UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Increasing Market and Planning Efficiency through Improved Software — Docket No. AD10-12-015

SUPPLEMENTAL NOTICE OF TECHNICAL CONFERENCE ON INCREASING REAL-TIME AND DAY-AHEAD MARKET AND PLANNING EFFICIENCY THROUGH IMPROVED SOFTWARE

(May 15, 2024)

As first announced in the Notice of Technical Conference issued in this proceeding on February 29, 2024, Commission staff will convene a technical conference on July 9, 10, and 11, 2024 to discuss opportunities for increasing real-time and day-ahead market and planning efficiency of the bulk power system through improved software. Attached to this Supplemental Notice is the agenda for the technical conference and speakers' summaries of their presentations.

While the intent of the technical conference is not to focus on any specific matters before the Commission, some conference discussions might include topics at issue in proceedings that are currently pending before the Commission. These proceedings include, but are not limited to:

PJM Interconnection, L.L.C.	Docket No. ER24-99-000
Southwest Power Pool, Inc.	Docket No. ER24-1317-000
Southwest Power Pool, Inc.	Docket No. ER24-1658-000
Southwest Power Pool, Inc.	Docket No. ER22-1697-000
Midcontinent Independent System Operator, Inc.	Docket No. ER22-1640-000
ISO New England Inc.	Docket No. ER22-983-000
PJM Interconnection, L.L.C.	Docket No. ER22-962-000
California Independent System Operator Corp.	Docket No. ER21-2455-000
New York Independent System Operator, Inc.	Docket No. ER21-2460-000
Midcontinent Independent System Operator, Inc.	Docket No. ER24-1638-000

The conference will allow presenters and attendees to participate either in-person or virtually. Further details on both in-person and virtual participation will be available on the conference webpage.[1]

Attendees are requested to register through the Commission's website on or before June 3, 2024. Registration will help ensure that Commission staff can provide sufficient physical and virtual facilities and to communicate with attendees in the case of unanticipated emergencies or other changes to the conference schedule or location. Access to the conference (virtual or in-person) may not be available to those who do not register by June 3.

Slides are due from selected speakers by 5:00pm EDT on July 1, 2024. Before 1:00pm EDT on July 8, 2024, Commission staff will work with presenters to provide quality assurance that their presentation materials are prepared, formatted correctly, and ready for delivery during the conference. All updates to slides submitted before 1:00pm on July 8, 2024 will be posted to the Commission website in advance of the conference. Any updated slides submitted after 1:00pm on July 8, 2024 will be posted to the Commission website after the conference; however, the live conference may use slides versions submitted by 1:00pm on July 8, 2024.

The Commission will accept comments following the conference, with a deadline of August 12, 2024.

There is an "eSubscription" link on the Commission's web site that enables subscribers to receive email notification when a document is added to a subscribed docket(s). For assistance with any FERC Online service, please email FERCOnlineSupport@ferc.gov, or call (866) 208-3676 (toll free). For TTY, call (202) 502-8659.

FERC conferences are accessible under section 508 of the Rehabilitation Act of 1973. For accessibility accommodations please send an email to accessibility@ferc.gov or call toll free (866) 208-3372 (voice) or (202) 502-8659 (TTY), or send a fax to (202) 208-2106 with the required accommodations.

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[1] https://www.ferc.gov/news-events/events/increasing-real-time-and-day-ahead-market-and-planning-efficiency-through-1

For further information about these conferences, please contact:

Sarah McKinley (Logistical Information)
Office of External Affairs
Sarah.McKinley@ferc.gov

Alexander Smith (Technical Information)
Office of Energy Policy and Innovation
Alexander.Smith@ferc.gov

Monica Ferrera (Technical Information)
Office of Energy Policy and Innovation
Monica.Ferrera@ferc.gov

Debbie-Anne A. Reese,
Acting Secretary.

