Electric Vehicle Batteries for Second Life Application **M. Muhammad**, M. Ahmeid, Z. Milojevih, P.S. Attidekou, S. Lambert *Newcastle University, United Kingdom*

Abstract: Electric vehicles (EV) typically have around 80% of their initial energy and capacity at the end of the battery life. It is widely anticipated that these EV batteries will retain significant capacity remaining and potentially operate for an additional years in their second life. Finding ways to repurpose the technology is becoming more urgent as the global stockpile of EV batteries is expected to reach 3.4 million packs by 2025. Many applications are expected to come online in the next decade, the most promising application been home, industrial and grid-scale energy storage system. This would require development of energy storage technologies for each application. Establishing or verifying battery performance in comparison to these targets is a principal objective. Non-availability of onboard diagnostics data and accurate assessments of the automotive and second use battery degradation stand out in particular. To characterise the energy and power capability of each cell, a hybrid pulse power characterisation (HPPC) test profile has been employed. Five randomly selected cells from disassemble Nissan leaf pack that reach end of Life has been characterise. The capacity of the pack prior to dismantling is 50.49 Ah whilst that of the cells after disassembly is between 50- 54 Ah. The pulse data obtained from the measurement indicate a resistance growth at 1.5 mΩ and the discharge and regen power capability of the cell is 537 W and 480 W respectively. The full paper will include the analysis and decision matrix for repurposing spent EV cells based on HPPC test that can be done in 60 s, which makes it one of the fastest method of sorting EoL batteries.

GE023-A	02:45pm-03:00pm Digital in an Aanalog World **Andrew West** *SUBNET Solutions, INC, Canada*

Abstract: Digitization of the power grid is the current buzz. Modern automation and protection systems are predominantly digital and many benefits have been derived from

this evolution. But the underlying systems are fundamentally analog and the digital model of that system is an approximation that always has at least a few rough edges. There is a tendency to ignore this and assume that the digital representation is perfect and infallible.

This paper considers some of the assumptions and shortcomings of digital representations and the ways that systems handle data. A clear understanding of how these processes are performed allow designers to avoid errors and allow users to better interpret information.

GE0101

03:00pm-03:15pm

A Network of BIMGs Participating in Demand Response Using EVs and HVAC Units

Ehsan Rezaei, Hanane Dagdougui

Polytechnique Montreal, Canada

Abstract: Distributed energy resources, energy storage systems, photo-voltaic(PV) systems, and electric vehicles charging systems are being increasingly installed in many residential units. This paper presents an optimal power management mechanism for a network of grid-connected buildings integrated with microgrids. The current paper attempts to propose a high-level centralized control problem for apartment-buildings, where each building includes on-roof photovoltaic power unit, stationary local batteries, residential apartments and EVs. We developed a model predictive control for apartment-building energy management system, which controls the heating, ventilation, and air conditioning (HVAC) system, and the electric vehicles. The solution aims to dynamically control the power demand in the building by properly controlling each apartment HVAC in the network in order to improve the matching performance between the renewable power generation and consumption in the network of BIMGs and minimize the power exchange with the main grid. The problem is solved for a network of multi-unit apartments building in Montreal area.

GE0106

03:15pm-03:30pm

Statistical Sizing of a 100% Renewable Energy System with Battery Energy Storage System

Samuel Raafat, Nabil M. Hamed, **Yasser G. Hegazy**

German University in Cairo, Egypt

Abstract: This paper presents a statistical framework to size a 100% renewable energy system (RES) integrated with battery energy storage system. The framework introduces innovative statistical power generation models. The framework includes both raw hourly meteorological data of (wind speed, solar irradiance, and ambient temperature) that form typical meteorological year (TMY) and loading requirements. Sizing optimization was

based on genetic algorithm (GA) as a minimum seeking algorithm. The results shows the effect of loading percentages on the different statistical parameters. The parameters can form, in separate or together, decision-making parameters to select the desirable size of the 100% RES and the associated battery energy storage system that needed to be installed.

SESSION 8

Micro Energy Grids

01:30pm-03:30pm

Venue: Room UA2130

Chair: Dr. Hadis Karimipour
University of Guelph, Canada

GE089	01:30pm-01:45pm Experimental Evaluation of Energy Transfers by an Energy Packet Switch in a Digital Microgrid **Zhengqi Jiang**, Lenin Ham, Diego Ramos, Alvin J. Sarmiento, Haim Grebel, Roberto Rojas-Cessa *New Jersey Institute of Technology, the United States*

Abstract: In this paper, we experimentally demonstrate the performance of the recently proposed Energy Packet Switch (EPS) for energy distribution. The $N \times M$ EPS aggregates the energy from N sources and dispatches energy to M outputs, each of which feeds one or many loads. Energy is distributed from a source to a load in the form of energy packets. The operation of the EPS is an enabler device to realize a digital microgrid. We carry out exhaustive experiments to show that the EPS grants energy to keep demand satisfied and even in cases when the demand overwhelms the EPS capacity. Results of the experiments show that the EPS ably grants all energy requests that fall within its capacity, and it controls the distribution of energy under extenuating conditions by approaching a level of fairness. The experiments also show the average time that a request waits for the corresponding grant.

