# Program

| New York time | Thursday, October 21 | Friday, October 22 | | Saturday, October 23 | Sunday, October 24 | | Friday, October 29 | Saturday, October 30 | Sunday, October 31 |
|---|---|---|---|---|---|---|---|---|---|
| 9:30 - 10:00 | | Welcome: *Welcome Session* | | | | | | | |
| 10:00 - 10:30 | | | | | | | | | |
| 10:30 - 11:20 | | Keynote 1: *Keynote Speaker* | | Keynote 4: *Keynote Speaker* | TSM1: *Technical Session 1 - Morning Day 3* TSM2: *Technical Session 2 - Morning Day 3* TSM3: *Technical Session 3 - Morning Day 3* | | | TSM1: *Technical Session 1 - Morning - Day 4* TSM2: *Technical Session 2 - Morning - Day 4* TSM3: *Technical Session 3 - Morning - Day 4* | Keynote 6: *Keynote Speaker* |
| 11:20 - 11:30 | | | | | | | | | |
| 11:30 - 12:00 | | Keynote 2: *Keynote Speaker* | | Keynote 5: *Keynote Speaker* | | | | | TS1: *Technical Session 1 - Day 5* TS2: *Technical Session 2 - Day 5* |
| 12:00 - 12:20 | | | | | | | | | |
| 12:20 - 12:30 | TW: *Technical Writing Seminar for Young Professionals* | | WIE: *Women In Engineering Panel* | | | | TW1: *Writing Technical Reports for Industry Professionals* | | |
| 12:30 - 13:00 | | Keynote 3: *Keynote Speaker* | | | | | | | |
| 13:00 - 13:30 | | | | TS1: *Technical Session 1 - Day 2* TS2: *Technical Session 2 - Day 2* TS3: *Technical Session 3 - Day 2* | TSA3: *Technical Session 3 - Afternoon - Day 3* TSA3-1: *Technical Session 3.1 - Afternoon - Day 3* | TSA1: *Technical Session 1 - Afternoon - Day 3* TSA2: *Technical Session 2 - Afternoon - Day 3* | | TSA1: *Technical Session 1 - Afternoon - Day 4* TSA2: *Technical Session 2 - Afternoon - Day 4* TSA3: *Technical Session 3 - Afternoon - Day 4* | Closing: *Closing Ceremony* |
| 13:30 - 14:00 | | | | | | | | | |
| 14:00 - 14:20 | | TS1: *Technical Session 1 - Day 1* TS2: *Technical Session 2 - Day 1* | | | | | | | |
| 14:20 - 15:00 | | | | | | | | | |
| 15:00 - 15:15 | | WIE: *Women In Engineering Panel* | | | | | | | |
| 15:15 | | | | | | | | IP1: | |

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| - 15:20 | | | | | | | | |
| 15:20 - 16:00 | | | | | | | | |
| 16:00 - 16:30 | | | | | | | *Industrial Panel* | |
| 16:30 - 17:15 | | | | | | | | |

# Thursday, October 21

## Thursday, October 21 10:00 - 16:30

### TW: Technical Writing Seminar for Young Professionals

Eric Tung

Chairs: Celia L Desmond (World Class Telecommunications, Canada), Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran)

Brochure Introduction

Engineers can't write. That's the popular conception anyway, but tell that to the ghosts of Nevil Shute and Robert Heinlein. Engineers can indeed write, and an engineer's analytical skills can be a great benefit in organizing information, prioritizing what really matters to the reader, and incorporating relevant content to technical documents. This seminar will show you how to apply these skills to create clear, to-the-point written material that people will want to read. It includes numerous interactive group workshops and practice exercises, along with individual constructive feedback on your writing, to bring your writing skills to the next level.

Seminar Description

What are key elements of an effectively written document? What should I focus on in my emails, proposals, reports, and other documents?

Your clients and colleagues often judge you based on whether you can write clearly and concisely. Your audience may skim your documents, so you need to ensure that you articulate your key points and your content is organized. Your writing ability is important.

This seminar is focused on helping you to do exactly that: to write more effectively. You'll learn to tailor your writing for your audience (both technical and non-technical audience groups) and purpose. You'll apply the strategies required for effective emails, technical memos, proposals, reports, and more. In addition, you'll also incorporate key principles for editing and revising your documents.

We'll cover multiple topics, including:

1. Planning your documents
2. Writing cohesive paragraphs
3. Avoiding common mistakes
4. Writing effective emails
5. Responding to proposals
6. Drafting your reports and other formal documents

This interactive seminar will consist of instructor-led lecturing, along with group workshops and

practice exercises. After the session, you'll also have the option to submit a brief writing sample to receive individual feedback.

About the Instructor

Eric Tung, MA, is an English Instructor at the University of British Columbia's Extended Learning, where he teaches various writing courses, including a course on advanced business writing. He previously designed and taught a course specifically for Engineers, along with courses on grammar, writing with style, and strategic conversations and meetings. He is also a Lecturer at Simon Fraser University, where he teaches Business Communications to senior-level Bachelor of Business Administration students at the Beedie School of Business.

As a Principal Consultant at Prolepsis Consulting, Eric designs and delivers customized business, proposal, and technical writing workshops to various organizations, including engineering and consulting firms. He has an extensive background in technical writing and business communications, including writing technical documentation, drafting business development plans, crafting proposals, and writing other complex documents.

Eric is also a Change Management Consultant and specializes in change management strategy and implementation, organizational readiness and assessments, stakeholder engagement, coaching, facilitation, instructional design, and training. He has extensive experience implementing enterprise-wide transformation programs and projects for both private and public sector clients.

## Friday, October 22

# Friday, October 22 9:30 - 10:30

## Welcome: Welcome Session

Ali Nabavi, Jason Gu, Deepa Kundar

Chair: Alireza Siadatan (University of Toronto, Canada)

# Friday, October 22 10:30 - 11:20

## Keynote 1: Keynote Speaker

Energy Storage Overview and Research

Claudio Canizares

Chair: Mehrdad Rostami (Stantec Consultant Co. & IEEE Smart Grid Publication Committee, Canada)

Abstract: As the penetration of variable renewable generation increases in power systems, issues such as grid stiffness, larger frequency deviations, and grid stability are becoming more relevant. In this context, Energy Storage Systems (ESSs) are proving to be effective in facilitating the integration of

renewable resources, and thus are being widely deployed in both microgrids and large power grids. This talk will review several energy storage technologies, particularly Compress Air Energy Storage (CAES), flywheels, batteries, and thermal energy systems, and their modeling and applications in power systems. An overview will be provided of the work being carried out by Prof. Canizares group at the University of Waterloo on all these energy storage systems, focusing on novel models and applications in microgrids and distribution and transmission grids for system stability and control, in particular for frequency regulation.

Biography: Dr. Claudio Canizares is a University Professor and the Hydro One Endowed Chair at the Electrical and Computer Engineering (E&CE) Department of the University of Waterloo, where he has held various academic and administrative positions since 1993. He received the Electrical Engineer degree from the Escuela Politecnica Nacional (EPN) in Quito-Ecuador in 1984, where he held different academic and administrative positions between 1983 and 1993, and his MSc (1988) and PhD (1991) degrees in Electrical Engineering are from the University of Wisconsin-Madison. His research activities focus on the study of stability, control, optimization, modeling, simulation, and computational issues in bulk power systems, microgrids, and energy systems in the context of competitive energy markets and smart grids. In these areas, he has led or been an integral part of many grants and contracts from government agencies and private companies worth millions of dollars, and has collaborated with multiple industry and university researchers in Canada and abroad, supervising/co-supervising dozens of research fellows and graduate students. He has authored/co-authored numerous publications with large citation indices, including journal and conference papers, technical reports, book chapters, disclosures and patents, and has been invited to deliver keynote speeches, seminars, tutorials, and presentations at many institutions and conferences worldwide. He is the Editor-In-Chief of the IEEE Transactions on Smart Grid, the 2021-2023 IEEE Division VII Director-Elect and Director of the IEEE Board, and a Fellow of the Institute of Electrical & Electronic Engineering (IEEE), a Fellow of the Royal Society of Canada, where he was the Director of the Applied Science and Engineering Division of the Academy of Science from 2017 to 2020, and a Fellow of the Canadian Academy of Engineering. He is also the recipient of the 2017 IEEE Power & Energy Society (PES) Outstanding Power Engineering Educator Award, the 2016 IEEE Canada Electric Power Medal, and of multiple IEEE PES Technical Council and Committee awards and recognitions, holding leadership positions in several IEEE-PES Committees, Working Groups, and Task Forces.

# Friday, October 22 11:30 - 12:20

## Keynote 2: Keynote Speaker

Volt-Var Control in Power Distribution System
Bikash Pal

Chair: Ali Nabavi (University of Toronto, Canada)

Abstract: Electrical generation, transmission and distribution systems all over the world have entered a period of significant renewal and technological change. There have been phenomenal changes/

deployments in technology of generation driven by the worldwide emphasis on energy from wind and solar as a sustainable solution to our energy need. Increasingly energy demand from heating and transportation are being met by electricity. These changes have significantly influenced the planning, design, operation and control of the power distribution system. Accommodating uncertainties in renewable generation and demand forecast in a cost-effective manner is now a very complex optimization problem. This talk will share our recent research efforts Volt/VAr control (VVC) strategy in distribution systems to address the uncertainties. Efficient chance constrained conic optimisation technique accelerated through scenario reduction approach will be discussed to demonstrate the significant reduction of voltage violations when compared with the deterministindc cases while not relaxing the conservativeness of the final solutions. It will also touch upon treatment of certain types of load characteristic in the proposed solution framework. Future research challenges and opportunities will be highlighted.

Biography:Bikash Pal is a Professor of Power Systems at Imperial College London (ICL). He is research active in power system stability, control, and estimation. Currently is leading a six university UK-China research consortium on Resilient Operation of Sustainable Energy Systems (ROSES) as part of EPSRC-NSFC Programme on Sustainable Energy Supply. He led UK-China research consortium project on Power network stability with grid scale storage (2014-2017): He also led an eight- university UK-India research consortium project (2013-2017) on smart grid stability and control. His research is conducted in strategic partnership with ABB, GE Grid Solutions, UK, and National Grid, UK. UK Power Networks. GE commissioned sequel of projects with him to analyse and solve wind farm HVDC grid interaction problems (2013-2019). Prof Pal was the chief technical consultant for a panel of experts appointed by the UNFCCC CDM (United Nations Framework Convention on Climate Change Clean Development Mechanism). He has offered trainings in Chile, Qatar, UAE, Malaysia and India in power system protections, stability and control topics. He has developed and validated a prize winning 68-bus power system model, which now forms a part of IEEE Benchmark Systems as a standard for researchers to validate their innovations in stability analysis and control design. He was the Editor-in-Chief of IEEE Transactions on Sustainable Energy (2012-2017) and Editor-in-Chief of IET Generation, Transmission and Distribution (2005-2012). He is Vice President, PES Publications (2019-). In 2016, his research team won the President's outstanding research team award at Imperial College London (ICL). He is Fellow of IEEE for his contribution to power system stability and control. He is an IEEE Distinguished Lecturer in Power distribution system estimation and control. He was). He has published about 100 papers in IEEE Transactions and IET journals and authored four books in power system modelling, dynamics, estimations and control. Two of his papers in power system stability and control topics have received annual best journal paper award. He was Otto Monstead Professor at Denmark Technical University (DTU) (2019) and Mercator Professor sponsored by German Research Foundation (DFG) at University of Duisburg-Essen in 2011. He worked as faculty at IIT Kanpur, India. He holds a Visiting Professorship at Tsinghua University, China.

# Friday, October 22 12:00 - 13:00

## WIE: Women In Engineering Panel

Cyber Security Landscape and Today's Virtual World!

Chair: Fatima Hussain (Ryerson University, Canada)

Panelist: Utpal Mangla, IBM, Toronto

Utpal Mangla ( MBA, PEng, CMC, ITCP, PMP, ITIL, CSM ) is a Vice President and Senior Partner in IBM. He is the Global Leader of IBM's Telecommunications, Media and Entertainment (TME) Industry's Center of Competency. In addition, he leads the 'Innovation Competency' focusing on AI, 5G EDGE, Hybrid Cloud and Blockchain Innovations for TME clients worldwide. In his role as senior executive in the business and thought leader in emerging technologies, Utpal's mission is to fuel growth by building, selling and implementing differentiated competitive market service solution offerings to meeting critical business imperatives of our customers.

Panelist: Alexander Ferworn, Professor, Ryerson University, Toronto

Dr. Ferworn is a Professor of Computer Science. He earned his PhD from the U of Waterloo, his MSc from the U of Guelph and his B. Tech from Ryerson. He serves as the Graduate Program Director (GPD) of The Master of Digital Media program and the GPD of the graduate programs in the Department of Computer Science where he is also an Associate Chair. He is the creator of over 30 Certificate and other programs in the Chang School. Previous roles are varied and include; progressively senior roles in telecommunication companies, service as a police auxiliary and as an infantry Company Commander in the Canadian Forces Reserve. His research focuses on "Computational Public Safety". He seeks out collaborations with individuals and groups in fields as varied as Archaeology, Law Enforcement, Physics, Disaster Management, Fire Protection, English, Early Childhood Education, Performance and Fashion. In 2019 his work in finding lost people living with dementia was featured at the CRAM Festival.

Panelist: Amit Kumar Tiwari, Director, Behavioral Analytics & Insider Threat, Data Protection at RBC, Toronto

Amit Kumar Tiwari is leading behavioral analytics services and methods for insider threat and data protection at RBC. His background in Analytics has enabled services in several key areas within Cyber Security, Fraud, Identity, AML etc. He is focused on value driven analytics as a means of achieving security, protection and privacy. He specialized in Big Data systems with MSc in computing Science from Simon Fraser University.

Moderator: Dr. Fatima Hussain, Manager, Event Management and Analytics, Global Cyber Security at RBC, Toronto

Adjunct Professor, Ryerson University, Toronto, Canada

Dr. Fatima is working as a ManagerEvent Management and Analytics in "Behaviour Analytics and Insider Threat" team, Global Cyber Security, Royal Bank of Canada (RBC), Toronto, Canada. She is responsible for employee risk profiling and detection of insider threats, by establishing baseline behaviours. She applies cutting edge analytical tools and techniques to detect the malicious insiders and mitigate the potential risk to the organisation.

She is also an Adjunct Professor at Ryerson University; Toronto and her role includes the supervision of graduate research projects. Dr Hussain's background includes a number of distinguished professorships at Ryerson University and University of Guelph, where she has been awarded for her research, teaching and course development accomplishments within Wireless Telecommunication, Internet of Things, Cyber Security, Insider Threat, API Security and Machine Learning. She is a prolific author with various books, conference and journal publications to her credit. She is editor of IEEE Newsletter Toronto. Dr Hussain has delivered many technical talks in the realm of Internet of Things and API Security, in top research/ industrial venues; such as IEEE PIMRC, IEEE-Toronto research forum, RBC International Expo, IEEE FIT etc. Dr. Hussain holds Doctorate and Master of Science degrees in Electrical & Computer Engineering, from Ryerson University, Toronto. Upon graduation she joined the Network-Centric Applied Research Team (N-CART) as a postdoctoral fellow where she worked on various NSERC-funded projects in the realm of the Internet of Things.

# Friday, October 22 12:30 - 13:30

## Keynote 3: Keynote Speaker

Climate Change and Resilience Plannin of Electric Power System
Shay Bahramirad

Chair: Mehrdad Rostami (Stantec Consultant Co. & IEEE Smart Grid Publication Committee, Canada)

Abstract:. The electricity sector is the key enabler of all critical infrastructure sectors that billions of people across the world depend on. However, electricity sector is under increased threat due to the ever-evolving impacts of climate change and weather events that are becoming more frequent and severe. Disruptions to the electrical infrastructure propagate to other sectors creating a domino effect. Climate change and its consequences have direct impacts on the electric grid; e.g., heat waves and record breaking winter temperatures cause demand surges beyond expectations and distribution substations are highly vulnerable to flooding. These threats are compounded in the face of aging infrastructure. The direct impacts from climate change put great emphasis on developing resiliency planning frameworks to adapt to the impacts of severe events on the functions of the electric grid. Increasing frequency of events make it inevitable for resiliency planning and solutions to become a part of coordinated planning functions in the electricity sector and investment prioritization frameworks including generation, transmission, and distribution. Resiliency planning is even more

critical since not only the climate change and its impacts are evolving, but also the grid is evolving toward a more sustainable and renewable future with emerging solutions including Microgrids and distributed energy resources. More importantly, a resilient infrastructure is the building block of incorporating renewables and emerging technologies into the grid.