Technical Conference: Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software

Agenda

AD10-12-015
July 9 – 11, 2024

Tuesday, July 9, 2024

9:15 AM	Introduction Alex Smith, Federal Energy Regulatory Commission (*Washington, D.C.*)
9:30 AM	Session T1 **A MRI-Based Resource Capacity Accreditation** Feng Zhao, ISO New England (*Holyoke, MA*) **Development of a Regional Energy Shortfall Threshold** Jinye Zhao, ISO New England (*Holyoke, MA*) Stephen George, ISO New England (*Holyoke, MA*) Ke Ma, ISO New England (*Holyoke, MA*) Hannah Johlas, ISO New England (*Holyoke, MA*) **Study of DER Responses Using Transmission and Distribution Systems Co-Simulation** Mingguo Hong, ISO New England (*Holyoke, MA*) Xiaochuan Luo, ISO New England (*Holyoke, MA*) Tongxin Zheng, ISO New England (*Holyoke, MA*) Pradip Vijayan, ISO New England (*Holyoke, MA*) Eva Mailhot, ISO New England (*Holyoke, MA*) Brad Marszalkowsky, ISO New England (*Holyoke, MA*) Trevor Hardy, PNNL (*Richland, WA*) Alok Kumar Bharati, PNNL (*Richland, WA*) Wei Du, PNNL (*Richland, WA*) Frank Tuffner, PNNL (*Richland, WA*) Aaron Hanenkratt, National Grid (*Boston, MA*) Dan Kopin, Vermont Electric Power Company (*Rustland, VT*) **Optimising Energy and Reserve Schedules for Post-Contingency Scenarios: A Security Constrained Unit Commitment Approach** Matthew Musto, New York ISO (*Rensselaer, NY*) Kanchan Upadhyay, New York ISO (*Rensselaer, NY*) Edward Lo, Hitachi Energy (*San Jose, CA*)
11:30 AM	Lunch

Tuesday, July 9, 2024	
12:30 PM	Session T2 **Optimizing Locational Minimum Installed Capacity Requirements** John Meyer, New York ISO (*Rensselaer, NY*) Sushant Varghese, New York ISO (*Rensselaer, NY*) **Hourly Electricity Load Forecasting Using Machine Learning Algorithms** Yinghua Wu, PJM Interconnection (*Audubon, PA*) Laura Walter, PJM Interconnection (*Audubon, PA*) Anthony Giacomoni, PJM Interconnection (*Audubon, PA*) **Optimizing Synchronous Condensers in PJM's Day-Ahead Energy Market Using a Hybrid Multiple Configuration Resource Model** Anthony Giacomoni, PJM Interconnection (*Audubon, PA*) Danial Nazemi, PJM Interconnection (*Audubon, PA*) Qun Gu, PowerGEM (*Clifton Park, NY*) Boris Gisin, PowerGEM (*Clifton Park, NY*) **Stochastic Nodal Adequacy Pricing Platform** Geoff Brigham, Midcontinent ISO (*Carmel, IN*) Aleksandr Rudkevich, Newton Energy Group (*Newton, MA*) F. Selin Yanikara, Newton Energy Group (*Newton, MA*) Russ Philbrick, Polaris Systems Optimization (*Shoreline, WA*) Richard Tabors, Tabors Caramanis Rudkevich (*Newton, MA*) Bing Huang, Midcontinent ISO (*Carmel, IN*) Mojtaba Sepehry, Midcontinent ISO (*Carmel, IN*)
2:30 PM	Break
3:00 PM	Session T3 **Short-Term Forecasting During Extreme Climate Events** Amber Motley, California ISO (*Folsom, CA*) **Modeling The Impact of Regulation Service on Battery Energy Storage State of Charge** Guillermo Bautista Alderete, California ISO (*Folsom, CA*) Kun Zhao, California ISO (*Folsom, CA*) **Energy Storage Resource Model** Khaled Abdul-Rahman, California ISO (*Folsom, CA*) George Angelidis, California ISO (*Folsom, CA*) Fan Zhang, BP (*Houston, TX*) Yannick Degeilh, California ISO (*Folsom, CA*) Juan Alvarez Lopez, California ISO (*Folsom, CA*) **Flexibility Reserve Products and Structural Changes to Unit Commitment in Real-Time Markets and Operations** Mort Webster, Pennsylvania State University (*University Park, PA*) Anthony Giacomoni, PJM Interconnection (*Audubon, PA*) Aravind Retna Kumar, Pennsylvania State University (*University Park, PA*) Shailesh Wasti, Pennsylvania State University (*University Park, PA*) **Interregional Transmission Operational Coordination** Yonghong Chen, National Renewable Energy Laboratory (*Golden, CO*) Jose Daniel Lara, National Renewable Energy Laboratory (*Golden, CO*)
5:30 PM	Adjourn