 GE071	01:45pm-02:00pm Transformerless Grid-Connected Converters Using Active Virtual Ground Technique for Single-Phase Microgrids **Ken King Man Siu**, Carl Ngai Man Ho *University of Manitoba, Canada*

Abstract: The paper presents the state-of-the-art technique Active Virtual Ground (AVG) in the design of single-phase grid-connected converters. The whole series of single-phase converters are based on the latest AVG technique. All of the designed topologies are with high efficiency, low leakage current, and single-stage structure. Focusing on the applications in ac microgrids, all of the evaluated topologies are classified into three different groups. They are associated with the three key components in the microgrid networks, which are power consumers, renewable energy sources and energy storage systems. The topology advantages and the design limitations of each converter type are analyzed in detail. The working principle of the AVG technique is demonstrated through the circuit equivalent model and is successfully verified in a set of 600 to 800 W prototypes. All of the experimental results are in good agreement with theoretical knowledge.

GE401

02:00pm-02:15pm

A Robust Operational Dispatch Model for Prosumer Dominated Microgrids Incorporating a Utility-Scale Battery

Uyikumhe Damisa, Nnamdi I. Nwulu

University of Johannesburg, South Africa

Abstract: Due to its advantages over alternating current microgrids, direct current microgrids are becoming an attractive alternative. This growth of interest in direct current microgrids, coupled with the rise in prosumers makes a case for the study of direct current prosumer microgrids. Prosumers intermittently import/export power to/from the grid thereby complicating operational planning of prosumer grids. In this paper, a robust dispatch model, which uses a utility-scale battery to handle uncertainty in prosumer power import/export, while respecting prosumers' privacy, is developed. The model is tested using a six-bus direct current microgrid, by the interior point optimizer in Gekko package, in Python. Other analyses suggest that a microgrid that interconnects prosumers with dissimilar power import/export profiles tends to have lower voltage drops on buses and lesser power loss than one that interconnects prosumers with similar profiles.

GE025

02:15pm-02:30pm

Functions of Microgrid Hierarchal Control Structure

Alshammari Fahad, El-Refaie Ayman

Marquette University, United States

Abstract: Recently, the microgrid has becomes an attractive solution to improve the reliability of the power system and integrate more small-scale renewable energy resources in a well-controlled manner. The hierarchal control structure is proposed to improve the controllability and effectiveness of the microgrid. In this paper, a survey of

the hierarchal control structure is presented in terms of functionalities and requirements of each level. The power quality control is independently studied including inertia control, harmonic, and unbalanced voltage compensation control. Also, the primary control level is reviewed based on two sub-levels namely output control level and power-sharing control level. The power-sharing level is classified based on the utilization of the communication network. Besides, the secondary control level is reviewed based on the functions provided by this level of control. Finally, the tertiary control level is briefly explained in the context of the hierarchal control structure.

GE012

02:30pm-02:45pm

Uncertainty Analysis for Day Ahead Stochastic Power Dispatch of Islanded Microgrid

Sara Ashfaq, Daming Zhang, Zhao Yang Dong

University of New South Wales, Australia

Abstract: Optimization of renewable distributed generation's (DGs) uncertainty can make the profit of electricity market more certain. Struggles are continuously in progress to develop the tools for accurate prediction of power output from renewable DGs. This paper presents an uncertainty analysis method for optimal day-ahead power dispatch of islanded microgrid (MG) based on net demand forecasting method. Firstly a multiobjective optimization algorithm has developed to optimally place and size the DGs. Then wind power uncertainty is handled and analyzed under the stochastic programming. Optimal power dispatch strategy has been performed for islanded microgrid. IEEE 33-bus standard test system has been converted into microgrid with the integration of wind power and conventional DGs.

GE080

02:45pm-03:00pm

Design of Microgrid with Distribution Static Synchronous Compensator (D-STATCOM) for Regulating the Voltage Fluctuation

Linggom Enrico Christian, **Lesnanto Multa Putranto**, Sasongko Pramono Hadi

Universitas Gadjah Mada, Indonesia

Abstract: Future of small and isolated power system depend on microgrids based on solar and wind power plan, which the technology is immature. Poor power factor and voltage fluctuation could affect the system's power quality, which can decrease the reliability. This paper discusses about the power factor correction and voltage fluctuation improvement using distribution static synchronous compensator or D-STATCOM. For demonstrating the proposed idea, D-STATCOM is installed on a radial distribution system and simulated under different operating condition. Variable and flexible reactive power support from this device corrects the power factor and regulates the voltage. The

performance of D-STATCOM installation is proven by simulation in increasing the system power factor and voltage regulation.