Biography:Dr. Bahramirad has held several positions in the Energy Sector, including Vice President of Engineering and Smart Grid at ComEd: the electric utility in Illinois. In these roles, she has overseen and/or executed "grid of the future" visions, technical roadmaps, analytical frameworks, and investment strategies of distribution system and communication network; Fiber of over $4B. She has also been responsible for system reliability, DER integration, grid strategy and analytics, standards, maintenance inspection, emerging technologies, STEM programming, and reimagining the power grid to mitigate and adapt to climate change. She has also developed talent strategies, industry engagement plans, and advocacy programs to support business objectives. She has been the expert witness and testified on several state and federal regulatory proceedings around microgrids, energy storage, investment strategies, and Distributed generation interconnection; 1547. Dr. Bahramirad is an editorial board member of the Electricity Journal, US CIGRE Executive member, an adjunct professor at the Illinois Institute of Technology, and the IEEE/PES Vice President of New Initiatives and Outreach, overseeing the organization's engagement with policymakers globally around technical issues, investment strategies, emerging technologies, and developing plans for the next generation of frameworks including smart cities, and clean energy and running the philanthropy activities of IEEE/PES; Smart Village. She is the contributor to the United Nations SG7, Affordable and Clean Energy. She is responsible for assisting cities and utilities with climate change risk assessments for their assets, operations, and services and for developing mitigation strategies and investment strategies for adapting to climate change. Dr. Bahramirad will address global impact of climate to electric infrastructure and local resilience plan to address it.

# Friday, October 22 14:00 - 15:00

## TS1: Technical Session 1 - Day 1

System Resilience

Chairs: Ali Nabavi (University of Toronto, Canada), Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran)

**14:00** ***Corrective Congestion Management in Transmission Grids Using Fast-Responding Generation, Load and Storage***

Martin Lindner (TU Dortmund University, Germany); Denis Mende (Fraunhofer IEE, Germany); Andreas Wasserrab, Ilhami Saçar and Mitra Ariatabar (TenneT TSO GmbH, Germany); Christian Lakenbrink (Netze BW GmbH, Germany); Tobias van Leeuwen (Amprion GmbH, Germany); Marcus Lässig (Mitteldeutsche Netzgesellschaft Strom

mbH, Germany); Ulf Haeger (TU Dortmund University, Germany)

This paper elaborates a corrective congestion management concept for transmission grids involving fast flexible units and storage systems referred to as "grid booster". This post-fault remedial action acts as a first temporary relief for congested lines. It enables system operators to trigger subsequent corrective congestion management measures with significant lead times to re-establish an (N-1)-secure system state. This paper covers different aspects of integrating grid booster technologies and configurations into existing operational planning and real-time operation processes.

### 14:20 *The Texas Freeze of February 2021: Event and Winterization Analysis Using Cost and Pricing Data*

Soham Ghosh (University of Kansas & Black & Veatch, USA); Arpit Bohra (The University of Texas at Austin, USA); Sreejata Dutta (University of Kansas Medical Center, USA)

On February 2021, the winter storm Uri caused massive damages and economic losses upwards of $130 billion in Texas, worsened due to a combination of multiple power grid-related events. Severe winter weather conditions caused several generation sources to fail, with a significant underperformance of natural gas-based generation, and eventually causing the overall state electric grid to reach under-frequency levels that could have resulted in catastrophic blackouts. During these few trying days, the natural gas price spiked to exceed $400/MMBTU with a few delivery points reaching $1,250/MMBTU before falling back to the normal price levels of under $4/MMBTU. Real-time settlement point price for electricity spiked and hovered at $9,000/MWh price point for several days. The extreme price surges of these resources eventually caused large-scale financial fallouts in the event's aftermath. In the wake of the February event, conclusions have primarily been drawn towards to need for winterization of the Texas grid, improved scope for information sharing between state regulatory agencies, and an overall expansion of demand response resources. Alongside, the need to rethink the scarcity pricing mechanism, the methods and cost of winterization of the state's electric grid/ natural gas infrastructures, and the necessity to improve the emergency response service program at the Energy Reliability Council of Texas (ERCOT) form the primary components of discussion in this paper.

## TS2: Technical Session 2 - Day 1

Smart Grid (part 1)

### 14:00 *A Proof of Concept for the Application of Second-Life Electric Vehicle Batteries as A Stationary Energy Storage System*

Amir Fazeli (Automotive, United Kingdom (Great Britain) & Honda R&D Europe UK Ltd, United Kingdom (Great Britain))

The electrification of transport is currently underway, as the share of Electric Vehicles in the transportation sector continues to increase globally. This has resulted in a significant importance for various aspects of electric vehicle batteries during their full life cycle, not only for when batteries are inside vehicles, but also their application in second life as well as recycling and retrieval of original raw battery materials at the end of their life. One possible application of Electric Vehicle batteries in second life is for provision of Behind the Meter energy services for the end use customers. In this paper we showcase steps involved for creating a 40kW/68kWh Battery Energy Storage System, comprised of second life Electric Vehicle batteries. The operation of this energy storage system to provide Behind the Meter services for a commercial office

building is also demonstrated.

**14:20** ***A Techno-Economic Investigation for the Application of Second-Life Electric Vehicle Batteries for Behind-The-Meter Services***

Amir Fazeli (Automotive, United Kingdom (Great Britain) & Honda R&D Europe UK Ltd, United Kingdom (Great Britain))

Energy Storage is expected to play a significant role in realization of a Smart Grid paradigm. Energy storage devices can compensate for the variation and shortfall of the output from stochastic renewable generation. They can participate and provide different types of grid services, alleviate peak demand, and maximize self-consumption for the end user. Once Electric Vehicle (EV) batteries reach their end of life for utilization inside a vehicle, they may still have sufficient capacity to be used as a Battery Energy Storage System (BESS) in second life. In this paper we present research outcomes showing the cost benefit analysis for operating EV batteries in second life for Behind the Meter (BTM) services for residential, fleet, and commercial customers. Our investigation has shown that there may be a viable case specially when there is preexisting co-located renewable generation on customer site.

**14:40** ***Application of DC Electric Spring in Modern DC Microgrids, Review and Proposition***

Danial Moeini (ETS, Canada); Ambrish Chandra (Ecola de Technologie, Superieure, Canada); Amirabbas Kaymanesh (École de Technologie Supérieure, Canada)

Dc electric springs (DCESs) are a new and innovative solution for addressing the common issues of DC microgrids and paving the way toward wide implementation of DC microgrids especially in remote areas and in the presence of renewable energy resources. In this work, different proposed applications of DCES in DC microgrids are reviewed. Next, a list of gaps is given to be considered in any future study based on the previous works. Finally, a roadmap for a practical and successful DCES integration into future modern DC microgrids is proposed.

# Friday, October 22 15:00 - 16:00

## WIE: Women In Engineering Panel

Recent Trends in Product and Technical Innovation in the Financial Domain

Chair: Fatima Hussain (Ryerson University, Canada)

We will discuss how to develop great innovative products for financial services . Our focus will be on product innovation, testing criteria of technology solutions and new ways to engage clients in the market. Discussion will be about the various applications, products available in the market, the solutions they provide for people and how they also drive client engagement within the financial domain. These applications are usually built on AWS, leveraging a common pipeline and pattern. We will also talk about how to leverage re-use, build cross application capabilities and help teams innovate faster. As a use case, we will discuss Mydoh, which is an application helping kids learn the value of money through real-world experience.

We will also share our career stories, career experiences, and answer any questions from the audience. Women in tech are still in a minority - and we want to help other people along their career path. We

are looking forward to a lively discussion!

Katherine Kurtz, Senior Director, RBC Ventures

Katherine is a technology leader, currently the lead for Principal Engineering at RBC Ventures. RBC Ventures is looking at new ways to innovate - both for product and technology, to go beyond banking to solve problems and transform the way you live your life. Prior to joining RBC Ventures, Kate was the head of architecture governance for Personal and Commercial Banking at RBC, driving the evolution and oversight of all strategies, decisions and technical debt for 50+ architects.

Prior to joining RBC, Katherine also worked as part of IBM, leading a globally dispersed cross-functional development & architecture team responsible for the deployment of the IBM Bluemix Private and Hybrid Cloud. Hybrid Cloud solutions were delivered to to over 25 top 500 companies worldwide, generating $1MM in monthly recurring revenues. Transformation and Agile leader, successfully implementing the squads-tribes- chapter agile practice in the new IBM Private Cloud team.

On a personal note…

I have 3 kids, 2 dogs and a really noisy house. During COVID I have tried new hobbies - sourdough bread (complete fail), golfing (learning) and my vegetable garden (so far successful). For rest and relaxation, I love to be outside - hiking, canoeing and camping.

Megha Sharma, Head of Technology, RBC Ventures

She leads a high-performing team of software engineers to solve exciting and complex problems in the world of fintech and payments. In this role, Megha defines Mydoh's technical roadmap, manages stakeholder relationships, and provides technical direction and expertise. Prior to joining RBC, Megha has worked at TD Bank as an microservices architect, building a public API platform to support Open Banking. She has also worked as a developer in the start-up ecosystem for companies such as the DMZ at Ryerson, Sensibill, Magnet Today, and Crowdbabble. Megha is passionate about payments technology, systems architecture and design, diversity in recruitment, and effective team building. Megha is a graduate of Ryerson University and holds a Bachelor of Engineering in Computer Engineering.

Moderator: Dr. Fatima Hussain, Manager, Event Management and Analytics, Global Cyber Security at RBC, Toronto

Adjunct Professor, Ryerson University, Toronto, Canada

Dr. Fatima is working as a ManagerEvent Management and Analytics in "Behaviour Analytics and Insider Threat" team, Global Cyber Security, Royal Bank of Canada (RBC), Toronto, Canada. She is responsible for employee risk profiling and detection of insider threats, by establishing baseline

behaviours. She applies cutting edge analytical tools and techniques to detect the malicious insiders and mitigate the potential risk to the organisation.

She is also an Adjunct Professor at Ryerson University; Toronto and her role includes the supervision of graduate research projects. Dr Hussain's background includes a number of distinguished professorships at Ryerson University and University of Guelph, where she has been awarded for her research, teaching and course development accomplishments within Wireless Telecommunication, Internet of Things, Cyber Security, Insider Threat, API Security and Machine Learning. She is a prolific author with various books, conference and journal publications to her credit. She is editor of IEEE Newsletter Toronto. Dr Hussain has delivered many technical talks in the realm of Internet of Things and API Security, in top research/ industrial venues; such as IEEE PIMRC, IEEE-Toronto research forum, RBC International Expo, IEEE FIT etc. Dr. Hussain holds Doctorate and Master of Science degrees in Electrical & Computer Engineering, from Ryerson University, Toronto. Upon graduation she joined the Network-Centric Applied Research Team (N-CART) as a postdoctoral fellow where she worked on various NSERC-funded projects in the realm of the Internet of Things.

## Saturday, October 23

# Saturday, October 23 10:30 - 11:20

## Keynote 4: Keynote Speaker

Cy (Tony) Chung

Chair: Mehrdad Rostami (Stantec Consultant Co. & IEEE Smart Grid Publication Committee, Canada)

Biography:Prof. Chi Yung CHUNG, BEng(Hons), PhD, P.Eng., FIEEE, FEIC, FIET, FHKIE Prof. C.Y. Chung is a Professor, the NSERC/SaskPower Senior Industrial Research Chair in Smart Grid Technologies, and the SaskPower Chair in Power Systems Engineering in the Department of Electrical and Computer Engineering at the University of Saskatchewan, Canada. He is a prominent leader for advancing academic activities and applied research in power systems engineering development in the province of Saskatchewan. He is now leading a research team, supported by SaskPower and NSERC of Canada, to conduct cutting-edge and long-term smart grid research for SaskPower and address critical technical issues associated with smart grid technologies and their applications to real power systems. Prof. Chung is currently a Senior Editor of "IEEE Transactions on Power Systems", a Vice Editor-in-Chief of "Journal of Modern Power Systems and Clean Energy" and a Subject Editor of "IET Generation, Transmission & Distribution". He is an IEEE PES Distinguished Lecturer and a member of IEEE PES Fellow Evaluation Committee. He is also the recipient of the 2021 IEEE Canada P. Ziogas Electric Power Award and a Fellow of IEEE, EIC, IET and HKIE.

# Saturday, October 23 11:30 - 12:20

## Keynote 5: Keynote Speaker

Dealing with High Penetration of Distributed Energy Resources in Power Electronics Dominated Grids
Innocent Kamwa

Chair: Ali Nabavi (University of Toronto, Canada)

Abstract: The much-desired emergence of a 100% renewable economy is closely linked to electrical systems dominated by decentralized energy resources, carbon-free and interfaced by power electronics. This radical change requires rethinking the way of designing, protecting, controlling and optimizing the operation of electrical networks, which will have to be smarter to control the uncertainties and risks of instability inherent in the massive switch to autonomous energy systems, capable of interactions. decentralized. Our talk targets several technologies essential to meet these challenges: (a) Transactive energy systems, which empower electricity consumers and encourage the co-adoption of storage, solar and electric vehicles. (b) Controls and automatisms ensuring the stability of power systems dominated by electronics (c) Simulation tools facilitating the implementation of such systems and the optimization of their flexibilities for enhanced network security. Emerging industrial and academic research trends to enable these technologies will be underlined, with emphasis on the critical role of simulation in this context of growing complexity.

Biography: Innocent Kamwa obtained his Ph.D. in Electrical Engineering from Université Laval in 1989. A full professor in the Department of Electrical Engineering and Tier 1 Canada Research Chair in Decentralized Sustainable Electricity Grids for Smart Communities at Laval University, he was previously a researcher at Hydro-Québec's Research Institute, specializing in the dynamic performance and control of power systems. He was Chief Scientist for Hydro-Québec's Smart Grid Innovation Program and an international consultant in power grid simulation and network stability. Dr. Kamwa is a Fellow of the IEEE for his innovations in power system control and a Fellow of the Canadian Academy of Engineering. He is also the 2019 recipient of the IEEE Charles Proteus Steinmetz and Charles Concordia Awards.

# Saturday, October 23 13:00 - 15:00

## TS1: Technical Session 1 - Day 2

HVDC, Facts and High Power Converteres

Chairs: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran), Alireza Siadatan (University of Toronto, Canada)

**13:00** ***A Novel Control Method to Improve the Performance of Single-Phase Cascaded H-Bridge Multilevel Converter Under Variable DC Voltages***

Omid Zolfagharian (Shahrood University of Technology, Iran); Alireza Siadatan

(University of Toronto, Canada)

Improvement of the performance of cascaded H- Bridge multilevel converters is considered as an important factor in the conditions of input DC voltages change. In this paper, using a novel control algorithm, the improvement of the performance of a seven-level converter under variable DC voltages has been examined. Since changing the input DC voltages changes the output phase voltage, the proposed controller has been used to control the modulation index to compensate for the effect of the phase voltage reduction. One of the challenges of presenting the control algorithm is the nonlinear variation of modulation index per input DC voltages change, which has been improved by presenting a suitable method by which phase voltage control is done instantly and online. In this paper, the phase voltage range has also been controlled without measuring DC voltages and only with the phase voltage measurement. This causes the lowest sensor to be employed to control the output voltage. The switching method used in this paper is the phase disposition pulse width modulation (PD-PWM). Finally, the simulation results in MATLAB software confirm the proposed algorithm.

### 13:20 *Dual-Input H-Bridge Based 3-Phase Cascaded Multilevel Converter for Utility Scale Battery Applications*

Ahmed Sheir (UOIT, Canada); Vijay K. Sood (Ontario Tech University, Canada)

In this paper, a modified cascaded H-bridge CHB multilevel converter is introduced for utility-scale battery applications. The conventional H-bridge module, used as a building block in CHB, is replaced with a dual-input H-bridge module. In this, a boost converter is connected to a separate battery-set and integrated to each leg of the H-bridge. Such a configuration not only eliminates one power switch from each boost converter, but it also maintains the converter's flexibility i.e. each boost converter can operate at its own duty cycle. The relationship between the boost duty cycle and modulation index is derived. The proposed topology is able to maintain uniform charging/discharging operation among all connected battery-sets while supplying/absorbing the desired reference power. The validity of the proposed converter is tested using a Matlab/Simulink model in a grid connected mode under different operating conditions.