Wednesday, July 10, 2024

9:15 AM	Introduction	
9:30 AM	Session W-A1 **Ambient-Adjusted Ratings for Improved Market Efficiency: Design and Implementation** Kwok W. Cheung, GE Vernova (*Redmond, WA*) Tory McKeag, GE (*Bothell, WA*) **Improving Grid Performance: Innovative Solutions for Evaluating Grid-Enhancing Technologies (GETs) in Generation Interconnection and Transmission Planning** Wonbae Choi, Grid Insights INC. (*British Columbia, Canada*) Zemeng Wang, Grid Insights INC. (*British Columbia, Canada*) **Congestion and Overload Mitigation with Optimal Transmission Reconfiguration – Experience in the MISO and SPP Footprints** Pablo A. Ruiz, NewGrid, Inc. and The Brattle Group (*Somerville, MA*) Paola Caro, NewGrid, Inc. (*Somerville, MA*) Rodica Donaldson, EDF Renewables (*San Diego, CA*) German Lorenzon, NewGrid, Inc. (*Somerville, MA*) Mitchell Myhre, Alliant Energy (*Madison, WI*) Ruchi Singh, ENGIE North America (*Houston, TX*) Steve Leovy, WPPI Energy (*Sun Prairie, WI*) Thomas J. Butz, Minnesota Power (*Duluth, MN*) **Grid-Enhancing Technology Benefit Assessment with Advanced OPF PowSyBl Metrix** Violette Berge, Artelys Canada Inc. (*Montreal, Canada*) Nicolas Omont, Artelys (*Paris, France*) Felipe Gonzales Venegas, Artelys (*Paris, France*) Gladys Leon Suros, Artelys España (*Valencia, Spain*)	
9:30 AM	Session W-B1 **Reliability Assessment of Power Grid Operations Considering Correlated Dependency from Gas Pipeline Delivery over Extreme Weather** Zhi Zhou, Argonne National Laboratory (*Lemont, IL*) Neal Mann, Argonne National Laboratory (*Lemont, IL*) David Sehloff, Argonne National Laboratory (*Lemont, IL*) Eric Tatara, Argonne National Laboratory (*Lemont, IL*) Sinem Perk, Argonne National Laboratory (*Lemont, IL*) Mitchell Krock, Argonne National Laboratory (*Lemont, IL*) **Parallel Computing for Stochastic Power System Capacity Expansion Planning** Tomas Valencia Zuluaga, Lawrence Livermore National Laboratory & University of California, Berkeley (*Berkeley, CA*) Shmuel Oren, University of California, Berkeley (*Berkeley, CA*) Amelia Musselman, Lawrence Livermore National Laboratory (*Livermore, CA*) Jean-Paul Watson, Lawrence Livermore National Laboratory (*Livermore, CA*) **Extreme Weather Impacts and Considerations on the Transmission Planning Process** Eknath Vittal, Electric Power Research Institute (*Palo Alto, CA*) Parag Mitra, Electric Power Research Institute (*Palo Alto, CA*) Dinesh Dhungana, Electric Power Research Institute (*Palo Alto, CA*) **Dynamic Assessment and Determination of Contingency Reserves** Miguel Ortega-Vazquez, Electric Power Research Institute (*Palo Alto, CA*)	
11:30 AM	Lunch	

