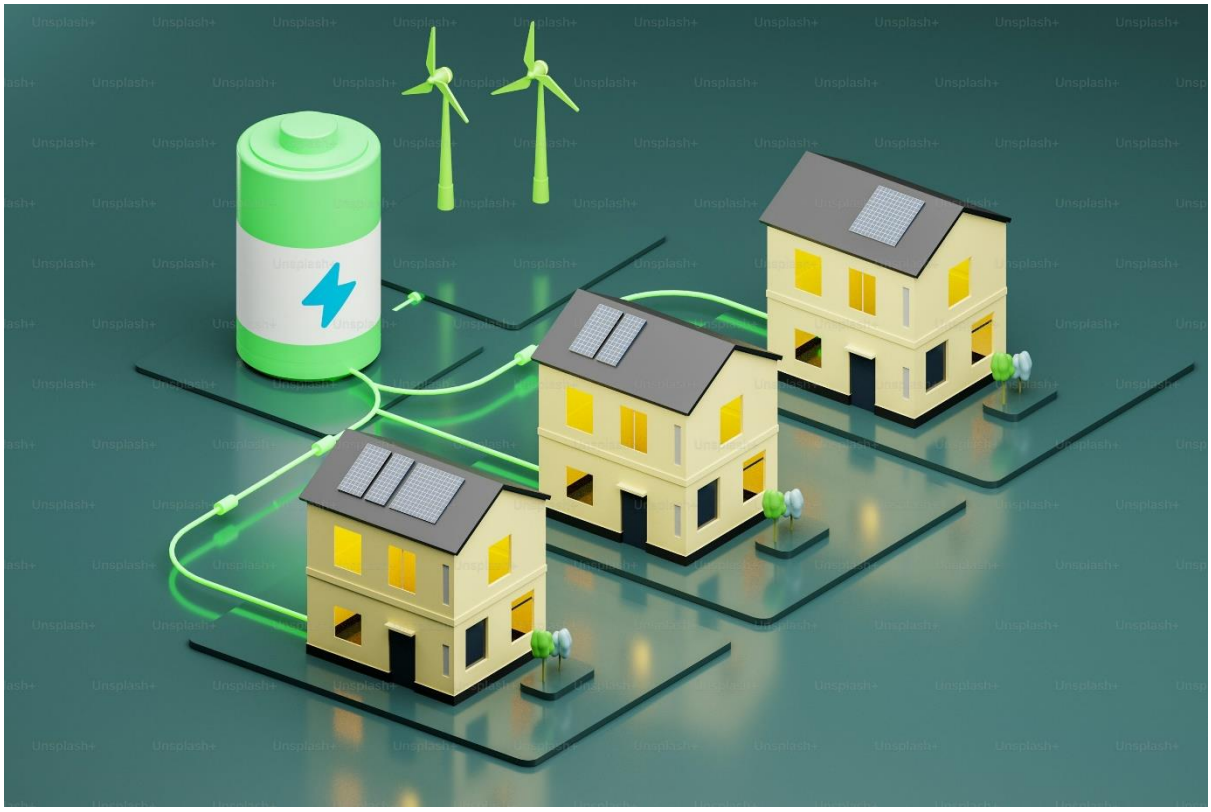
SECURITY CHALLENGES OF NEXT GENERATION ENERGY DISTRIBUTION NETWORKS



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INCS-CoE held an on-line seminar on the above topic on Wednesday 5 June 2024. We had three speakers whose biographies may be found at the end of this note.

Fei Teng spoke about cyber resiliency of digitalised power grids. He observed that the increasing cyber-physical dependency causes potential vulnerabilities against cyberattacks that may lead to catastrophic damage to the power grid. He presented a timeline of cyber attacks on energy systems highlighting a new trend of attacks on Electronic Vehicle (EV) charging stations and also on wind turbine manufacturers. It is hence critical to understand such vulnerabilities and develop capabilities to maintain safe operations under those attacks. A key research goal is to minimise the physical impact for a given level of cyber degradation – there is an acceptance that successful cyber attacks will occur, so the ability to keep operating under attack and recover fast afterwards becomes a key goal. He presented a cyber-resiliency framework and his recent research on cyberattack detection, mitigation and recovery strategies for digitalized power grids. In detail, he spoke about a blended data and physics approach to detecting cyber attacks, he introduced the notion of "cyber-safe" mode of operation for riding through the cyber degradation of a network, and a methodology for faster recovery.