### 13:40 *Analytical Conduction Loss Calculation Method for Hybrid Three-Level Converters*

Levi Bieber (University of British Columbia, Okanagan, Canada); Liwei Wang and Juri Jatskevich (University of British Columbia, Canada); Wei Li (OPAL-RT Technologies Inc., Canada)

A new class of hybrid three-level converters (H3LC) has been recently proposed for voltage-source-converter high-voltage direct current (VSC-HVDC) transmission technology. It features both a small footprint and high efficiency. In the literature, however, the H3LC's semiconductor losses have only been verified quantitatively through detailed simulation, and only at two operating voltages. This paper presents an analytical method to determine the H3LC's efficiency over its entire operating range by taking into consideration the conduction power losses of its semiconductor devices, which are assumed to be dominating. Lacking in the literature, this paper presents a method to simplify the determination of the theoretical semiconductor conduction power losses for hybrid three-level converters to improve the converters' design-to-implementation time. To verify the accuracy and effectiveness of the proposed analytical methodology for power loss calculation, the results are compared against the values obtained from the simulations using the detailed equivalent model (DEM). The proposed analytical method is demonstrated to give accurate predictions of the dominant power losses over a wide range of operating conditions, which may be used for determining the optimal design and operation the H3LCs in practice.

**14:00 *Model Predictive Control of Multi-Level Neutral Point Clamp (NPC) Grid-Connected Inverter Using Power Block Geometry(PBG) Approach***

Haitham Kanakri and Euzeli Santos, Jr. (Indiana University (IUPUI), USA)

In a grid connected renewable energy resources, where multiple DC power sources supply current to the grid, controlling the injected current is an important issue. When considering renewable energy resources, such as photovoltaic (PV), multi-level converters are needed to convert the DC power to AC power suitable for the grid with less harmonic distortion. Since different sources may have different power delivery levels model predictive control (MPC) is proposed to control the neutral-point clamp (NPC) inverter to regulate the injected power to the grid. Further, since there are numerous power electronics (PB) converters topologies used to solve this problem the power block geometry (PBG) is proposed to facilitate the analysis of multi-level converters and the design of MPC controller. This paper presents a model-predictive control-based on power block geometry method, single-phase and three-phase NPC converter based MPC are simulated in MATLAB, to control the injected current into the grid. The power block geometry speeds up both analysis of the multi-level converters and the MPC design since it is based on geometrical representation with specific rules to establish a formation law.

**14:20 *Analysis of Pole-To-Pole Faults in Half-Bridge and Full-Bridge MMCs***

Ramin Parvari (University of Manitoba, Canada); Xianghua Shi (RTDS Technologies, Canada); Shaahin Filizadeh (University of Manitoba, Canada)

Pole-to-Pole (PTP) faults are considered as the most severe type of faults that may occur on the DC side of Modular Multilevel Converters (MMCs) in High Voltage Direct Current (HVDC) transmission systems. It is indispensable to study this type of fault to understand its characteristics that enable design of respective protection systems. This paper analyzes PTP faults in MMCs with common Half-Bridge (HB) and Full-Bridge (FB) submodule structures. Dividing the duration of the fault into two stages, the paper presents equivalent circuits for both the DC and AC sides of the converter for each stage. A simulation case study with a 101-level MMC is carried out in the PSCAD/EMTDC simulator for both HBSM and FBSM MMCs. The results confirm the validity of the presented equivalent circuits.

# TS2: Technical Session 2 - Day 2

Microgrids and Isolated Grids

Chair: Ali Nabavi (University of Toronto, Canada)

**13:00 *A State-Observer Based Controller for CCM Flyback Converters with Constant Power Loads***

Mahesh Srinivasan (The University of Texas at Austin, USA)

This paper proposes a controller for a continuous conduction mode (CCM) flyback converter supplying constant power loads (CPL)s. The controller is implemented in two stages and is based on sensing only the output voltage of the converter. The inner loop implements active damping by performing feedback of core/air-gap flux in order to damp limit cycle oscillations due to CPL. To overcome the challenge of sensing and feedback of a magnetic quantity, a state observer is implemented. To compensate for voltage deviation due to active damping and to perform voltage regulation, an integral controller is added in the outer loop. Reasonable assumptions are made to the system to derive the state observer while also maintaining model accuracy. The controller achieves exponential stability and the stability conditions are

derived. Simulation results show that the proposed observer tracks the state variables accurately and also verifies the validity of the control approach.

### 13:20 *Microgrid Sizing and Operation*

Anindita Golder and Francois Bouffard (McGill University, Canada)

The increasing penetration of renewable energy sources and electric vehicles introduce challenges to the methods used in the design and operation of conventional power systems. One major problem is the inherent variability present in them as it introduces supply and demand imbalance. To ensure efficient usage of all resources in the microgrid, it is important that the microgrid is sized appropriately with a proper energy management system to ensure meeting the supply and demand balance. This paper proposes the sizing and operation of microgrid in three steps. In the first step, typical days representing the annual profiles are generated which is then used in a linear optimization problem to select and size the microgrid assets (second step). The results of the design formulation are then used to develop a decision tree-based energy management system (third step). The proposed methods are then used for a remote mine as a case study.

### 13:40 *Decentralized Reactive Power Sharing in Autonomous Microgrids*

Armin Fooladi savadkouhi (Iran University of Science and Technology, Iran); Farhad Elyasichamazkoti and Mahan Fakouri Fard (University of Utah, USA)

Microgrid control methods usually have three levels known as hierarchy control method. In this paper, primary and secondary control levels have been evaluated. Conventional droop control is one of the most common primary control methods which regulate frequency and active power well without any communication links, but it cannot regulate voltage and reactive power very well. With this method voltage and frequency of the microgrid will be deviated by changes in load demand. Hence, secondary control levels are used to eliminate this deviation. Centralized and distributed secondary control methods need communication links and reduce system reliability. Therefore, in this paper, decentralized control methods are introduced to improve reactive power-sharing.

### 14:00 *Probabilistic Imputation for High Resolution Univariate Electric Load Data with Large Gaps*

Patrick T Giles and Michael Ross (Yukon University, Canada)

The use of electric load data within power engineering applications is critical. Such data often contain missing observations, especially higher resolution datasets important for detailed modeling and simulation. Missing data frequently are handled by replacement with new values, in other words imputation. However, most readily available imputation methods will perform unsatisfactorily on electric load data when many successive observations are missing as they cannot capture the periodic variation. As well many methods only provide single point estimates, allowing for no assessment of probabilistic characteristics of the missing data. In this study a new imputation method is proposed that captures the periodic variation common in high resolution load data, as well as generate probabilistic and point estimates for the missing data. The method is evaluated on three real-world high resolution load datasets and compared with a typical imputation technique.

### 14:20 *Three-Port Partially Isolated Quasi-Switched-Boost LCL-Converter for Micro-Grids*

Praneydeep Rastogi and Ashoka Bhat (University of Victoria, Canada)

This paper proposes a new three-port partially isolated quasi-switched-boost integrated LCL-converter for DC micro-grid application. This configuration is obtained by integrating a quasi-switched-boost inverter with LCL-type resonant converter while accommodating a renewable energy source (RES) and energy storage device (ESD). This converter works in four modes. Operation of the converter for different modes of operation using waveforms and equivalent circuits for different intervals of operation are presented. Steady-state analysis leading to design equations are given. A systematic design procedure is illustrated with a design example of a 100kHz converter rated at 500W with 24V RES and 12V ESD. PSIM simulation results are given to evaluate the performance of the designed converter for 3 main modes of operation supporting the theoretical results. A comparison of theoretically predicted results with the simulation results are also given.

# TS3: Technical Session 3 - Day 2

Power System Stability and Control

Chair: Vijay K. Sood (Ontario Tech University, Canada)

**13:00** ***Benefits of Dynamic Line Rating on System Operation***

Paula Castillo (UPV/EHU, Spain); Igor Albizu, Miren T. Bedialauneta and Elvira Fernandez (University of the Basque Country UPV/EHU, Spain); Rafael Alberdi (University of the Basque Country, Spain)

This paper explores the benefits that ampacity dynamic line ratings (DLR) can offer to obtain a higher penetration of wind power generation in the grid. This paper presents an analysis of real examples where monitoring systems are achieving real benefits when operating the network. Monitoring systems not only provide economic benefits, but can also provide information for ampacity predictions. These predictions can help to plan the dispatch of energy in the electricity market, always taking into account the risk that such predictions may not be fulfilled. The case studies demonstrate the economic benefits and increased wind generation on the grid from the use of DLR on a 24-bus network. It is analyzed which line would obtain a greater benefit from the installation of the DLR, and considering the market prices of the fuel, the economic differences are analyzed by using static ampacity limits and using the dynamic limits obtained based on ampacity predictions.

**13:20** ***Performance Comparison of Fuzzy Logic and Deep Learning Algorithms for Fault Detection in Electrical Power Transmission System***

Nouha Bouchiba (University of Moncton, Canada); Azeddine Kaddouri (Université de Moncton, Canada)

This paper introduces a performance comparison of deep-learning and fuzzy-logic algorithms for power system fault detection. The interconnected IEEE 14-bus transmission power network is considered. Ten faults are integrated and simulated using SimPowerSystems toolbox in Matlab. For each fault condition, each bus voltage and current RMS values were measured in order to test both algorithms. Simulation results show the effectiveness of the deep-learning algorithm with a 100% accuracy in predicting faults compared with fuzzy logic.

**13:40** ***Synthetic Power System Models for PSS Tuning and Performance Assessment***

Fernando De Marco (National University of Rosario, Argentina); Pablo G Rullo

(Departamento de Ingenieria Electrica - FRSN - UTN & CIFASIS - CONICET, Argentina); Nelson Martins (Brazilian National Academy of Engineering, Brazil)

This paper presents four low-order synthetic power system models for the tuning and performance assessment of power system stabilizers (PSS). Each synthetic system comprises a family of two or three-bus power system models in which one or more parameters are changed in order to reproduce oscillatory poles in the whole range of the typical electromechanical frequencies, from the intra-plant to the inter-area. PSS tuning requirements are compared for synthetic systems of variable and fixed transmission angle, variable generator size and variable equivalent grid inertia.

**14:00** ***Frequency Support Provided by Inverted Based-Generation Using Grid-Forming Controllers: A Comparison During Islanded Operation***

Francisco Gonzalez-Longatt (University of South-Eastern Norway & Venezuelan Wind Energy Association, Norway); Jose Rueda (University Duisburg-Essen, Germany); Peter Palensky (TU Delft, The Netherlands); Harold Chamorro (KTH, Royal Institute of Technology, Sweden); Vijay K. Sood (Ontario Tech University, Canada)

Inverter based generation (IBG) is a necessary technology in the energy transition and reaching ambitious objectives of zero-net emission. However, the colossal penetration of IBG may create several issues. Using Voltage source converters (VSCs) equipped with the so-called grid forming control is thought of as a long-term solution of IBG-dominated power systems. This paper shows a glance of the dynamic performance during a system frequency event (SFE) considering three of the most common grid forming controller types used to emulate synchronous generation operation: Virtual Synchronous Machine (VSM), the Synchronverter and grid forming droop control; and compared with a classic synchronous generator (SG). Numerical results of time-domain simulations of a tests system show the enormous advantage of the grid-forming converters controls to provide an extremely fast frequency response when compared to the case of the traditional SG.

**14:20** ***An Optimization-Based Load Frequency Control in an Interconnected Multi-Area Power System Using Linear Quadratic Gaussian Tuned via PSO***

Parastoo sadat Hosseinian, Seyyedmilad Ebrahimi and Juri Jatskevich (University of British Columbia, Canada)

Mismatch between the generation and consumption results in deviation in the frequency of the power system, which negatively influences its operation, reliability, and efficiency. Secondary/load frequency controllers are used for compensating the power mismatch in the time-scale of up to several minutes. The Linear Quadratic Gaussian (LQG) control has been applied for regulating the frequency. However, the parameters in the LQG method are conventionally determined using trial and error methods. This makes the selection process challenging for large power system and cannot guarantee satisfactory response. In this paper, an optimal load frequency control (LFC) method is proposed where the Particle Swarm Optimization (PSO) method is exploited to optimize the selection of LQG parameters for a multi-area system. The performance of the proposed LQG+PSO method is verified on a test-bench three-area system using simulations. It is demonstrated that the proposed LQG+PSO method achieves superior frequency regulation compared to the conventional LQG method.

# Sunday, October 24

## Sunday, October 24 10:30 - 12:30

### TSM1: Technical Session 1 - Morning Day 3

Smart Grid (Part 2)

Chair: Alireza Siadatan (University of Toronto, Canada)

**10:30 *Time Series Anomaly Detection for Smart Grids: A Survey***

Jiuqi Elise Zhang, DI WU and Benoit Boulet (McGill University, Canada)

With the rapid increase in the integration of renewable energy generation and the wide adoption of various electric appliances, power grids are now faced with more and more challenges. One prominent challenge is to implement efficient anomaly detection for different types of anomalous behaviors within power grids. These anomalous behaviors might be induced by unusual consumption patterns of the users, faulty grid infrastructures, outages, external cyberattacks, or energy fraud. Identifying such anomalies is of critical importance for the reliable and efficient operation of modern power grids. Various methods have been proposed for anomaly detection on power grid time-series data. This paper presents a short survey of the recent advances in anomaly detection for power grid time-series data. Specifically, we first outline current research challenges in the power grid anomaly detection domain and further review the major anomaly detection approaches. Finally, we conclude the survey by identifying the potential directions for future research.

**10:50 *Direct Net Load Forecasting Using Adaptive Neuro Fuzzy Inference System***

Gamal Aburiyana (Dalhousie, Canada); Hamed Aly and Timothy Little (Dalhousie University, Canada)

Electricity generated from renewable resources such as wind, solar, geothermal, biomass, ocean waves and tidal is considered sustainable and emissions free. Among these kinds of clean energy resources, wind and solar energy are contributing the most to supplying the load demand all over the world. The stochastic nature of wind and solar power resources injects additional variability and uncertainty to the power system and makes it difficult for the system operator to maintain a continuous balance between the generated and the consumed power especially during high wind and solar power penetration levels. To secure a reliable and economic hybrid power system operation, it is important to provide the system operator with accurate net load forecasts. This research aims to reach optimal net load forecast by forecasting the net load directly using Adaptive Neuro Fuzzy Inference System (ANFIS) depending on the historical net load data.

**11:10 *Indoor and Outdoor Conditions Utilized Energy Saving Scheme for HVAC Cooling Water Systems in Smart Commercial Buildings***

Sandali Walgama, Sisil Kumarawadu and Chandima Dedduwa Pathirana (University of Moratuwa, Sri Lanka)

With the substantial contribution from the building sector for the inevitable growth of global energy consumption, involvement of energy efficient operation and control methods in buildings' Heating, Ventilating and Air Conditioning (HVAC) systems is of utter importance. This paper proposes an energy saving scheme for cooling water systems in central HVAC systems by employing indoor and outdoor

environmental conditions of the considered building. Simplified models of the system components were applied to formulate the energy minimization problem and simulation results were obtained by developing the proposed algorithm in MATLAB. The results verify that the proposed strategy allows a reduction of 1078.235 kWh on annual total energy usage with a 1.85% improvement on average system Coefficient of Performance (COP) compared to that of the water flow control method. Utilization of this innovative method for HVAC cooling water systems in smart commercial buildings is beneficial for real control applications due to the inherent efficiency, robustness, and simplicity.

### 11:30 *Two-Layer Structure for Initial Settings of Power-To-Hydrogen Devices in the Electricity System*

Elahe Sahraie (Université Laval, Canada); Innocent Kamwa (University Laval, Canada); Ali Moeini (Hydro-Québec/IREQ, Canada)

An increasing threat of climate change dangers propel humanity to decarbonize the carbon emission industries. Electrification through green Hydrogen is one of the most promising plans to achieve the decarbonization targets. Penetration of the Hydrogen Sector (HS) in the Electricity System (ES) with the aim of electrification of specific end users will require a well-thought operating and coordination structure to maintain both the ES safe operation and improving the electrification rate. To this aim, we present a two-layer structure. In the first layer, the optimal place and size of the power-to-Hydrogen (PtH) devices are recognized based on electrification targets and considering the ES critical condition constraints. This layer is planned to be in a separated layer from the ES operation and independently of the ES objectives, but new purposive constraints are suggested to create coordination and enhance the interaction between the ES and HS. In the second layer, the ES will operate under its objectives in the presence of the HS with predetermined settings. Implementing the presented two-layer structure results in the safe operation of the whole system even under critical conditions of the ES as well as a higher electrification rate with the most practical settings for PtH devices.