Wednesday, July 10, 2024

12:30 PM	Session W-A2 **Simulation Platform with Integrating Security Constrained Unit Commitment, DER Aggregation, and Distribution System Models** Brent Eldridge, Pacific Northwest National Laboratory (*Bel Air, MD*) Eran Schweitzer, Pacific Northwest National Laboratory (*Portland, OR*) Jesse Holzer, Pacific Northwest National Laboratory (*Richland, WA*) Matt Cornachione, Pacific Northwest National Laboratory (*Portland, OR*) Alok Bharati, Pacific Northwest National Laboratory (*Richland, WA*) Abhishek Somani, Pacific Northwest National Laboratory (*Denver, CO*) **Standardizing and Automating DER Company Registration and Connectivity Establishment for Utilities and Other Centralized Systems** Daniel Roesler, UtilityAPI and LFEnergy's Carbon Data Specification Consortium (*Oakland, CA*) **Increasing DER Operational Data and Telemetry** Brett Busold, American Electric Power (*New Albany, OH*) **A Real-Time Economic Dispatch Approach for Wholesale Energy Market with Multi-Transmission-Node DER Aggregations** Zhentong Shao, Stevens Institute of Technology (*Hoboken, NJ*) Weilun Wang, Stevens Institute of Technology (*Hoboken, NJ*) Brent Eldridge, Pacific Northwest National Laboratory (*Richland, WA*) Abhishek Somani, Pacific Northwest National Laboratory (*Richland, WA*) Lei Wu, Stevens Institute of Technology (*Hoboken, NJ*)

Wednesday, July 10, 2024

12:30 PM Session W-B2

PowerGEM TARA Worst Cluster TrLim Analysis for System-Wide Bus Injection Capability and Heatmap to Address FERC Order 2023

John Condren, PowerGEM (*Clifton Park, NY*)
Seungwon An, PowerGEM (*Clifton Park, NY*)
Boris Gisin, PowerGEM (*Clifton Park, NY*)

Unlocking Grid Potential: A Holistic Evaluation of Transmission Hosting Capacity

Swaroop Guggilam, Electric Power Research Institute (*Knoxville, TN*)
Sujit Tripathy, Electric Power Research Institute (*Knoxville, TN*)
Deepak Ramasubramanian, Electric Power Research Institute (*Knoxville, TN*)
Vikas Singhvi, Electric Power Research Institute (*Knoxville, TN*)
Jens Boemer, Electric Power Research Institute (*Seattle, WA*)
Anish Gaikwad, Electric Power Research Institute (*Knoxville, TN*)

A Novel, Unique, and Proven Approach to Performing Near Real Time Probabilistic Power System Risk Analyses as an Immediately Available Solution for Unlocking Existing Grid Capacity by Facilitating the Safe Encroachment Into N-1 Power System Engineering

Barry Bragger, Infinigrid (*Boynton Beach, FL*)
Arne Brufladt Svendsen, Infinigrid (*Bergen, Norway*)
Martin Groh, Infinigrid (*Oslo, Norway*)
Robert Nyiredy, Infinigrid (*Oslo, Norway*)
Mathieu Milenkovic, Infinigrid (*Oslo, Norway*)

An Analysis on Market-to-Market Coordination

Alinson Santos Xavier, Argonne National Laboratory (*Lemont, IL*)
Weihang Ren, University of Florida (*Gainesville, FL*)
Fengyu Wang, New Mexico State University (*Las Cruces, NM*)
Yongpei Guan, University of Florida (*Gainesville, FL*)
Feng Qiu, Argonne National Laboratory (*Lemont, IL*)

2:30 PM Break

Wednesday, July 10, 2024

3:00 PM Session W-A3

Bidding Strategies for Battery Energy Storage Addressing Uncertain Market Clearance Patterns

Yongpei Guan, University of Florida (*Gainesville, FL*)
Weihang Ren, University of Florida (*Gainesville, FL*)

