



PROCEEDINGS OF

**Third International Colloquium  
on Intelligent Grid Metrology  
(SMAGRIMET 2020)**

virtual event from Croatia

October 20-23, 2020



UNIVERSITY OF ZAGREB

Faculty of Electrical  
Engineering and  
Computing



**cigre**  
Croatia



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## MESSAGE FROM THE SMAGRIMET 2020 CHAIRS

Dear Colleague,

it is our great pleasure to welcome you for the third time to the International Colloquium on Intelligent Grid Metrology which has become more known by its abbreviation SMAGRIMET. This colloquium is jointly organized by University of Zagreb, University of Split and Croatian branch of the International council for large electric power systems (HRO-CIGRÉ), while it is also technically supported by the Croatian Chapter of IEEE Instrumentation and Measurement section.

In the year 2018 we have started the SMAGRIMET colloquium with the idea to get together the international experts in metrology-related development and deployment of smart grids and accompanying applications, and to exchange knowledge with our Croatian experts in this field. By now we have organized two events in Split, Croatia, and both events have successfully met our expectations. Both SMAGRIMET events have also attracted interest in other related scientific areas such as microwave communications engineering, image processing algorithms and acoustic measurements, thereby broadening the conference scope and adding to the charm of interdisciplinarity. In addition, the international experts had an opportunity to explore the vibrant Croatian coast and discover its surroundings, which relaxed the atmosphere and provided memorable and truly inspirational environment for all the participants.

This year we originally planned to build on this success and to organize the 3rd SMAGRIMET in ancient and famous Croatian cities of Dubrovnik and Cavtat. Again, we were looking forward to rich scientific program consisting of oral and poster sessions, invited speakers and workshops, and to continue providing a great atmosphere and get-together feeling of the previous SMAGRIMET editions.

Nevertheless, due to unprecedented health challenges and hence travel uncertainties which we are all witnessing this year, we have opted to safely move the 2020 event to the virtual (online) sphere. We deem that by doing that we have adequately addressed the issue of the attendees' health and well-being, but also ensured the stability in planning and organization for all. We also believe that moving online in such circumstances gave us relief to focus onto the core idea of SMAGRIMET, which is to reach wide international audience and maintain the high-quality scientific content.

This year the program is organized in six oral sessions where the attendees will be able to learn about the latest developments and algorithms in the areas of digital frequency measurement methods and algorithms, distributed energy generation, fibre optics sensors, synchrophasors, data acquisition systems, machine learning and many more. This is accompanied with two workshops and panel sessions where renowned international experts will discuss challenges and perspectives in intelligent grid management and digital substations. In addition, we have three keynote speakers from The Netherlands and The United States, by which we complete the presentation of the state-of-the-art scientific concepts.

We didn't forget social events either! Alongside virtual rooms for coffee breaks we will provide a virtual musical intermezzo where we will learn and hear about the oud (similar to arabic lute), the musical instrument known from the ancient times. By listening to the sound of oud we hope that you will get a glimpse into an authentic audio experience and that it would make it as close as possible to being there, at least for a moment.

We wish to thank the members of the Organization and Technical Committee for providing their logistical and professional support to make this event possible as well as helping us smoothly adapt to virtual format. We also thank the reviewers for their valuable voluntary work in reviewing papers and ensuring the quality of the presented material. Finally, we wish to thank our sponsors from Meinberg Funkhrehn GmbH, Germany, for valuable support that made this event possible and even more relevant.

With all of the above in mind we wish you a nice time online, and we promise to restore the live event as soon as possible!

Sincerely,

Prof. **Roman Malarić**, PhD  
SMAGRIMET 2020 General Chair  
University of Zagreb, FER

Prof. **Goran Petrović**, PhD  
SMAGRIMET 2020 General Co-Chair  
University of Split, FESB

Assoc. Prof. **Marko Jurčević**, PhD  
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[smagrimet.org/2020](http://smagrimet.org/2020)

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# Keynote Talks

## Success Factors for Sustainable Electrical Energy Delivery and Decarbonization

**Abstract.** Resilient, reliable and efficient electrical grid operation is critical to society. The electrical power and energy industry is changing rapidly to meet the demands of the society and address decarbonization needs. New technologies offer significant opportunities for realizing a resilient and sustainable energy future.