### 11:50 *Distribution Transformer kVA Load Estimation Using Smart Meter Data*

Hafiz M. Usman, Ramadan ElShatshat and Ayman El-Hag (University of Waterloo, Canada)

This paper presents a hardware-free novel strategy for a distribution transformer kVA load estimation, without requiring a fixed power factor assumption or reactive power load information across residential electricity consumers. The proposed strategy provides a simple and effective fixed-point iteration-based formulation for a balanced secondary distribution network. The efficacy and a detailed statistical analysis of the proposed scheme are studied on a balanced secondary distribution system against 1,000 random load profiles through Monte-Carlo simulations which represent uncertainty in smart meter data. The results indicate that the proposed scheme provides better results in comparison to fixed power assumptions for a distribution transformer kVA load estimation, and the results from this work may contribute to further smart-grid applications.

### 12:10 *Study of Ground Level Operations in Underground Vaults*

Sabryna Vendramin Fernandes (CERTI Foundation - Campus Universitário UFSC, Trindade, Brazil & CERTI Foundation, Brazil); Leticia Lagni Dagnese (Fundação CERTI, Brazil); Marcos Aurelio Izumida Martins (CERTI Foundation, Brazil); Ricardo de Oliveira Brandão (ENEL, Brazil); Silvia De Francisci (Enel Distribuzione S. p. a, Germany); Bruno Cecchetti (ENEL, Brazil)

With the constant population growth, mainly urban, the risks brought by the development of basic services will require a systematic and synchronized exploration of the urban subsoil, since a better understanding and evaluation of the management of the underground distribution network is required, pointing out inconsistencies among the others that use this area, such as gas and water utilities, for example. The installation of equipment underground has become a reality faced by several energy utilities and other providers of basic services, which has increased the disputes in the underground, the problems of locating the network, the difficulties of maintenance, and the high costs of deployment. Besides the disputed space, underground operations tend to be very difficult and risky, since there is the eminence of gases harmful to health and also the risk of events under uncontrolled conditions. Therefore, this paper proposes overhaul of mechanical and structural systems in underground vaults, where maneuvers can be performed directly from the sidewalk, without the need for the service provider to enter these vaults, reducing the possibility of accidents.

# TSM2: Technical Session 2 - Morning Day 3

## Renewable Sources of Energy and Cogeneration (Part 1)

Chair: Afshin Rezaei-zare (York University, Canada)

### 10:30 *Performance of Off-Grid Solar Based Agricultural Water Pump Controller*

Jeykishan Kumar K and Jothibasu S (Central Power Research Institute, India)

This paper provides performance evaluation of a 5.625 kW/ 7.5 Hp rated off-grid solar based agricultural water pump controller used for irrigation purpose. The performance evaluation was carried out as per IS/ IEC 61683-1999 (Reaffirmed 2020) standard and it was observed that the controller is able to delivery rated power with a maximum efficiency of 98.11% at nominal operating voltage of 600 V DC. Current harmonics exceed 5% limits at 25% and 50% loads, power factor increases with increase in percentage loads and with full load at 480 V dc input, the power factor is 0.85. Efficiency tolerance based of guaranteed efficiency calculations is observed to be -0.55%.

### 10:50 *The Augmented Unscented H-Infinity Transform with H-Infinity Filtering for Effective Wind Speed Estimation in Wind Turbines*

Erica M Owen and Jeff Pieper (University of Calgary, Canada)

Wind energy is a fast-growing industry in Canada and worldwide. As wind turbine size and capacity increase, control systems become exceedingly important in order to maximize the efficiency of the power output and to reduce loads to extend their longevity. Effective wind speed (EWS) is not easy to measure because wind speed varies in time and space across the rotor area of the turbine, nor is it a real physical signal. This research aims to provide better knowledge of the input wind speed and to design a turbine controller based on this normally unknown input. First, nonlinear robust methods of state estimation were considered in order to deal with the nonlinearities present in the wind turbine model and the large exogenous disturbance of wind speed. Specifically the unscented H-infinity filter was used for robustness and accuracy. This unscented H-infinity scheme was then adopted in combination with a data fusion technique to estimate effective wind speed. This technique utilized high frequency data from the anemometer and treated the turbine as a sensor of low frequency data. These signals were fused to create an EWS estimate. The methods are thus shown to be effective in wind speed estimation for two sizes of turbines.

### 11:10 *Application of an Augmented Unscented H-Infinity Effective Wind Speed Estimation to H-Infinity Control of Wind Turbines*

Erica M Owen and Jeff Pieper (University of Calgary, Canada)

Wind energy is a fast-growing industry in Canada and worldwide. As wind turbine size and capacity increase, control systems become exceedingly important in order to maximize the efficiency of the power output and to reduce loads to extend their longevity. Effective wind speed (EWS) is not easy to measure because wind speed varies in time and space across the rotor area of the turbine, nor is it a real physical signal. This research builds on a previous paper's method of EWS estimation to design a turbine controller based on this normally unknown input. The unscented H-infinity scheme was used in combination with a data fusion technique to estimate effective wind speed. The EWS was used to determine the optimal tip speed ratio (TSR) for the reference for the turbine. This was accomplished with a mixed sensitivity H-infinity tracking controller to optimize power output. The mixed sensitivity control was used to limit the bandwidth of the controller while also minimizing the tracking error. The methods are thus shown to be effective in wind speed estimation for two sizes of turbines and showed up to a 14.6 percent increase in power production the in maximum power point tracking region when compared to a baseline PI controller.

### 11:30 *Inverter Based Distributed Generation Comprehensive Optimization for Unbalanced Power Distribution Systems*

Tianjian Wang, Yan Hou, Ying Wang, Fei Gu, Wei Jin and Lin Liu (State Grid Zhengzhou Power Supply Company, China)

During these years, the integration of distributed generation (DG) devices has been very popular. The development of DG devices provide an opportunity to acquire better performances; for example, reducing the power loss, improving the better voltage profiles, superior energy saving function. As the novel algorithms develop, many optimization algorithms will be applied in the optimal powerflow (OPF) fields. In this paper, a multiobjective function is used to make five objects into one objective function (OF). Two kinds of DG units combination methods will be utilized. Cuckoo Search (CS) algorithm is investigated using for IEEE 123 test case. Comparing results of the two types of DG unites combination methods, it shows that placing microturbine generator (MTG) in three phases nodes and photovoltaic generation (PV) to one phase node at the end of system can play the better performance.

### 11:50 *8-Parameter Extraction in Photovoltaic Cell Using Firefly Optimization Technique*

Adedayo Farayola, Yanxia Sun and Ahmed A Yusuf Ali (University of Johannesburg, South Africa)

Photovoltaic (PV) cell modeling is an important study done to improve solar cell performance before fabrication. Different techniques have been implemented for the extraction of solar cell parameters to generate a high PV power. However, most of these techniques are considered less accurate and suffer some limitations that reduce their effectiveness. In this paper, five different techniques were compared under different cell temperature levels to determine the technique that yields the best results. Findings show that firefly algorithm exhibited the best performance and can be recommended for the extraction of solar cell parameters in PV cells.

**12:10** ***Interleave-Modes on a DC-DC Converter Using Three-Phase Transformer with Zero-Phase Current***

Yuki Itogawa, Takeshi Amimoto, Yuu Kawai and Kikuo Izumi (Mitsubishi Electric Corporation, Japan)

In this paper, interleave operation modes of a high frequency isolation circuit using zero-phase current of a three-phase transformer is studied. In the proposed circuit scheme, the amount of power transmission between the primary and secondary bus bars is controlled by the phase difference between the voltages output by the primary and secondary circuits. The proposed circuit system also controls the voltage ratio between the primary power supply and the primary bus bar voltage by the duty ratio output by the primary side. By adjusting the primary bus bar voltage, the proposed circuit method can regulate the amount of current flowing through the three-phase transformer, and can both superimpose the current to achieve soft-switching and suppress the conduction loss. In this paper, the interleave operation modes of the proposed circuit system is analyzed to clarify the conditions for achieving soft-switching. In this paper, the conditions for achieving soft-switching in the interleave operation modes are investigated and the operation is verified by simulation. The proposed circuit has a wide soft-switching area especially in the low power range, and it can be effectively used in the demand and supply adjustment applications where small charge and discharge operations are frequently required.

## TSM3: Technical Session 3 - Morning Day 3

Data Mining, Artificial Intelligence, Machine Learning (Part 1)

Chair: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran)

**10:30** ***Modelling Residential-Scale Consumer Demographics Using Monthly Electricity Consumption Data***

Abdur Rahman, Ameera Arif and Ahmad Nadeem (Lahore University of Management Sciences, Pakistan); Naveed Arshad (Syed Babar Ali School of Science and Engineering, Pakistan)

Electricity is one of the most widely used forms of energy that plays a significant part in sufficing the fundamental energy demand based on contemporary human needs. It is becoming highly tedious for the energy sector to manage and surveil the modern energy demands based on the constantly changing consumer demographics. In order to progress as a business, it has become pertinent for the distribution companies to evolve their development plans, tariffs, and business models according to the consumer requirements. This article proposes three different models to predict the attributes of a consumer household, namely the multivariate linear regression (MLR), the support vector regression (SVR), and the artificial neural network (ANN). The study uses the PRECON dataset, which is based on the monthly electricity consumption of households in Lahore, Pakistan. All of the proposed models play significant roles in predicting the required consumer demographics for forecasting. The linear model shows the ability to predict the number of people with very low MAPE of 3.57% as compared to other models. So far, ANN has shown the best results in predicting the number of fans, air conditioners, and rooms. However, the MAPE reports extracted from this study show the inability of the used models to explain the variation of property area confidently.

**10:50** ***Forecasting Electricity Prices from European Single Day-Ahead Coupling Using***

***Artificial Neural Networks***

Leo Lehr (E-Control Austria, Austria); Fabio Valdés (University of Hagen, Germany)

The electricity wholesale market is one of the most complex economic institutions. Prices on this fast-moving market depend on volatile factors such as weather conditions or abrupt changes in demand. Furthermore, the level of physical integration - and thus interdependence - between countries in Europe is increasing. As such, the electricity wholesale market demands most accurate price forecasting models to provide vital competitive advantages to actors on the market. This paper aims to develop and to evaluate the performance of different deep neural network models for the purpose of electricity price forecasting, focusing on the Austrian market. To incorporate the effect of market coupling in Europe, data from various other European countries are considered in the models.

**11:10** ***Real-Time Anomaly Detection in Distribution Grids Using Long Short Term Memory Network***

Ming Zhou and Petr Musilek (University of Alberta, Canada)

The massive amount of data generated by smart meters provides opportunities to better monitor and control power grids in real-time. However, making use of such enormous amounts of data can be a challenge. Sensor measurements collected in power systems can be anomalous, reflecting sensor malfunctions, power system disturbances, or any other problems that may cause abnormal readings. With the rapid deployment of distributed energy resources, traditional methods for protecting the grid, which relies on emergency load tripping through relay actions, have limited performance. For example, relay actions may be delayed. In addition, they cannot detect anomalies that are within the required voltage range. To address these shortcomings, this article proposes a data-driven framework based on a long-short-term memory network model to directly detect anomalies in distribution systems using voltage magnitude measurements. The proposed solution is validated against known anomalies using data from a real distribution grid. The simulation results show highly accurate anomaly identification.

**11:30** ***Framework for a Real-Time Autonomous Cascading Failure Prediction Model***

Mohamed O Mahgoub (University of Saskatchewan, Canada); Seyed Mahdi Mazhari (University of Tehran, Iran); Chi Yung Chung and Sherif Faried (University of Saskatchewan, Canada)

Blackouts cause significant damage to both consumers and utilities. Since blackouts usually start as a cascading failure, the prediction of such a cascade can effectively prevent blackouts from propagating. Majority of current cascading failure prediction models assume that the model only needs to be trained once, either when it is designed or when the system undergoes topology changes. However, this limits the efficacy and robustness of such models. Hence, this paper aims to design a framework for autonomous cascading failure prediction models that can self-improve while being connected to the grid in real-time. To successfully achieve this, importance sampling and case-based reasoning are used to optimize the amount of data and time needed to retrain the model in real-time. The results indicate that such an approach allows the model to naturally shifts to a different model as the inputs change and significantly improves the accuracy of the model as more datapoints are obtained.

**11:50** ***Segmentation of Portuguese Electricity Daily Load Demand Using Self-Organizing Maps***

Ricardo Pinto Moura (Portuguese Navy Research Center (CINAV) & Center for

Mathematics and Applications (CMA), Portugal); Nuno Sousa and Francisco Reis (NOVA University of Lisbon, Portugal)

From Portuguese historical data, a Kohonen's Self-Organizing Map (SOM) is used to classify the days of the year according to their load curve profile. The SOM Kohonen's algorithm is an unsupervised neural network clustering technique often used for pattern classification tasks that preserves the topology of data. Through the visualization of the data by projecting it into a bidimensional grid it is possible to identify the 'natural' clusters. The main objective of the classification is to separate the load demand by clusters for forecasting purposes. The classification/clustering via SOM will be the first phase of a so called Artificial Neural Networks hybrid model, where two or more ANN models are combined in order to draw more accurate predictions. The historical data used is the Portuguese continental load demand from 2009 to 2017 registered in periods of 15 min, comprising a total of 96 load registries per day. This data will be classified in different clusters according to its load curve profile.

**12:10 *Generation of Synthetic Ampacity and Electricity Pool Prices Using Generative Adversarial Networks***

Vadim Avkhimenia (University of Alberta & IEEE, Canada); Tim Weis and Petr Musilek (University of Alberta, Canada)

This work explores the generation of synthetic time-series of dynamic thermal line rating data and Alberta Electric System Operator's hourly pool price data using Wasserstein Generative Adversarial Networks, as part of a larger study on transmission line reliability. The generation of synthetic data is required due to a limited size of the available dataset. Synthetic data can aid in training deep learning and reinforcement learning models. The data is generated for 100 time-steps and is evaluated using quantitative metrics and qualitative assessment methods. Results show that the maximum mean discrepancy loss stabilizes and the trained Wasserstein generative adversarial network is able to reproduce the desired frequency distributions as well as produce a good overlap in the principal component analysis decomposition between the real and synthetic data. The final inspection of the produced synthetic data on both datasets is satisfactory.

# Sunday, October 24 13:00 - 15:20

## TSA1: Technical Session 1 - Afternoon - Day 3

Renewable Sources of Energy and Cogeneration (Part 2)

Chair: Afshin Rezaei-zare (York University, Canada)

**13:00 *Computational Intelligence Based Snow Cover Prediction for Photovoltaic Systems***

Behzad Hashemi (Université du Québec en Outaouais, Canada); Ana-Maria Cretu (University of Quebec Outaouais, Canada); Shamsodin Taheri (Université du Québec en Outaouais, Canada)

In northern snow-prone areas, photovoltaic (PV) systems are getting more popular. Accumulations of snow on panels after snowfall events, as a major challenge for PV systems' efficient use in these regions, can attenuate or obstruct solar radiation reaching the surface of the PV cells and cause a significant reduction in the PV system's power generation. This is an important issue in PV power forecasting (PVPF) for PV-penetrated power systems' scheduling. To address this issue, data-driven short-term snow cover prediction

models for PV systems are proposed in this paper. According to the best of our knowledge, utilizing computational intelligence techniques to predict the presence of a snow cover on PV panels with an hourly resolution solely based on the main meteorological parameters is performed for the first time in the literature. The output of these models can be used as an input for the PVPF stage and help to reduce PVPF errors in snow conditions by enabling the implementation of PVPF approaches compatible with the characteristics of snow-covered PV systems. The study is performed on the historical dataset of electrical and meteorological parameters of a PV system in Canada over 3 years. By applying 5-fold cross-validation and hyperparameter tuning, the best hourly snow cover prediction accuracy, 96%, has been obtained by the developed gradient boosting tree model. Testing this model on the unseen data of 2 other PV systems has resulted in 80% and 78% accuracy for snow cover prediction.

### 13:20 *A Multi-Level Inverter Based On-Load Tap Changer Transformer Topology for Harnessing Photo-Voltaic Energy*

Abolfazl Babaei (University of Manitoba, Canada); Waldemar Ziomek (PTI Transformers LP, Canada); Aniruddha Gole (University of Manitoba, Canada)

In this paper, a new topology is proposed in which the electro-mechanical tap changing arrangement is replaced with a variable voltage ac source derived using a multi-level converter transforming photovoltaic (PV) generated dc voltage. The multilevel inverter circuit substitutes the change-over switch in the conventional configuration of tap changer transformers. In addition to being a point for connecting the PV source, the arrangement also improves the OLTC operation by eliminating the change-over switch transient and the need for the tie-in resistor. To demonstrate the viability of the proposed system, an existing topology of a five-level multilevel inverter is employed in the PLECS software. The results proved that the proposed structure is capable of maintaining the load voltage at the desired value.