GE0111	03:00pm-03:15pm Realization of MPPT of PMSG-Based Wind Turbines Using New MPPT Indices **Ahmed A. Salem**, Ali H. Kasem Alaboudy, Hossam A. Gabbar *Canal University, Egypt*

Abstract: The energy extracted from the wind turbines depend not only on the wind speed, but also on the applied scheme of the maximum power point tracking (MPPT). In this paper new indices to assign the enhancement level of the MPPT schemes are proposed. These indices based on the relative convergence between actual and maximum values of power coefficient (Cp_max) moreover, actual and optimum values of tip speed ratio (λopt). The proposed indices are used to determine the efficient MPPT scheme. These indices are applied on grid connected permanent magnet synchronous generator (PMSG) with a full size back-to-back converter. Comprehensive models of wind speed, wind turbine, PMSG and power electronic converters along with their control schemes are implemented in MATLAB/SIMULINK platform. The results prove the robustness and feasibility of theses MPPT indices to determine the most efficient MPPT scheme.

 GE402	03:15pm-03:30pm Effect of Uncertainty on the Operation of DC Prosumer Microgrids Incorporating Dispatchable Loads **Uyikumhe Damisa**, Nnamdi I. Nwulu *University of Johannesburg, South Africa*

Abstract: It has become worthwhile to study prosumer direct current microgrids, considering the rise of interest in direct current microgrids coupled with the emergence of intermittent prosumers. The uncertainty introduced by prosumers affects planning and operation of prosumer grids, hence its impact is investigated in this paper. Firstly, a robust operational dispatch model which makes use of dispatchable loads to handle prosumer uncertainty is developed. The model considers power flow on lines and respects prosumer privacy. It is solved using the interior point solver in Gekko, an optimization package in Python. Then, analyses of uncertainty effects are performed. Results obtained suggest that both objective function value and power losses increase with an increase in uncertainty of prosumer power import. Hence, more accurate forecasts make for more economic operation of prosumer microgrids.

POSTER PRESENTATION ABSTRACT

Note:
• Poster session will be held simultaneously with the afternoon coffee break
• Authors are supposed to be present for their posters during the poster session.
• Session photo will be taken at the end of each session.
• The certificate for poster presentations will be handed out by session chair at the end of each session.
• To show respect to other authors, especially to encourage the student authors, we strongly suggest you attend the whole session

POSTER SESSION

01:30pm-06:00pm, August 13

Venue: Room UA2130

GE088	Assessment of Uncertainties in Energy Management Procedures Luca Giaccone , Paolo Lazzeroni, **Maurizio Repetto**, Hossam Gaber *Dipartimento Energia "Galileo Ferraris", Politecnico di Torino, Italy*

Abstract: Complex energy systems are made by a number of components interacting together by different energy vectors. The assessment of their performance under dynamic working conditions, where user demand and energy prices are varying in time, requires a simulation tool. Whichever the accuracy of this procedure, the uncertainty in data, both obtained by measurements or by forecasting, is usually non negligible and it requires the study of the sensitivity of results versus input data. In this work polynomial chaos expansion technique is used to evaluate the variation of cogeneration plant performance with respect to the uncertainty of energy prices and user requests. The procedure allows to obtain this information with a computational cost much lower than usual Monte-Carlo approaches.

LISTENERS

Note:
- Session photo will be taken at the end of each session.
- The certificate for listeners can be collected at the registration counter.
- To show respect to other authors, especially to encourage the student authors, we strongly suggest you attend the whole session

Listener 1

Siyan (Veronica) Guo

Opus One Solutions Energy Corporation, Canada

Listener 2

Lauhyuk Park

Chung-Ang University, Seoul, Korea

Lisener 3

Seyed Hossein Salamat

Pasargad Higher Education Institute, Iran

Lisener 4

Mohammed Abdulrahman Yousif Gardi

Subnex Company, Iraq

Listener 5

Simon Lubwama

Green Energy Uganda, Uganda

Listener 6

Mohammadreza Kia Darbandsary

Listener 7

Sungrae Cho

Chung-Ang University, Korea

Listener 8

Tariq Abu Issa

Laboratories Operations and Maintenance, UAE

Listener 9

Desire Nkuie Souop

Simplice Motors, South Africa

Listener 10

Hanson Ngwa

Frem Consult, South Africa

AUTHOR INDEX

Mudhafar L. Shanoob	GE030	S4	34
O-T			
Pallab Ganguly	GE002	S3	29
Pitshou N. Bokoro	GE095	S4	35
P.K. Ghosh	GE091	S7	48
Pradeep kumar	GE017-A	S5	38
Reinaldo Burian	GE100	S6	44
Roshani Kaluthanthrige	GE040	S2	27
Sara Ashfaq	GE012	S8	52
Sarjiya	GE078	S3	32
Shamsodin Taheri	GE055, GE044	S2, S5	28, 40
Tumiran	GE081	S7	47
U-Z			
Uyikumhe Damisa	GE0104, GE401, GE402	S1, S8	23, 51, 53
Wael Ahmed	GE076	S4	37
Wanghao Fei	GE074, GE072	S4	34, 36
Wolf Peter Jean Philippe	GE083	S4	34
Xueyang Jiang	GE069	S4	35
Yasser G. Hegazy	GE0106	S7	50
Yong-Su Noh	GE060	S5	40
Zhengqi Jiang	GE089	S8	50

Memo

Memo

Memo

Memo