Identifying the best strategies to ensure reliable, resilient, and cost-effective delivery of electrical power energy is needed to set a path to decarbonization to address climate change. Those strategies include integration of renewable energy resources and electrical storage and together with electrification of transportation and innovative approaches to building climate control are critical ingredients of any energy future. It is critical to ensure that inverter-based resources like solar PV and battery energy storage systems have the capability to provide essential reliability services to the electric power system.

The grid also continues to face evolving challenges, such as cyber and physical attacks, major weather events (e.g., catastrophic wildfires, hurricanes, significant rain/snow incidents) and aging infrastructure. We have the opportunity to make it better than it was before by taking more aggressive actions to adapt, including grid infrastructure hardening and improved grid and equipment monitoring. What we need now is a renewed understanding of the value of not just electricity, but the grid that enables it, and recognize the contributions of renewable energy resources, energy storage, and electrification in achieving environmental, resilience, reliability, and safety targets.

We are at a crossroads in making business and technical decisions that will allow us to optimally and cost-effectively manage the grid. This presentation will discuss success factors for sustainable electrical energy delivery in the context of industry trends and transformation drivers and opportunities for grid modernization with technologies for the changing nature of electricity delivery and decarbonization.



**Dr. Damir Novosel, President, Quanta Technology LLC** Damir is president and founder of Quanta Technology, a subsidiary of Quanta Services, a Fortune 500 company. Previously, he was vice president of ABB Automation Products and president of KEMA T&D US. Dr. Novosel is also an adjunct professor of Electrical Engineering at North Carolina State University.

Dr. Novosel is elected to National Academy of Engineers in 2014. He served as IEEE Power and Energy Society President (2016-2017) and Vice President of Technical Activities (2011-2012). He has been active with IEEE Standards, including membership of the IEEE Standards Board and committees, as well as with various IEEE PES initiatives, including chairing the Fellows

Committee and Power System Relaying sub-committee on System Protection. Damir is presently chairing Industry Technical Support Task Force organization responsible for IEEE cooperation with global regulatory agencies and corporate engagement. He is also a member of the CIGRE US National Committee and received the CIGRE Attwood Associate award. Damir has given numerous keynote presentations and has been involved with industry panels and events, including recent testimony to the US FERC Commissioners on “Managing the New Grid”.

Dr. Novosel has led development and implementation of pioneering concepts, methods, and products that improved resilience, reliability, and efficiency of electrical power systems. He holds 17 US and international patents and published over 140 articles in Transactions, Journals and Proceedings, receiving IEEE PES 2011 and 2013 Prize Paper Awards, and CIGRE distinguished paper award in 2006. He contributed to 5 books.

Damir Novosel, IEEE Fellow since 2003, holds PhD and MSc, BSc degrees in electrical engineering from Mississippi State University (where he was a Fulbright scholar), the University of Zagreb, Croatia, and the University of Tuzla, Bosnia and Herzegovina, respectively. Dr. Novosel was selected Mississippi State University Distinguished Engineering Fellow.

## Building a More Sustainable and Resilient Grid

**Abstract.** In this age of climate crisis, stakeholders are recognizing the need to integrate larger quantities of advanced energy technologies, from renewable generation to electrified transportation. Electric utilities the world over are challenged to integrate new technologies while limiting impacts to grid reliability. Further, the expectation of more frequent and intense weather events will drive the need for smart grid investments that provide greater energy resilience.

Commonwealth Edison (ComEd) is developing and deploying technologies that enable increased penetration of low-carbon technologies, mitigate the effects of climate change, and enable higher levels of resilience, helping the communities in the utility's service territory adapt to a changing environment. Many of these technologies are being demonstrated in Chicago where ComEd is installing the Bronzeville Community Microgrid (BCM). Within the BCM ComEd is deploying the first utility-operated microgrid cluster, serving 7 MW of load, that is being used as a living laboratory to demonstrate advanced technologies that support the integration of distributed energy resources (DERs). Together, these technologies ensure that ComEd can provide clean power, supporting communities to meet their goals.