### 13:40 *Wind Speed Forecasting Using ARMA and Neural Network Models*

Uzair Zaman, Hamid Teimourzadeh, Elias Hassani Sangani, Xiaodong Liang and Chi Yung Chung (University of Saskatchewan, Canada)

With the advancement of wind turbine generation technology, wind power plays an increasing role in modern power grids. To properly consider wind power for power systems planning and operation purpose, wind power and wind speed must be forecasted accurately. Wind is chaotic, random, irregular, and non-stationary in nature. This paper aims to forecast wind speed using both the statistical time series analysis method (autoregressive moving average (ARMA)) and neural network methods (feedforward neural network (FNN), recurrent neural network (RNN), long short-term memory (LSTM), and the gated recurrent unit (GRU)). The performance of the proposed five models is compared with the measured wind speed data, and the GRU model shows the best performance with the highest prediction accuracy, and the four ANN models outperform ARMA model.

### 14:00 *Dead-Time Effect on the Leakage Current of Grid Connected Single-Phase Photovoltaic Inverter*

Abdul Balıkcı (Dokuz Eylul University, Turkey); Eyup Akpinar (Dokuz Eylul Universty, Turkey); Enes Durbaba, Ali Kocamis and Buket Turan Azizoğlu, Türkiye (Dokuz Eylul University, Turkey)

The transformerless photovoltaic (PV) inverters are preferred in the PV systems because of its higher efficiency and lower cost. Due to the lack of galvanic isolation between the grid and PV panel, the leakage current flows through the parasitic capacitance of PV panel and the grounded neutral point of the power

transformer. Since the high-frequency components on the common-mode (CM) voltage is the main source for this current, the switching logic of devices in the PV inverter is usually arranged to suppress the leakage current circulation below the limit of safety standards. The dead-time is also a parameter of CM voltage waveform. The smaller dead-time of the wide-bandgap device GaN HEMT is considered as the advantage on the leakage current mitigation. It is experimentally investigated on the single-phase active clamped snubber-based inverter (ACSBI) topology here. The results with IGBT and GaN HEMT devices used in the ACSBI are compared in this paper.

**14:20** ***Identifying Influential Factors Affecting the Shading of a Solar Panel***

Farhad Khosrojerdi (Université du Québec en Outaouais (UQO), Canada); Stephane Gagnon (University of Quebec en Outaouais, Canada); Raul Valverde (Concordia University, Canada)

Photovoltaic (PV) systems produce less energy when operating under shadings. PV planners need to identify important factors affecting the shadings to forecast power generations in various ambient conditions. Using a case study, we show that overlooking the impact of an environmental factor, herein snowfalls, will result in overestimations in the power forecasting. In this paper, we study the context of the shading from different perspectives and introduce parameters that can affect the duration and severity of shading conditions. To identify key notions of the shading and important factors involved, we implement a literature review and include experts' knowledge by exploring PV planning tools and conducting a survey in the sector of solar energy. The identified factors can be used to develop a knowledge-based model representing key concepts associated with shading conditions. In addition, the identification of important factors affecting the duration and severity of shading conditions addresses new research domains that need to be explored in the field of PV shading and power estimation.

**14:40** ***Forecasting of Solar Power Volatility Using GJR-GARCH Method***

Sumana Ghosh (University of Central Florida, USA); Pawan Gupta (University of Maryland, Baltimore, USA)

The rapid increase in solar power plant installation creating considerable difficulties for power system operation and control, due to highly stochastic nature of solar energy. To ensure a smooth solar panel output, an accurate short time forecast plays a crucial role in grid energy management. In this paper a problem of hours ahead solar plant power prediction and forecasting is considered. This accurate prediction can significantly improve the electricity cost by planning the extra power generation for supplying loads. For a case study, a meteorological dataset for a real operated solar power plant is used to develop and verify the forecasting model. A detailed time series analysis of the solar power output (per second data) has been used to for model development and validation. Additionally, after investigating different techniques, a Glosten-Jagannathan-Runkle Generalized Auto Regressive Conditional Heteroskedasticity (GJR-GARCH) based forecasting has been proposed. The developed model predicts solar power with high accuracy with a confidence interval of 99%. The results and verification with real data set proves the capability on applying this method in industrial applications. These predicted models are utilized to generate battery control signal ensuring a smooth power flow to the grid or directly send to the grid for ensuring peak energy savings.

**15:00** ***Game-Theoretic Economic Models of Duopolies Applied to Green ICT Design***

Martina Cappelletti, Nicola Cibin and Leonardo Badia (Università degli Studi di Padova, Italy)

Green design of ICT products is fundamental to obtain sustainable global development of advanced technologies. Its implementation is influenced by many economic factors, including the choices of both operators and consumers, as well as government incentives. In this paper, we study this problem under a game theoretic perspective based on classic competition models, namely Bertrand and Cournot duopolies, with proper modification to capture the traits of green ICT conversion. We explore how market equilibria and public subsidies determine whether competing enterprises put into action green practices. Due to its generality, our proposed framework can be adapted to practical evaluations in specific contexts of local economies.

# TSA2: Technical Session 2 - Afternoon - Day 3

Data Mining, Artificial Intelligence, Machine Learning (Part 2)

Chair: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran)

### 13:00 *A Comparative Study of Hourly Wind Speed and Power Forecasting Using Deep Learning Networks, Weka Time Series, and ARIMA Algorithms for Smart Grid Integration*

Abdussalam T. Mohamed, Hamed Aly and Timothy Little (Dalhousie University, Canada)

In modern development, renewable energy is playing a crucial role for smart grid integration and in electricity demand growth as it is green and clean. Including all sources of renewable energy, wind power is particularly prevalent as it is pollution-free, cheap, and highly efficient. The main challenge that restrains the expansion of wind power utilization within the power grid is wind speed variation and uncertainties. Thus, precise wind speed forecasting is a difficult modeling approach, that greatly influences the wind power and optimal operation of the power grid. Prediction of wind speed is vital for wind power calculation and forecasting. Renewable energy forecasting is important for minimizing the power cost, scheduling energy resources, and planning maintenance. The advanced wind power forecast models help advances efficient operation and maintenance for wind turbines. This paper analytically studies the state-of-the-art approaches of wind speed forecasting regarding statistical methods (ARIMA, Weka time-series, and Deep Learning Networks), including data preprocessing, features engineering, and factors that touch prediction accuracy and modeling time. Likewise, this study provides a comparison to find the most accurate time series forecasting method based on performance evaluation.

### 13:20 *An Automated Data Validation Approach to Enterprise Asset Management for Power and Utilities Organizations*

Kennedy Oyoo (University of Arkansas at Little Rock (UALR) & Capgemni Invent, USA); Daniel Berleant (University of Arkansas at Little Rock, USA)

Power and Utilities (P&U) organizations generate important data from Enterprise Asset Management (EAM)systems, which are used to help manage physical asset life cycle, operations, and related business processes. A range of physical asset types are used in power generation, transmission, and distribution. Asset Data Quality (ADQ) in EAM is one area which is often overlooked during EAM system implementation. The information quality focus has been on the final database, leading to rework and even persistent data quality deficiencies, thereby losing the significant benefits of enforcing data quality by designing data structures correctly at their source before data records are added to the database. Good quality asset data supports organizational objectives, where quality is associated with the "fitness for use" of data as the

overarching, multidimensional perspective on the quality of the data. This is about the fitness of data for supporting operations, and distinct from the fitness for use of the equipment itself. A high quality asset data set also directly contributes to the decisions the asset owner must make to increase asset availability, optimize overall cost of asset maintenance, and reduce risks associated with asset operation. This paper proposes the Automatic Data Validation (ADV) Approach for validating fitness for use of asset data using three data quality dimensions: completeness, uniqueness, and consistency. An implementation, ADV Tool, is also presented as a proof of concept to show how it can benefit EAM business processes in P&U organizations by improving asset data quality.

### 13:40 *Ensemble Learning Framework for Partial Discharge Detection*

Abdarahmane Traoré, Mohamed Chetoui, François-Guillaume Landry and Moulay A. Akhloufi (Université de Moncton, Canada)

Partial discharges (PD) are small discharges which, in the medium and long term, can severely damage electric transmission lines' equipment. If not timely solved, partial discharges can lead to a permanent damage and stop the equipment from functioning properly. A solution to this problem would therefore be part of the tools used in the transition from the standard electricity grid to a smart grid. In this work, we propose an ensemble learning approach to predict partial discharges. The ensemble model is formed of four sub-models based on deep recurrent neural networks (Long Short-Term Memory) and linear regression. Multiple tests, various feature extraction techniques and hyperparameter optimizations were conducted. The obtained results are promising and show the high performance obtained by the proposed model with an accuracy of 97.3%, outperforming many past works in the field.

### 14:00 *Locational Marginal Price Forecasting Based on Deep Neural Networks and Prophet Techniques*

Abdussalam T. Mohamed, Hamed Aly and Timothy Little (Dalhousie University, Canada)

In many of the electricity markets in North America, the electricity prices are in terms of the locational marginal price (LMP) which reflects the cost of supplying the next MWh of electricity at a bus, considering transmission constraints. Electricity price forecasting provides vital information on system conditions to the independent system operator (ISO). It indicates important signals pertaining to the need of investing in the new generation, upgrading transmission, or reducing electricity consumption. Power suppliers and consumers use the forecasted price to optimize the profit in the day-ahead market and bilateral contracts. Facility owners rely on the forecasted price to make investment decisions. Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) networks are applied to improve short-term (time series) LMP forecasting accuracy. Dataset from the ISO-NE power market is utilized in modeling and analysis in which the proposed techniques are applied using Matlab and Python software. Various methods are evaluated and compared, and the conclusions achieved show that LSTM has lower error rates and higher accuracy than the Prophet forecasting model in 24 h-ahead LMP forecasting.

### 14:20 *An Iterative Clustering Approach for Tracking Server Logs for Monitoring SCADA EMS/DMS*

Jit Biswas (Singapore U of Tech and Design, Singapore); David Yau (Advanced Digital Sciences Center, Singapore); Ming Yu and Ih-Lunn Kon (Power Automation Pte. Ltd., Singapore); Zihao Li and KianWee Chua (Singapore University of Technology and Design, Singapore); KengNan Tan, Zhimin Zhang, Jimmy Chua, Waiann Tso and

Yongkean Heng (Power Automation Pte. Ltd., Singapore)

Due to continuity of operation, software upgrades and patches may need to be incorporated without adequate testing. Tracking system log messages allows us to compare a system's behavior over periods of time. We present an iterative clustering approach for weekly system logs that are maintained by servers in SCADA EMS/DMS systems. The main goal is to monitor behavior from one week to the next, for the purpose of summary reporting and diagnostics. The algorithm identifies clusters iteratively by reducing the data-set to a remaining set of outliers at each iteration. Details of the identified clusters are retained for further exploration and analytics. A set of tracking scores is obtained as a concise representation of weekly system behavior. The tracking scores are based on different metrics. We demonstrate the application of our algorithms using two real-life datasets from SCADA EMS/DMS. We also extend basic clustering algorithm through application of template matching rules to assign feature labels to each line of an input log, thereby preparing the datasets for machine learning applications. The algorithms presented are proposed as a means for monitoring weekly operations as well as studying the effect of long term changes caused by patched and upgraded software.

**14:40 *Wind Speed Forecasting by Conventional Statistical Methods and Machine Learning Techniques***

Shah Mohammad Rezwanul Haque Shawon, Md Abu Saaklayen and Xiaodong Liang (University of Saskatchewan, Canada)

Intermittency is the main challenge for wind power integrated in power grids. The intermittent nature of wind speed gives rise to fluctuations of output power from a wind turbine that poses serious concerns over power system stability and reliability. Therefore, accurate wind speed forecasting is essential for planning and operation of wind power generation. In this paper, short term wind speed forecasting methods are investigated using one-year historical data. Conventional time series methods (Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA)) and machine learning methods (Artificial Neural Network (ANN) and three Support Vector Machine (SVM) algorithms (Linear SVM, Polynomial SVM and radial basis function (RBF) SVM)) are considered in this study. The forecasted wind speed data are compared with historical wind speed data in terms of Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). Results obtained in this paper show that machine learning methods outperformed conventional time series methods in short-term wind speed prediction.

# Sunday, October 24 13:00 - 14:20

## TSA3: Technical Session 3 - Afternoon - Day 3

Real-Time Simulation

Chair: Hani Vahedi (Ossiaco Inc., Canada)

**13:00 *Case Study of Designing a Locally Distributed Real-Time Simulation Infrastructure***

Moritz Weber and Michael Kyesswa (Karlsruhe Institute of Technology, Germany); Uwe Kuehnapfel (KIT, Germany); Veit Hagenmeyer (Karlsruhe Institute of Technology, Germany); Huseyin Cakmak (Karlsruher Institut für Technologie, Germany)

With an increasing number of power electronics connected renewable energy sources, electromagnetic

transient (EMT) simulations become increasingly important to accurately simulate the behavior of electric power grids. EMT simulations are computationally expensive, and often specialized hardware, such as Real-Time Digital Simulators (RTDS), are used to run simulations in real-time. As individual simulators are limited in their computational capabilities, they can be interconnected in order to fully leverage their potential and enable more complex simulations. However, since these simulators are expensive and often located near power hardware for hardware-in-the-loop simulation, they are regularly distributed across multiple locations of different research institutions or organizations. The main contribution of this paper is the assessment of different approaches to connect multiple RTDS systems to form a locally distributed simulation infrastructure. For this, we combine a realistic and comprehensive model of a campus grid with a microgrid model to investigate the benefits and limitations of the different connection approaches.

### 13:20 *Evaluating a Microgrid Control System Using Controller Hardware in the Loop Simulations*

Mo'ath Farraj, Roshani Kaluthanthrige and Athula Rajapakse (University of Manitoba, Canada)

In recent years, microgrids have become significantly complex due to the integration of inverter-based distributed energy resources (DERs) along with conventional generation resources. Proper deployment of microgrid control strategies is imperative to achieve a reliable, secure, and stable power system operation. This paper presents a hierarchical controller embedded in a model predictive control framework. The functionality of the proposed microgrid controller is demonstrated on a controller hardware in the loop (CHIL) simulation platform. The structure of the testbed, the development and coordination of the hierarchical control levels, and the integration of the IEC-61850 communication protocol are discussed. The overall study confirms the effectiveness of the proposed hierarchical controller as well as the applicability of the developed testbed in providing a realistic operation evaluation platform.

### 13:40 *H-Infinity Robust Control of a Transparent Power-Hardware-In-The-Loop System*

Zhaolin Liu (Australian Nuclear Science and Technology Organisation, Australia); Marcello Colombino (Fortum OY, Switzerland); Dmitry Rimorov (Hydro-Quebec IREQ, Canada)

Power-Hardware-in-the-Loop system is a testing infrastructure capable of integrating real equipment and highly accurate real-time simulation models of power grids. The interface operating between the hardware and software is a complex hybrid control system tasked with ensuring that the both the hardware and simulation system are seamlessly integrated. As such, it may face stability, robustness and performance issues, for which different methods have been proposed in the literature. This paper proposes a novel method of designing the control interface using H-infinity robust control tools. We utilise a nominal model with parameter uncertainties, allowing the resulting controller to not only achieve robust stability within the uncertainty space but also improve performance and accuracy. Based on simulations containing a wide range of parameters, the H-infinity robust control method shows promising results compared with the state of the art in the literature. It offers the ability to synthesise a controller that is robust against uncertainties in time delay and impedance values, and at the same time, allows the designer to have more flexibility in characterising the performance and stability of the interface algorithm.

### 14:00 *An Overview of Cold Load Pickup Modeling for Distribution System Planning*

Mario Gonzalez, Keaton A. Wheeler and Sherif Faried (University of Saskatchewan,

Canada)

The study of the load diversity in networks with high penetration of thermostat-controlled loads is an important process in the distribution system planning stage as it provides useful information for the proper selection and sizing of power equipment, and calibration of protective devices. However, as the load diversity in a power system could be negatively impacted during extended outages, the estimation of the cold load pickup current magnitudes during restoration must be taken into account, as these may cause significant overloading and interfere with the intended operation of overcurrent devices. In this paper, several cold load pickup (CLPU) models are recompiled from the literature and an analytical comparison between them is presented with the purpose of presenting the differences in the estimation of the CLPU levels during service restoration.