Dirceu Cavendish spoke about secure EV charging in smart grids. Electric vehicles have been recently produced at a very aggressive pace as a way to curb carbon emissions in the 21st century. Public utility companies are rushing to provide electric vehicle charging station infrastructure needed to serve a rapidly growing fleet of EV users in various countries around the world. Equipped with smart meters, charging stations must check vehicle's characteristics prior to charging, as well as securely report charging data back to public utility companies. He spoke about how to leverage an Authentication and Key Agreement protocol used in cellular networks into an electric vehicle authentication and secure metering framework. Starting with a vehicle Subscriber Identification Module, he discussed how generic vehicle services can be securely provided, including mutual authentication, key agreement, and key management issues.

Ali Mehrizi-Sani focussed on the new cybersecurity issues raised by the increasing integration of renewables, especially through grid-forming (GFM) inverters, in the energy system. Compared with other modes of operation, GFM inverters can support a wider host of functionalities leading to a more pronounced impact on the system performance in case of malfunctions including those resulting from cyberattacks. This complicates the design of their

cybersecurity detection and mitigation algorithms as attackers can compromise GFM inverters through different attack types, circumventing the existing cybersecurity approaches that are largely designed for one specific attack type. He discussed his team's work to address this gap via a diverse set of detection and mitigation methods. Specifically, he spoke about physics-informed machine learning-based cybersecurity of control and power sharing algorithms for renewable generation units. This approach is validated using offline and real-time simulation studies on standard test power systems as well as on the digital twin representing the Virginia Tech-owned utility, VTES. He also discussed how the twin problems of the design of the control system and the design its cybersecurity algorithms can be considered as one simultaneous problem.

Some of the key research challenges which emerged during the seminar Included:

1. The need for techniques to combine physics and traditional cyber security approaches to detect cyber attacks and reduce false positive rates.

2. Given that, as more renewables are integrated into the energy systems, there will be a proliferation of edge devices with poor security, there is a need for more focus on cyber resilience rather than cyber security – this might involve the development of cyber-safe modes of operation by analogy with safe mode in some modern operating systems.

3. How can Advanced Metering Infrastructure already deployed be retrofitted to better meet the security challenges of tomorrow?

4. Given the mix of technologies expected to be deployed in next generation power distribution systems – renewables, advanced artificial intelligence and machine learning algorithms and next generation cellular networks (5G/6G) - what does security-by-design mean?

More information about the individual presentations and the resulting research questions may be found on the INCS-CoE website (incs-coe.org) or by contacting the speakers. We encourage the community to start conversations which might lead to the solutions of some of these challenges.

Speakers

Dr Fei Teng, Imperial College London, UK

Fei Teng is the Director of Education at Energy Futures Lab, a pan-university hub promoting inter-disciplinary research in energy, and a Senior Lecturer in the Department of Electrical and Electronic Engineering at Imperial College London. He holds visiting positions at MINES Paris, France, PolyU, Hong Kong and KTH, Sweden. His research primarily focuses on the interplay of energy and digital technologies. He is a leading researcher in software-defined power grids and the cyber resiliency of digitalized power grids.

Dr Dirceu Cavendish, Kyushu Institute of Technology, Japan

Dirceu Cavendish received his bachelor degree in Electronics from Federal University of Pernambuco, Brazil in 1986. He spent five years as a telecommunications engineer in the Business Communications Division of Philips. He received his M.S. in Computer Science from Kyushu Institute of Technology, Japan, in 1994, and his Ph. D. from Computer Science Department-UCLA in 1998. From 1998 to 2006, Dr. Cavendish conducted research in Optical Transport Networks, IP, and Ethernet technologies at NEC Labs America. Since 2007, Dr. Cavendish has been part of the Faculty Staff of Kyushu Institute of Technology. His current research interests include LEO satellite networks, security of medical systems and electrical grids.

Dr Ali Mehrizi-Sani, Virginia Tech, USA

Ali Mehrizi-Sani received the Ph.D. degree in electrical engineering from the University of Toronto in 2011. He is currently an Associate Professor with Virginia Tech. He is a Senior Editor for IEEE Transactions on Energy Conversion and is or has been on the editorial board of IEEE Transactions on Power Delivery, IEEE Transactions on Power Systems, IEEE Power Engineering Letters, and IET Generation, Transmission and Distribution. Among his recognitions are the 2018 IEEE PES Outstanding Young Engineer Award and the 2017 IEEE Mac E. Van Valkenburg Early Career Teaching Award. He has over 180 refereed publications.