With support from the Department of Energy (DOE), ComEd developed and is demonstrating a microgrid master controller that can operate two or more connected microgrids. Also in partnership with the DOE, ComEd developed a microgrid-integrated solar storage technology that uses smart inverters, energy storage, and a microgrid controller that enables solar PV to operate as a controllable resource. This technology is being demonstrated with 750 kW of solar PV and 500 kW/2MWh of energy storage. Finally, ComEd is demonstrating a distributed linear estimation capability that supports the integration of DER.

ComEd is deploying such technologies to enable higher penetration of renewable generation that can increase the grid's sustainability, foster resiliency, and mitigate the effects of energy-disruptive events. These innovations support efforts to make communities even more sustainable, by embracing electrification. Doing this requires rich partnerships with community stakeholders to maximize the impact of these innovations, by identifying which technological solution can meet the needs of an individual community, and how it can be best leveraged. In the neighborhood of Bronzeville, Chicago, ComEd is doing just this as part of a broader community of the future initiative, which deploys technologies from an electric vehicle mobility program to STEM education opportunities, all built on the foundation of a community microgrid. The community-level approach pursued by ComEd will drive meaningful change on a local level that can be replicated regionally, nationally or globally.



**Dr. Shay Bahramirad** is the Vice President of Engineering and Smart Grid at ComEd, where she serves as a strategic business leader, driving efforts to visualize and implement the 21st century power grid transformation and the new energy economy. She holds executive responsibility for ComEd's vision of the grid of the future as well as communities of the future, developing frameworks for emerging technologies including distributed generation, microgrids, electrification, as well as investment strategies for enabling improved resilience, sustainability and energy equity. Dr. Bahramirad is an Editorial Board Member of Electricity Journal,

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 policy makers globally, and developing strategies for next generation of standards and frameworks, including Smart Cities. Dr. Bahramirad holds multiple advanced degrees, including a Ph.D. in Electrical Engineering from the Illinois Institute of Technology. She is also a graduate of Kellogg School of Management at Northwestern Women's Senior Leadership program.

# Intelligent Grid Metrology: Measurement Science for a Reliable Electricity Supply

**Abstract.** Metrology is at the heart of the present development of intelligent grids: there is no such thing like an intelligent grid without measurements. This presentation will highlight the significant contributions metrology presently is making to the development of intelligent grids, with an outlook to the challenges that still lie ahead. This will among others cover the calibration of PMUs and digital instrumentation for grid monitoring and control, ensuring correct metering under highly polluted grid conditions, measurement of power quality up to the supraharmonics range, testing of grid components at increasingly high grid voltage levels, and reliable efficiency measurements of power transformers and reactors. The challenges are unprecedented, with needs for traceability of digital instrumentation, for on-site measurement in grids and at test sites, and for metrology support to data analytics aiming to turn the vast amounts of grid measurement data into actionable information for grid operators.



**Dr.ir. Gert Rietveld, Chief Metrologist, VSL.** Gert is Chief Metrologist at VSL, the national measurement institute of the Netherlands. After two decades of work on electrical quantum standards, his current research focuses on power and energy metrology and in particular metrology for smart electrical grids. He has coordinated a 22-partner EU project on Smart Grid Metrology, was the founding chair of the EURAMET expert group on power and energy, and he presently is leading the European Metrology Network on Smart Electricity Grids. He has published over 180 articles in transactions, journals and proceedings.

Dr. Rietveld is member of the International Committee for Weights and Measures and President of its Consultative Committee for Electricity and Magnetism (CCEM). He is a senior IEEE member, and member of several EURAMET, CIGRE, and IEEE Working Groups. Gert Rietveld received the M.Sc. (cum laude) and Ph.D. degrees in low temperature and solid-state physics from the Delft University of Technology, The Netherlands, in 1988 and 1993, respectively.