# Sunday, October 24 14:20 - 15:20

## TSA3-1: Technical Session 3.1 - Afternoon - Day 3

Transactive Energy and Electricity Markets

Chair: Mehrdad Rostami (Stantec Consultant Co. & IEEE Smart Grid Publication Committee, Canada)

**14:20** ***Market-Clearing Mechanism for Demand Aggregation at the Distribution Level Through Transactive Energy***

David Camilo Toquica Cardenas (Université du Quebéc à Trois-rivières, Canada); Kodjo Agbossou (Universite du Quebec à Trois-Rivieres, Canada); Nilson Henao (Univesité du Québec à Trois Rivieres, Canada); Roland P Malhame (Ecole Polytechnique de Montreal, Canada); Sousso Kelouwani (Université du Québec à Trois-Riviéres, Canada); Juan Oviedo Cepeda (Hydroquebec, Canada)

Demand aggregators work as service providers for both demand- and supply-side agents. Thus, they can add value to all the electric sector and link solutions across the complete power systems infrastructure. However, their implementation faces challenges related to outdated regulatory and market frameworks and customers' uninterest. Indeed, the traditional hierarchical grid structure, which considers consumers as passive agents, does not incentivize the appearance of demand aggregators. This condition is currently changing due to Transactive Energy (TE) mechanisms that empower customers to contribute to grid management. Therefore, TE could be the appropriate environment to incentive demand aggregators to provide their services. In this context, the present paper analyzes a market-clearing mechanism in local distribution markets for demand aggregators to benefit from TE features coordinating flexible residential resources. The proposed configuration is a Stackelberg game where the aggregator parametrizes the residential demand to formulate an optimal pricing strategy. Simulations of the transactions show the feasibility of using an approximate model to parametrize and flatten the aggregated demand.

**14:40** ***A Design for an Urban Electricity Market to Reduce the Expansion of the Low Voltage Distribution Grid***

Franz Teske (FAU Erlangen-Nürnberg, Germany); Iris Wittl (Katholische Universität Eichstätt-Ingolstadt, Germany); Felix FF Funk (University of Erlangen-Nuremberg, Germany); Adrian Fehrle (FAU Erlangen-Nürnberg, Germany); Jörg Franke (FAU

Erlangen-Nuremberg, Germany)

The transition from a centralized to a decentralized energy system is driven by prosumers, i.e., private households who operate flexible decentralized energy systems (DES). The demand and supply peaks resulting from their volatile consumption and generation can lead to grid bottlenecks and thus make expensive grid expansion necessary. Therefore, various approaches to use the existing power grid more efficiently by controlling private DES are being researched. In this paper, we propose a smart market platform (SMP) that reduces the need for grid expansion and incentivizes prosumer participation. The SMP also avoids grid congestions in the short term and provides suitable investment incentives in the long term. We conduct a scenario analysis to demonstrate that even using limited grid infrastructure, energy demands can be met in most scenarios. Our results show that market-based and decentralized coordination of control measures to reduce grid expansion can achieve advantages over existing solutions. These include more efficient asset dispatch in the short term, long-term investment incentives and, integration of different DES as well as individual needs of prosumers.

**15:00** ***Trading Strategy in a Local Energy Market, a Deep Reinforcement Learning Approach***

Olamide Jogunola, Yakubu Tsado, Bamidele Adebisi and Raheel Nawaz (Manchester Metropolitan University, United Kingdom (Great Britain))

In response to energy transition fueled by the increasing energy generation mix and dynamic environment, this paper presents an energy trading strategy utilising real microgrid data. Specifically, we adapted the deep Q-network (DQN) with prioritised experience replay (PER) to develop a DQN-PER-based energy market algorithm to optimise the utility derived by prosumers participating in a local energy market (LEM). The problem of exercising energy trading actions is formulated as a sequential decision-making problem to optimise the prosumer's utility in a variety of energy trading scenarios. This includes the contingencies/ flexibility provided by the energy storage system (ESS), the incorporation of PV sources and the decision to trade with the grid or in a LEM. The results show the benefit achieved in trading energy in LEM with higher benefits when more sources of renewable energy are incorporated. For instance, the average benefit of trading in the LEM over the grid with ESS is 35%, which increased to 54% when PV and ESS are incorporated.

# Friday, October 29

# Friday, October 29 10:00 - 16:30

## TW1: Writing Technical Reports for Industry Professionals

Eric Tung

Chairs: Celia L Desmond (World Class Telecommunications, Canada), Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran)

Brochure Introduction

Engineers are great at analyzing a problem and determining what needs to be done to resolve it. This is the exact skill needed to create clear, concise, and interesting written technical reports and documents. This seminar provides a highly interactive environment, with group workshops and

practice exercises that are focused on technical writing that is tailored for different readers. You'll also receive individual feedback on your writing and learn how to craft a report that will be read past the executive summary.

Seminar Description

How can I ensure my reports are effective for both technical and non-technical audiences? What do I need to do to convey complex information clearly?

Whether you're writing for internal or external audiences, and for technical or non-technical audiences (or both), this seminar is focused on building your writing skills, with an emphasis on pragmatic strategies and techniques that you can apply immediately for your reports.

You'll incorporate the strategies required for conveying complex subject matter effectively, along with conveying negative news and writing persuasively. You'll apply the strategies required for effective reports and more. In addition, you'll also incorporate key principles for writing concisely.

We'll cover multiple topics, including:

1. Following a structured approach to planning, drafting, and revising your technical reports
2. Writing reports for multiple audience groups, ranging from technical to non-technical audiences
3. Incorporating graphics, tables, and additional information in your reports
4. Writing concisely
5. Conveying negative news
6. Writing persuasively
7. Making clear recommendations

This interactive seminar will consist of instructor-led lecturing, along with group workshops and practice exercises. After the session, you'll also have the option to submit a brief writing sample to receive individual feedback.

About the Instructor: Eric Tung, MA, is an English Instructor at the University of British Columbia's Extended Learning, where he teaches various writing courses, including a course on advanced business writing. He previously designed and taught a course specifically for Engineers, along with courses on grammar, writing with style, and strategic conversations and meetings. He is also a Lecturer at Simon Fraser University, where he teaches Business Communications to senior-level Bachelor of Business Administration students at the Beedie School of Business.

As a Principal Consultant at Prolepsis Consulting, Eric designs and delivers customized business, proposal, and technical writing workshops to various organizations, including engineering and consulting firms. He has an extensive background in technical writing and business communications, including writing technical documentation, drafting business development plans, crafting proposals,

and writing other complex documents.

Eric is also a Change Management Consultant and specializes in change management strategy and implementation, organizational readiness and assessments, stakeholder engagement, coaching, facilitation, instructional design, and training. He has extensive experience implementing enterprise-wide transformation programs and projects for both private and public sector clients.

## Saturday, October 30

# Saturday, October 30 10:30 - 12:30

## TSM1: Technical Session 1 - Morning - Day 4

Distributed Energy Resources (Part 1)

Chair: Tu Nguyen (Sandia National Laboratories, USA)

**10:30 *A Game-Theoretic Approach for Charging Demand Management of Electric Vehicles During System Overload***

Akhtar Hussain and Petr Musilek (University of Alberta, Canada)

To manage the charging demand of electric vehicles (EVs) under maximum power limit constraints, a single-leader-multi-follower Stackelberg game theory-based solution approach is proposed in this study. A utility function is formulated for EVs considering the sensitivity of the EV owners to the battery degradation and the current energy level. A pricing mechanism for charging station operators is also devised to incentivize EVs for managing their charging demands locally, without violating the maximum power limit set by the distribution system operator. To this end, a decentralized welfare maximization model is formulated, where EVs do not need to share their private information with the charging station operator. The developed model is solved in a distributed way using the primal-dual subgradient method. The performance of the proposed method is analyzed for different power limits along with different sensitivity and energy levels. Results have shown that the proposed method can manage the charging demand of EVs considering individual sensitivities and maximum power limits of the charging station.

**10:50 *Energy Efficiency Diagnosis and Improvements for Electrical Systems in Brazilian University Buildings Using RTQ-C Regulation***

Dayane C. P. Oliveira (Universidade Federal Rural do Semi-Árido, Brazil); Max Chianca Pimentel, Filho (UFRN, BRAZIL, Brazil); Antônio Alisson Alencar Freitas (Universidade Federal Rural do Semi-Árido, Brazil)

This work proposes the diagnosis and suggestions for improvements to the electrical systems of buildings at the Federal Rural University of the Semi-arid Campus of Caraúbas- RN. The systems assessment is supported by the Technical Quality Regulation for the Energy Efficiency Level of Commercial, Service and Public Buildings (RTQ-C) of the National Electricity Conservation Program. The analyses consider the installed power density of the lighting system, the electrical circuits division, natural lighting of the environments, automation of the lighting system and efficiency of the air conditioning devices., was made a comparative analysis between the real level of energy efficiency of buildings and the level of efficiency

expected based on the implementation of improvements.

### 11:10 *Multi-Objective Spatiotemporal Optimization of Transportation and Power Management by Using Multiple Electric Vehicles in Nanogrid Networks*

Hiroshi Uchigaito and Mamoru Okamoto (Hitachi, Ltd., Japan); Gleb Astashkin (Yandex, Russia); Yuki Furubayashi, Norihiro Obata and Thantip Krasienapibal (Hitachi, Ltd., Japan); Hiroshi Teramoto (Kansai University, Japan); Yuta Mizuno, Masato Kobayashi, Atsuyoshi Nakamura and Tamiki Komatsuzaki (Hokkaido University, Japan); Takashi Takemoto (Hitachi, Ltd., Japan)

For achieving a low-carbon society and providing stable energy supply to local areas, we propose a distributed energy system in which multiple small grids are installed in a distributed manner in an area. Multiple electric vehicles located in the area are used as mobile batteries for power leveling between grids and used as regional transportation. To construct this system, it is necessary to provide practical solutions in accordance with the needs in various areas by adjusting the balance between optimization of power management and transportation, which are in a trade-off relationship, while dealing with uncertainties such as climate change and time-varying transportation demand in a short time. In this paper, we propose a multi-objective spatiotemporal optimization algorithm for solving the above problem. We compared the performance of the proposed algorithm with a vehicle-routing-problem solver of Google OR-Tools, demonstrating that the transportation rate increased by 13% and sum of power excess and shortage in grids decreased by 87%. The proposed algorithm can also adjust the balance between optimizations of transportation and electricity-management, suggesting that it can be applied in various areas.

### 11:30 *Modeling and Control of Solar PV System Combined with Battery Energy Storage System*

Mahmoud M Badreldien, Mohammed Allehyani, Mohamed Abuagreb and Brian K Johnson (University of Idaho, USA)

The sun is the main source for much of power in our global system. So, the research activities in solar systems should be endless, especially with the high cost and pollution problems caused by the conventional power sources. This paper presents modeling, control of a solar photovoltaic system using a maximum power point tracking technique. Because of the intermittent nature of the solar irradiation, an energy storage system is connected in parallel with the PV system. The proposed system in this paper includes a battery energy storage system and the required DC-DC and DC-AC controllers. Different scenarios have been studied such as changing irradiation levels at a fixed load and load variation at a certain irradiation value to verify the control response of the proposed system. The control systems modeled in d-q reference frame for controlling the active and reactive power from the system is been simulated using electromagnetic transient simulation to verify the system operation.

### 11:50 *Active Distribution Network Optimal Power Flow Deploying the Benders Decomposition Method*

Mahan Fakouri Fard and Farhad Elyasichamazkoti (University of Utah, USA); Armin Fooladi savadkouhi (Iran University of Science and Technology, Iran)

The goal of this paper is to solve the problem of optimal power flow (OPF) in the presence of various elements such as microgrid (MG), distributed energy resources (DER), Electrical Vehicle charging stations (EVCS), renewable energy sources (RES) including wind turbines, photovoltaic cells, energy storage

elements, and so on. Using centralized techniques to address such a high-burden computing problem is the most common method. However, in this study, the Benders decomposition method is used to keep the data privacy among distribution users and also save the computation time for solving the OPF problem.

**12:10** ***Triangular-Shaped and Simultaneous Adjustment of Inertia and Damping in VSG-Based Distributed Energy Resources for Improved Frequency Response***

Erfan Mostajeran and Arash Safavizadeh (The University of British Columbia, Canada); Seyyedmilad Ebrahimi and Juri Jatskevich (University of British Columbia, Canada)

The concept of virtual synchronous generators (VSGs) has been introduced as a viable control methodology for interfacing power electronic-based distributed energy resources (DERs) with the grid. This paper investigates a family of VSG control mechanisms with variable parameters; and proposes a new approach that simultaneously adjusts both the virtual inertia and damping in order to improve the overall frequency response of the DERs. The proposed method employs simplified triangular-shaped trajectories for changing the inertia and damping coefficients. Specifically, the proposed controller simultaneously increases both the virtual inertia and damping parameters based on the measured load disturbance in the power system, and decreases them linearly with an adjustable slope, which offers a simple implementation. The effectiveness of the proposed method is verified using computer simulations of a small-scale power system including a DER and a load. It is shown that the proposed control method improves the dynamic frequency response compared to the existing state-of-the-art VSG control techniques.

## TSM2: Technical Session 2 - Morning - Day 4

Electric Vehicle Infrastructure (Part 1)

Chairs: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran), Alireza Siadatan (University of Toronto, Canada)

**10:30** ***Energy Based PMSM Drive Electric Vehicle to Eliminate High Frequency Switching***

Vonteddu Shanmukha Naga Raju (University of Petroleum and Energy Studies, India); Kollu Ravindra (JNTU Kakinada, India); Prasanthi Nunna (University of Petroleum and Energy Studies, India)

This paper presents the design of Electrical Vehicle (EV) model which is suitable for hardware deployment. Energy based modeling is employed to avoid high frequency switching. The behavior of the EV is estimated subjected to the driver inputs and environmental conditions. Energy based Permanent Magnet Synchronous Motor (PMSM) drive system, cooling system, electric and thermal system and vehicle control systems are modeled in MATLAB environment. A test run of vehicle climbing the hill is considered in MATLAB/Simulation to evaluate the parameters such as torque, vehicle speed, throttle, cruise, brake, motor torque, temperature.

**10:50** ***DFACTS-Based Mitigation of Power System Voltage Unbalance for Wide Adoption of EV Fast Charging Systems***

Iman Babaeiyazdi, Afshin Rezaei-zare and Shahab Shokrzadeh (York University,

Canada)

This paper aims to investigate the unbalanced voltage effects of three-phase fast charging stations on power systems and devise an effective mitigation approach. A detailed three-phase fast charging system (FCS) with power factor correction capability is implemented in the EMTP-RV time-domain simulation environment and its operation characteristic is derived under unbalanced voltage conditions. This characteristic is employed in the power flow calculation and unbalanced voltage analysis. The results indicate that the FCS integration into the power system exacerbates the voltage unbalance if the system possesses a background unbalanced voltage. As a result, with a heavy adoption of the fast-charging systems, the system unbalanced voltage can exceed the standard limits. To mitigate the unbalanced voltage and accommodate higher capacity of FCSs in the system, PWM-based converters are employed as distributed flexible AC transmission system (DFACTS) to mitigate the negative-sequence voltage resulting from the FCSs. With such a mitigation approach, optimal charging capacity in the system under study is obtained such that the voltage and the unbalanced voltage standard limits are not violated. The simulation results demonstrate that the proposed method can effectively mitigate the unbalanced voltage impacts and enable the power system to accommodate more fast charging stations.

**11:10** ***Battery Electric Bus System Schedule-Based Optimization***

Mohammad A Kharouf and Morad Abdelaziz (University of British Columbia, Canada)

Battery electric buses are a promising substitute for diesel buses that can help in reducing GHG emissions. In order to help municipalities and transit authorities in making informed decisions about their transit bus system electrification, this work presents a mixed integer linear programming model that is developed to find the optimal transit bus system electrification decisions taking into consideration the actual operation bus schedule and electric utility demand charges. The proposed model identifies the optimal size of each bus battery, the type and distribution of fast charging infrastructure, as well as energy storage systems capacity and location. The ideal combination of flash and opportunity charging modes is considered in the model.

**11:30** ***Dynamic V2V Power-Sharing for Collaborative Fleets of Autonomous Vehicles***

Juan Múgica González (Universidad Politecnica de Madrid, Spain); Naroa Coretti Sanchez (Massachusetts Institute of Technology, USA); Pablo Garrido Martínez Llop (Universidad Politecnica de Madrid, Spain); Luis Alonso (Massachussets Institute of Technology, USA); Kent Larson (MIT, USA)

The current trends towards electrification, autonomy, and vehicle-sharing are predicted to transform mobility. However, the charging process is one of the main issues preventing electric vehicles from populating our roads. We envision a future in which fleets of autonomous vehicles will work as a bio-inspired collaborative system. In this future, vehicles will share battery with other vehicles while moving, doing what is more efficient for the system as a whole instead of following their own independent rulesets. As a result, vehicles will access energy anywhere and anytime. This lightweight infrastructure solution will minimize costs and infrastructure availability problems. Vehicle downtime and the miles traveled related to charging will also be reduced, making the use of vehicles more efficient. This paper proposes a connection that allows sharing battery while moving by combining wireless power transfer and an electromagnet. A proof of concept prototype has been built to validate the proposed connection.

**11:50** ***Towards a Co-Simulation of Electric Vehicles with Power Grid***

Arsham Bakhtiari and Francesco Ciari (École Polytechnique Montréal, Canada); Ali

Moeini (Hydro-Québec/IREQ, Canada); Ali Hajebrahimi (Hydro Quebec & HQ, Canada)

Electric vehicles have gained much more attention in the last decades, as they are considered a promising substitute for internal combustion engine vehicles, in terms of lower CO2 emissions and dependence on fossil fuels. Many developed and developing countries have announced incentive policies to support the electric vehicle industry. As a result of these advantages and incentives, it is anticipated that the number of electric vehicles overtakes the number of fossil-fueled vehicles in near future. This high penetration of electric vehicles might cause some problems to the power network grid, as the current power grid infrastructures are not designed for mobile loads. Therefore, in order to evaluate the potential impacts of high penetration of electric vehicles on the power grid, electric vehicles cannot be evaluated alone and a co-simulation approach between electric vehicles and the electric power grid should be considered. After, reviewing the previous studies on these potential impacts and the available solutions to address them, this paper proposes a co-simulation approach between electric vehicles and the power grid. If the co-simulation approach introduced in this work be accurately implemented, policymakers and authorities will be able to manage and mitigate the potential impacts of electric vehicles on the electric power grid.

### 12:10 *Performance Evaluation and Enhancement of an Electric Vehicle DC Fast Charging Station in a Weak Distribution Feeder*

Zhi Jin Zhang (Georgia Institute of Technology, USA); Reza Iravani (University of Toronto, Canada)

This work investigates and evaluates the performance and impact of a dc fast charging station (DCFCS) in a rural distribution feeder under various grid conditions. The station includes three dc fast chargers, each of which is rated at 360 kW and 900 V. The studies are conducted in time-domain using the off-line PLECS software platform. The studies show that the point of common coupling (PCC) voltage drop limits the lowest short-circuit ratio (SCR) that the DCFCS can satisfactorily operate with. An enhancement method, utilizing both a load curtailment strategy and a battery energy storage system, is consequently proposed to maintain the PCC voltage above its lower limit under low SCR conditions, thereby extending the charging station's range of operation. RTDS-based real-time simulation results i) verify that the enhanced DCFCS is able to operate under the extended grid condition and ii) demonstrate the hardware implementation feasibility of the proposed methodology.

## TSM3: Technical Session 3 - Morning - Day 4

Active Distribution Systems

Chair: Mehrdad Rostami (Stantec Consultant Co. & IEEE Smart Grid Publication Committee, Canada)

### 10:30 *Live Testing of Flexibilities on Distribution Grid Level - Simulation Setup and Lessons Learned*

Fabian Erlemeyer and Christian Rehtanz (TU Dortmund University, Germany); Annegret Hermanns (EON SE, Germany); Bengt Lüers (Oldenburg University & DFKI, Germany); Marvin Nebel-Wenner and Reef Eilers (OFFIS eV, Germany)

In the DESIGNETZ project real flexibility units were connected to a distribution grid simulation to investigate the integration of decentralized flexibilities for different use-cases. The simulation determines

the demand for unit flexibility and communicates the demand to the flexibilities. In return, the response of the flexibilities is integrated back into the simulation to consider not-simulated effects, too. This paper presents the simulation setup and discusses lessons learnt from deploying the simulation into operation.

**10:50** ***A Revenue-Cost Sharing Methodology for the Peer-To-Peer Energy Trading in a Residential Community***

Mojtaba Dadashi (University of Tabriz, Iran); Sara Haghifam (University of Vaasa, Finland & University of Tabriz, Iran); Kazem Zare (University of Tabriz, Iran); Hannu Laaksonen and Miadreza Shafie-khah (University of Vaasa, Finland)

Generally, the low selling price of energy to the utility has increased local prosumers' tendency to exchange their surplus power with their neighbors at the distribution level. Nonetheless, to this end, providing an appropriate paradigm based on Peer-to-Peer (P2P) energy trading is highly required. Accordingly, this research work seeks to present a new revenue-cost sharing methodology for trading the generated energy as well as the storage capacity of several types of households with one another in a residential community. The proposed algorithm implements an energy management program in a way to not only optimize the performance of the residential community but also minimize its total operating costs. On the other hand, to determine the P2P electricity price and calculate the electricity cost of each household, one pricing mechanism according to traded powers is employed in this study. In the end, to assess the efficiency of the raised P2P framework, the optimal operation of a typical community in the presence of wide ranges of real as well as virtual resources in two case studies, without and with considering P2P energy sharing, is investigated and compared.

**11:10** ***Electric Vehicles Load Forecasting Considering the Effect of COVID-19 Pandemic***

Ahmad Abu Nassar, Kandarp Gandhi and Walid Morsi (Ontario Tech University (UOIT), Canada)

This study addresses the problem of the electric vehicles load forecasting through the application of a modified Kalman filter method. The electric vehicles charging demand for the years 2019 to 2020 are used to predict the electric vehicles load demand for the year 2021, which incorporate the effect of COVID-19 pandemic. Such effect on the electric vehicles load and the forecasting method are discussed and the conclusion are drawn.

# Saturday, October 30 13:00 - 15:00

## TSA1: Technical Session 1 - Afternoon - Day 4

Electrical Machines & Drivers (Part 1)

Chairs: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran), Alireza Siadatan (University of Toronto, Canada)

**13:00** ***Influence of Carbon-Based Winding on Maximum Torque and Specific Torque Designs of SPM Machines***

Robert Sag (TU Berlin & Robert Bosch GmbH, Germany); Uwe Vollmer and Martin

Köhne (Robert Bosch GmbH, Germany); Uwe Schäfer (TU Berlin, Germany)

The article deals with optimal design of surface-mounted permanent-magnet machines with carbon-based conductors. Owing to its high electrical and thermal conductivity, as well as low mass density, carbon-based conductors could be a break-through technology in achieving more power-dense electric machines. Authors analytically optimize machines with different winding parameters for maximum torque and specific torque taking into account both electromagnetic and thermal phenomena. The optimized machines are compared to machines with copper winding and improvements of up to 50% in torque density are obtained.

### 13:20 *Design of DC-Link Nonlinear Controller for Two-Stage DC-AC Converter for Drive Applications*

Youssef El Haj (Ontario Tech University, Canada); Ahmed Sheir and Ruth Milman (UOIT, Canada); Vijay K. Sood (Ontario Tech University, Canada)

As electric machine drives are growing in complexity, controlling the dc-link voltage within their drive train becomes an increasing challenge. This paper implements a nonlinear peak current mode (PCM) controller in a dc-dc converter in drive applications. Unlike conventional PCM controllers which rely on constant or linear slope that is generated by the converter's inductor current to control its output voltage, the piecewise quadratic slope (PQS) utilizes a nonlinear piecewise quadratic compensation signal that provides a wider range of operation and higher immunity against disturbances. In this paper, a comparative study is conducted between the nonlinear PQS controller and a conventional voltage mode controller. A two-stage dc-ac drive train consists of a dc-dc boost converter and a 3-leg 3-phase inverter driving an induction machine (IM) is used as a test bed for both controllers. The simulation results show that the PQS controller not only reduces system oscillations, overshoot / undershoot, and settling time, but also it helps in mitigating protentional converter failures during transients by stabilizing its internal dynamics.

### 13:40 *A Study on AC Resistance Calculation of Single Rectangular Conductors*

Barzan Tabei (University of Manitoba, Canada); Akihiro Ametani (University of Manitoba, Japan); Aniruddha Gole and Behzad Kordi (University of Manitoba, Canada)

This paper presents a study on calculating the ac resistance of single rectangular conductors using finite element method (FEM), considering a quasi-static approximation. Different analytical approximations for ac resistance of rectangular conductors are also presented, and their accuracy with different conductor thicknesses are examined by comparison with FEM results. Two examples are considered: a very thin rectangular conductor, and a square conductor. A transient simulation is performed using the square conductor to investigate the effect of different ac resistant calculations on damping in the time domain simulation. This work would help in appropriate selection of analytical approximation of ac resistance of rectangular conductors for engineering applications depending on the thickness of conductors.

### 14:00 *Salient Effects of Spoke-Type Permanent Magnets on Power Factor Characteristics of Vernier Machines*

John Mushenya and Mohamed Azeem Khan (University of Cape Town, South Africa)

Over the years, Permanent Magnet Vernier (PMV) Machines have emerged as a promising topology for low-speed direct-drive applications such as wind power generation. Their high torque capability, which is attributed to the magnetic gearing and flux-modulation nature of their operation, has been discussed and validated in many studies. However, the poor power factor characteristics associated with the conventional

PMV machine have prevented its mass adoption for industrial application, owing to the requirement of a large-sized power electronics converter. This paper analyzes the salient effect of the rotor permanent magnets on the flux density and power factor characteristics of Spoke-type PMV machines. The analytical derivations and Finite-Element simulation results presented in this paper demonstrate the capability of the conventional PMV machines to yield power factor as high as 0.92, albeit with the expected minor detriment to its torque capability.

### 14:20 *Dynamic Performance Improvement of Brushless DC Motors Using a Hybrid MTPV/MTPA Control*

Jinhe Zhou, Seyyedmilad Ebrahimi and Juri Jatskevich (University of British Columbia, Canada)

Brushless dc (BLDC) motors are widely utilized in many applications. The classical maximum torque per ampere (MTPA) and maximum torque per voltage (MTPV) control strategies are commonly used with BLDC motors due to being straightforward and easy to implement. However, these classical control techniques have their own drawbacks. Specifically, the MTPA achieves high efficiency in steady-state but does not fully utilize the torque capability during transients. Meanwhile, the MTPV allows faster dynamic response but degrades the efficiency in steady-state conditions. To fully exploit the advantages of both methods, this paper proposes a new combined control scheme which utilizes MTPA and/or MTPV methods based on the operating conditions. Specifically, during steady-state operation, the MTPA is adopted due to its high efficiency, while the controller smoothly converts to the MTPV in transients to fully exploit the torque capability and achieve faster dynamic response. The proposed hybrid control method is demonstrated on an example industrial BLDC motor and is shown to achieve high efficiency in steady-state (similar to MTPA) and fast dynamic response (similar to MTPV).

## TSA2: Technical Session 2 - Afternoon - Day 4

Distributed Energy Resources (Part 2)

### 13:00 *Optimization of Placement and Sizing on Distributed Generation Using Technique of Smalling Area*

Jangkung Raharjo, Kharisma Bani Adam and Wahmisari Priharti (Telkom University, Indonesia); Hermagasantos Zein (Politeknik Negeri Bandung, Indonesia); Jaspar Hasudungan and Efri Suhartono (Telkom University, Indonesia)

The quality of the electrical distribution system is very important in a power system. One of the efforts that have been made to improve the quality of the electricity distribution system is the installation of distributed generation (DG). The Large to Small Area Technique was proposed to optimize the placement and size of the DG to improve the voltage profiles and reduce losses. Optimal conditions were obtained for 500 candidates, where the placement of DG on Buses 8, 12, 13, and 14 with DG sizes were 0.088 kW, 0.012 kW, 0.929 kW, and 0.489 kW, respectively. The proposed method was able to reduce distribution losses by 81.575% and provided better performance than the previously Genetic Algorithm method.

### 13:20 *Virtual Synchronous Generator Controller for Solar Photovoltaic System*

Mahmoud M Badreldien and Brian K Johnson (University of Idaho, USA)

The concern about the green-house gases has led to government policies to encourage adoption of renewable resources. These policies combined with decreased and improved performance of photovoltaic

and wind generation resources has fostered a significant increase in installations worldwide. Furthermore, the number of these renewable energy resources is expected to continue increasing over the next few decades. Thus, the number of inverter-based resources is expected to rise in electric power systems. This non-negligible share of electric power from the power converters with respect to conventional synchronous generators could have a dramatic effect on power system stability due to reduction in the total system inertia. To overcome this problem, inverter-based resources are combined with energy storage to emulate the synchronous generator characteristics, and act as virtual synchronous generators. This approach of control of power converters emulates the effects of the inertia of traditional SG. This paper provides an explanation for general features offered by a virtual synchronous generator control strategy, mathematical model and its controller design and the system simulation has been verified using electromagnetic transient simulation.

### 13:40 *An Optimal Configuration of Diesel Generator and Battery Storage System for Off-Grid Residential Applications*

Nadheera Dishani Premadasa, Rusiru Sanjaya Silva and Chandima Dedduwa Pathirana (University of Moratuwa, Sri Lanka)

Diesel generators are secure and a reliable alternative for rural areas where the grid extension is not available. Isolated load running under a diesel generator is effortless and looks economical since its low investment cost. But in the long term, hybrid systems like diesel generators and battery systems give more benefits in cost-savings and reduce carbon emissions. This paper discusses the long term benefits of the hybrid system consists of diesel generators and battery storage for off-grid residential applications. Also, this study proposes a new method to optimally size and operate the hybrid system. A new loading percentage optimization concept for the diesel generator has introduced to increase its efficiency and lifetime. The multi-objective optimization has been performed under an off-grid residential load using MATLAB software. Results are discussed and compared to the same load with only a diesel generator. It found that long term investment costs and operating costs of the hybrid system reduced by 5.4% due to optimal sizing. Also, carbon emissions are reduced significantly by hybridization. Diesel generator's working hours have decreased by 68.5% due to the addition of battery storage and the generator's optimal loading.

### 14:00 *Fault-Tolerant Performance Enhancement of DC-DC Converters with High-Speed Fault Clearing-Unit Based Redundant Power Switch Configurations*

Tohid Rahimi (University of Tabriz); Hossein Khounjahan and Armin Abadifard (University of Tabriz, Iran); Mohsen Akbari (K N Toosi University of Technology, Iran); Pedram Ghavidel, Masoud Farhadi and Seyed Hossein Hosseini (University of Tabriz, Iran)

Fault detection and reconfiguration in fault-tolerant converters may complicated and necessitate using all-purpose microprocessors and high-speed sensors to guarantee the satisfactory performance of power converters. Therefore, providing fault-clearing feature without increasing the processing and sensing burdens and reducing the transition time between faulty to normal state are of great importance. This research proposes a new redundant-switch configuration to address the mentioned challenges. The proposed configuration uses one diode and two fuses to eliminate the faulty switch and replace the reserve one, spontaneously. Open-circuit fault in the proposed configuration is spontaneously clarified instantly. Moreover, the short-circuit fault is dealt as an open-circuit fault by using a fuse. Thus, the fault-tolerant feature of the proposed switch configuration is achieved without using a complex, versatile and

multifaceted fault managing unit. Resultant behaviors of the case studies are derived using MATLAB/ SIMULIN. Also, steady-state thermal distribution of power switches which are implemented on a monolith heat sink, analyzed in COMSOL Multi-physics environment. Finally, the viability of the proposed configuration is demonstrated by a laboratory-scaled prototype.

# TSA3: Technical Session 3 - Afternoon - Day 4

Power System Protection and Wide Area Protection

Chairs: Ali Nabavi (University of Toronto, Canada), Lian Zhao (Ryerson University, Canada)

### 13:00 *Comparison of Harmonic Blocking Methods in Transformer Differential Protection Under GIC Conditions*

Afshin Rezaei-zare and Babak Ahmadzadeh-Shooshtari (York University, Canada)

Geomagnetically induced current (GIC) causes the transformer core saturation, which increases the magnitudes of harmonic components in the transformer currents. In such a condition, the transformer differential protection can fail to trip and clear internal short-circuit faults, due to harmonic blocking (HB). This paper compares the performance of existing HB methods, employed in the transformer differential relays, during the occurrence of internal faults and under the GIC flow in the transformer. The time-domain simulations, conducted for bolted and unbolted faults under loaded and unloaded transformer conditions, show that there are GIC-based scenarios in which common and independent HB methods cause the differential protection failure to trip the transformer.

### 13:20 *Study of Partial Discharge Audio Recordings Towards Identifying Features for Classification*

Afsaneh Ghanavati, Seth G Bannish and Douglas E Dow (Wentworth Institute of Technology, USA)

Episodes of Partial Discharge (PD) induce changes to the conductors or insulation that may degrade electrical performance and lead to larger faults and ultimate failure of assets or network outages. All the mentioned responses have been used in developing different PD-inspection techniques. The focus of this work is on acoustic (audio, ultrasonic) PD detection. In this work, we have used the Discrete Fourier Transform (DFT) to analyze a large collection of real-world audio recordings of PD to identify their types as they may be classified by their unique signatures in both the time domain and frequency domain. Through the analysis of the field data, this project explored the signatures of each type of PD (tracking, arcing and corona) and how they can be distinguished from background noise. The result of this work will be used for further algorithm development for detection of episodes of PD. Having a system in place to autonomously detect PD would help to direct maintenance toward prevention of major faults. This would lead to large cost-reduction and improved quality of service.

### 13:40 *Power System Protection Enhanced with IoT Based Support - A Real Implementation Case*

Diogo Vinicius Joao (CERTI, Brazil & Fundacao CERTI, Brazil); Marcos Aurelio Izumida Martins (CERTI Foundation, Brazil); Daniel Filgueiras (ENEL Distribuição São Paulo, Brazil); Sophia Boing Righetto (CERTI Foundation, Brazil)

The Internet of Things (IoT) approach has been one of the major trend technologies in the last years. This concept brings advantages in many areas including the power system protection, where a real time information can be transmitted and processed faster than actual protection systems. In this paper a real case implementation of an IoT Gateway, named Smart Grid Gateway (SGG), is proposed to concentrate relevant protection information and build an adaptive protection system, logical selectivity philosophy, and self-healing concept. The implementation are an outcome of the R&D project hosted by ENEL Distribuic ̧ ̃ao S ̃ao Paulo called Urban Futurability.

**14:00** ***Molecular Orbital Properties of C4-PFN and C5-PFK with DFT Analysis***

Hidir Duzkaya (Gazi University, Turkey); Süleyman Tezcan (Turkey & Gazi University Engineering Faculty, Turkey); Sebla Dincer (Ankara University, Turkey); M. Sezai Dincer (Near East University, Cyprus)

This study aims to examine the molecular orbital parameters of C4-PFN (C3F7CN) and C5-PFK (C5F10O), which are important alternatives to SF6 which is widely used in power system equipment. The molecular structures of these alternative gaseous dielectric materials are optimized with Gaussian 09 and GaussView 5.0 and molecular orbital parameters are calculated using Density Functional Theory (DFT). The examined molecular orbital parameters are zero potential energy, energy profiles, harmonic vibration frequency, IR spectrum, ionization potential, electron affinity and electron energy gap. These calculated parameters provide a better understanding of the dielectric behavior and decomposition mechanisms of C4-PFN and C5-PFK with a holistic approach.

# Saturday, October 30 15:15 - 17:15

## IP1: Industrial Panel

Improving Utilization of Transmission Network for Renewable Integration and Grid Transformation Using Grid Enhancing Technologies
Amir Motamedi

Chair: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran)

List of Session Topics and Presenters Each topic be presented in 15 - 20 minutes, followed by a 30 minutes Q&A session amongst the panelists. • Topic 1: Efficient Integration of Renewables in Canada o Presenter: Robert Hornung, CEO of Canadian Renewable Energy Association (CanREA) • Topic 2: AESO's Transmission Planning Approach in Alberta to Maximize the Transmission Grid Utilization o Presenter: Ata Rehman, Director of System Planning and Operations Engineering at the AESO • Topic 3: Leveraging Transmission Technology to Address Challenges to Integrate DERs and Rapid Growth in Ontario o Presenter: Robert Reinmuller, Director of Transmission Planning at Hydro One • Topic 4: UK Application Case Study: Using Innovative Approaches to Enhance Transmission Capability o Presenter: Afshin Pashaei, Power System Expert at National Grid UK

Session Chair: Amir Motamedi, General Manager of Smart Wires in Canada

3. Abstract Electric networks around the world are undergoing rapid transformation, and power system planners are facing many challenges to plan their network with enough flexibility to accommodate these changes. Key trends include the integration of a

significant volume of renewable energy, rapid DER integration, decarbonization of generation fleets and major transmission assets reaching their end of life. Improving network flexibility while enhancing the utilization of existing assets is crucial for successful grid transformations. In this panel session, four of the senior leaders in Electric Power System Industry in Canada and Europe will share their perspective on the major challenges that they are facing in developing a robust and flexible transmission plan that ensures value for future generations. One key way they are all achieving their plans is to deliver more network capacity by improving the utilization of their existing infrastructure.

Similar to other utilities around the world, Canadian utilities are working on large scale of renewable integration and grid decarbonization. The AESO is facing significant renewable integration, DER penetration and coal phase out in Alberta. Hydro One is facing large-scale DER integration, rapid growth in some areas and major transmission facilities reaching their end of life. National Grid UK is also facing large-scale renewable integration and growing electricity demand (electrification of heat and transport) that is requiring more power to be transferred on their network. In this panel, the senior leaders in these utilities will present their key challenges and how they are using grid enhancing technologies to solve these problems by improving network utilization and flexibility.

4. Panelist Biographies Topic 1: Efficient Integration of Renewables in Canada Presenter: Robert Hornung, CEO of Canadian Renewable Energy Association (CanREA) Robert Hornung is the President & CEO of the Canadian Renewable Energy Association (CanREA) - the voice for wind energy, solar energy and energy storage solutions that will power Canada's energy future. Robert represents the interests of more than 275 member companies that are active in the deployment of these technologies in a variety of applications - from the residential to utility scale - in the Canadian market. Prior to becoming the founding President & CEO of CanREA, Robert served as the President of the Canadian Wind Energy Association (CanWEA) for 17 years, and also worked on climate change issues with the Pembina Institute, Environment Canada, the Organization for Economic Co-operation and Development and Friends of the Earth Canada. Robert is currently a part of the Advisory Council of Positive Energy, a University of Ottawa initiative.

Topic 2: AESO's Transmission Planning Approach in Alberta to Maximize the Transmission Grid Utilization Presenter: Ata Rehman, Director of System Planning and Operations Engineering at the AESO Ata Rehman is currently Director, Grid Planning and Operations Engineering at the Alberta Electric System Operator (AESO). His accountabilities include Transmission System Planning, Operations Planning and Coordination, Operations Engineering and Market Support, and Power System Restoration Planning. He is also leading the Energy Storage Roadmap Initiative on behalf of the AESO. Ata has more than 30 years of experience in the field of transmission system planning, power system studies, power system operations planning, interconnections, project delivery and regulatory affairs.

Topic 3: Leveraging Transmission Technology to Address Challenges to Integrate DERs and Rapid Growth and to in Ontario Presenter: Robert Reinmuller, Director of Transmission Planning at Hydro One As a senior member of the Hydro One management team, Robert Reinmuller brings over three decades of energy sector experience. With exposure to municipal services, utility industry, grid engineering and outage planning, real time power system operations, emergency management and overall system planning & asset management, he brings a strong focus on not only securing and maintaining the current grid, but also in finding the right solutions for the customers and the economic development of the province. In his current role, Robert and the Transmission System Planning Team are responsible for Regional Planning activities, Customer connections as well as delivering over one billion dollars/year in capital development and sustainment projects. Robert is a Senior IEEE Member as well as Member of Professional Engineers Ontario and over the last decade contributed to multiple industry organizations. Currently, he serves as a member on the NERC RSTC Executive Committee, CEA Transmission Council, IESO Technical Panel, OEB RPPAG as well as the NATF Resiliency Advisory Group.

Topic 4: UK Application Case Study: Using Innovative Approaches to Enhance Transmission Capability Presenter: Afshin Pashaei, Power System Expert at NationalGrid UK Afshin Pashaei is currently a power system expert in National Grid UK and his field of expertise is complex power system studies and applications of power converters in power system. He received PhD degree from Newcastle University, Newcastle Upon Tyne, United Kingdom and has more than 20 years of work experiences in different sectors of power industry including manufacturing, consultancy, utility and academia. He is the author and co-author of number of technical papers in IEEE and CIGRE and he is active member of IEC and CIGRE study working groups.

Panel Organizer and chair

Amir Motamedi is currently the General Manager of Canada at Smart Wires. He is a power systems leader and expert with over 15 years of experience in power system planning, operation, and economics in different companies. Before joining Smart Wires, Amir was leading the System Planning team at the AESO. He holds a Ph.D. degree from the University of Calgary in Electrical Engineering, where he has been an adjunct professor with the ECE department for the past nearly 10 years. He holds a professional engineer designation with APEGA. Amir is a senior member of IEEE. Amir has published 14 peer-reviewed technical research papers with over 500 citations on power systems area.

## Sunday, October 31

# Sunday, October 31 10:30 - 11:20

## Keynote 6: Keynote Speaker

The Future Requirements of Smart Grid => Grid Modernization

John McDonald

Chair: Ali Nabavi (University of Toronto, Canada)

Abstract: This talk will familiarize participants with a vision for Grid Modernization, focusing on technological advancements beyond Smart Grid. The technological advancements include discussions of key industry/societal trends, Smart Grid concepts, holistic solutions, integration of microgrids and distributed generation, and Advanced Distribution Management System (ADMS) software applications. John will also cover feeder automation business models, managing different types of data, big data, analytics, enterprise data management, Smart Grid standards and interoperability, and Smart Grid deployments and lessons learned.

Biography: John D. McDonald, P.E., is Smart Grid Business Development Leader for GE's Grid Solutions business. John has 46 years of experience in the electric utility transmission and distribution industry. John received his B.S.E.E. and M.S.E.E. (Power Engineering) degrees from Purdue University, and an M.B.A. (Finance) degree from the University of California-Berkeley. John is a Life Fellow of IEEE (member for 50 years), and was awarded the IEEE Millennium Medal, the IEEE Power & Energy Society (PES) Excellence in Power Distribution Engineering Award, the IEEE PES Substations Committee Distinguished Service Award, the IEEE PES Meritorious Service Award, the 2016 CIGRE Distinguished Member Award and the 2016 CIGRE USNC Attwood Associate Award. John is Past President of the IEEE PES, the VP for Technical Activities for the US National Committee (USNC) of CIGRE, the Past Chair of the IEEE PES Substations Committee, and the IEEE Division VII Past Director. John was on the Board of Governors of the IEEE-SA (Standards Association) and is on the IEEE Foundation Board of Directors. John received the 2009 Outstanding Electrical and Computer Engineer Award from Purdue University. John teaches a Smart Grid course at the Georgia Institute of Technology, a Smart Grid course for GE, and Smart Grid courses for various IEEE PES local chapters as an IEEE PES Distinguished Lecturer (since 1999). John has published one hundred fifty papers and articles, has co-authored five books and has one US patent.

# Sunday, October 31 11:30 - 12:30

## TS1: Technical Session 1 - Day 5

Digital Transformation of Power and Energy Systems

Chair: Marjan Alavi (McMaster University, Canada)

**11:30** ***Analyzing the Propagation of Disturbances in CPES Considering the States of ICT-Enabled Grid Services***

Anand Narayan (University of Oldenburg & OFFIS - Institute for Information Technology, Germany); Marcel Klaes (TU Dortmund University, Germany); Sebastian Lehnhoff (University of Oldenburg & OFFIS - Institute for Information Technology, Germany); Christian Rehtanz (TU Dortmund University, Germany)

Power Systems (PS) are becoming increasingly dependent on Information and Communication Technologies (ICT). On one hand, ICT enables the grid services which aid in the safe and secure operation of PS; on the other, also causes disturbances to propagate further due to the interdependencies between the two systems. In this paper, a simulation based approach for analyzing the interdependency between power and ICT systems within cyber-physical energy systems (CPES) is presented. The main focus is on the propagation of disturbances in CPES (both cascading and escalating) across the boundaries of the two systems considering their interdependencies. The performance degradation of the grid services, especially the partially degraded state, is also considered. The resulting state trajectory of CPES, i.e. states of PS as well as states of grid services, provides insights on design decisions (e.g. robustness and fallback measures).

### 11:50 *Application of Magnetic Sensors for Measurement of Current Phasors in Power Systems*

Prasad Shrawane and Tarlochan Sidhu (Ontario Tech University, Canada)

Digital Instrument transformers play a vital role in digitization of electric power substations and power systems network. The advances in magnetic sensors research offer more precise and accurate current measurement that can be useful for monitoring the state of the system and detecting faults and thus leading to more reliability and dependability. Anisotropic magnetoresistive (MR) sensor can be used to measure the AC current by sensing the magnetic field generated by a current carrying conductor. This can be achieved through contactless method which is less complex in installation and maintenance compared to conventional current transformers. This paper describes a novel method of current phasor measurement with the help of a low-cost, broadband and high-sensitivity Tunneling Magnetoresistance (TMR) sensor for noninvasive AC current measurement. A detail analysis of calibration and validation is performed for two sensors and results of comparison of their performances based on a few factors such as distance from current source and insulation are described in this paper.

### 12:10 *Energy System Observatory of Honduras*

Wilfredo Flores (Technologyc University UNITEC, HONDURAS & UNITEC, Honduras); Gracia M. Pineda (UNITEC, Honduras); Harold Chamorro (KTH, Royal Institute of Technology, Sweden); Milad Soleimani (Texas A&M University, USA); Payman Dehghanian (George Washington University, USA); Francisco Gonzalez-Longatt (University of South-Eastern Norway & Venezuelan Wind Energy Association, Norway); Vijay K. Sood (Ontario Tech University, Canada)

Data management is a strategic tool to make decisions, planning and monitoring the energy sector. Recently, the Engineering Faculty of the Universidad Tecnológica Centroamericana, UNITEC, from Honduras have launched the Energy Observatory of Honduras. This tool come to fill the gap in the access to energy data in the country, in such a way that this access is carried out in a free and easy way. In this document, data from demand and generation of electricity are shown. Also, the consume of fossil fuels and firewood as well as the access to real time data and energy indexes are shown.

## TS2: Technical Session 2 - Day 5

Electrical Machines & Drivers (Part 2) & Electric Vehicle Infrastructure (Part 2)

Chairs: Maryam Sepehrinour (McClick Technology Inc., Ontario, Iran), Alireza Siadatan (University of Toronto, Canada)

**11:30** ***Design and Construction of a Sensor-Less Drive for Synchronous Reluctance Motor with Offset Voltage Injection Technique for Rotor Position Estimation***

Alireza Siadatan (University of Toronto, Canada)

This paper proposes a new controller with a high-frequency (HF) offset voltage injection technique for rotor position estimation in sensor-less synchronous reluctance drive systems. In this regads, the theory, mathematical model and simulation are presented to show the use of a HF injection method that takes into account the effects of unequal inductances and the influence of speed reduces the rotor position estimation error. To demonstrate the practicability, the proposed method are implemented in a test bench using a LPC-1768 Cortex M3 digital Microprocessor to control a 750W prototype synchronous reluctance motor (Syn-RM) drive. Experimental results are presented to show that the load disturbance and tracking responses of the proposed drive system. Both experimental and simulation analyses clearly indicate that the proposed HF offset voltage injection method offers improved performance in adjustable speed synchronous reluctance drive systems.

**11:50** ***Role of Charging/Discharging in the Integration of EVs to Grid as Intermittent Energy Sources***

Anekant Jain (Thapar Institute of Engineering and Technology, India); Pallavee Bhatnagar (IES College of Technology, Bhopal, India); Krishna Kumar Gupta (Thapar Institute of Engineering and Technology, India); Hani Vahedi (Ossiaco Inc., Canada)

An extensive use of electric vehicles (EVs) is evolving as an important solution to counter environmental pollution, rapid exhaustion of fossil fuels and insecurity caused by fluctuations in the price of petroleum products in the international market. The integration of EVs to the grid is required for the future enhancement of the transportation system. Grid integration of EVs also presents an interesting opportunity to solve the issues faced due to intermittent nature of renewable energy sources (RES) connected to the grid. The charging of EVs must be well coordinated with the grid otherwise it will result into an uncertain large electric load, causing peak-load and grid issues. Thus, the EV technology presents opportunities as well as challenges to the electricity grid. The development in EV technologies, battery systems, and different charging methodologies are reviewed with special focus on vehicle to grid technology as a solution to many grid issues, especially with RES connected to it. This paper presents a brief overview of these issues and various solutions.

## Sunday, October 31 13:00 - 15:00

## Closing: Closing Ceremony

Chair: Vijay K. Sood (Ontario Tech University, Canada)