Integrating Battery Storage into Electricity Markets: Accounting for Degradation Costs and Participation Models in the IESO Wholesale Markets

Nitin Padmanabhan, Electric Power Research Institute (*Ontario, Canada*)
Bo Yuan, Cornell University (*Ithaca, NY*)
Erik Ela, Electric Power Research Institute (*Palo Alto, CA*)
Sasoon Assaturian, Independent Electricity System Operator (*Toronto, Ontario*)

Energy Storage Participation Algorithm Competition (ESPA-Comp) Design and Pilot Results

Matthew Cornachione, Pacific Northwest National Laboratory (*Richland, WA*)
Brent Eldridge, Pacific Northwest National Laboratory (*Richland, WA*)
Brittany Tarufell, Pacific Northwest National Laboratory (*Richland, WA*)
Jesse Holzer, Pacific Northwest National Laboratory (*Richland, WA*)
Liping Li, Pacific Northwest National Laboratory (*Richland, WA*)
Arun Veeramany, Pacific Northwest National Laboratory (*Richland, WA*)
Kostas Oikonomou, Pacific Northwest National Laboratory (*Richland, WA*)
Abhishek Somani, Pacific Northwest National Laboratory (*Richland, WA*)

Evaluating Benefits of Long Duration Energy Storage

Aleksandr Rudkevich, Newton Energy Group LLC (*Newton, MA*)
Ninad Kumthekar, Tabors Caramanis Rudkevich (*Newton, MA*)
Joseph Silvers, Tabors Caramanis Rudkevich (*Newton, MA*)
Sydney Swearigen, Tabors Caramanis Rudkevich (*Newton, MA*)
Richard Tabors, Tabors Caramanis Rudkevich (*Newton, MA*)
Russ Philbrick, Polaris Systems Optimization (*Shoreline, WA*)

A Theoretical Framework for Monitoring and Mitigating Energy Storage Market Power in Real-Time Markets

Ningkun Zheng, Columbia University (*Pittsburgh, PA*)
Zhiyi Zhou, Xi'an Jiaotong University (*Shaanxi, China*)
Bolun Xu, Columbia University (*New York, NY*)

Wednesday, July 10, 2024

3:00 PM	Session W-B3 **Completing ISO Markets** Richard P. O'Neill, (*Silver Spring, MD*) **Average Incremental Cost Pricing for the Alternating Current Unit Commitment Problem** Manuel Garcia, Los Alamos National Laboratory (*Los Alamos, NM*) **Deep Learning-Based Transmission Line Screening for Unit Commitment** Farhan Hyder, Rochester Institute of Technology (*Rochester, NY*) Sriparvathi Shaji Bhattathiri, Rochester Institute of Technology (*Rochester, NY*) Abigail Broscius, Rochester Institute of Technology (*Rochester, NY*) Bing Yan, Rochester Institute of Technology (*Rochester, NY*) Michael E. Kuhl, Rochester Institute of Technology (*Rochester, NY*) **Recent Advances in Solving Large-Scale Security-Constrained UC ACOPF** Andy Sun, Associate Professor, Massachusetts Institute of Technology (*Cambridge, MA*) **AC Unit Commitment in the Grid Optimization Competition Challenge 3** Jesse Holzer, Pacific Northwest National Laboratory (*Richland, WA*)
5:30 PM	Adjourn

Thursday, July 11, 2024

9:15 AM	Introduction
9:30 AM	Session H-A1 **Software for System Model Validation** Eric H. Allen, SmartGridz, Inc. (*Sudbury, MA*) Jeffrey Lang, Massachusetts Institute of Technology (*Cambridge, MA*) Marija Ilic, Massachusetts Institute of Technology (*Cambridge, MA*) **A Day-Ahead Contingency Planning Solution that Captures the Physics of Electric and Gas Networks** Wallace Kenyon, encoord Inc. (*Denver, CO*) Will Frazier, encoord Inc. (*Boulder, CO*) Carlo Brancucci, encoord Inc. (*Denver, CO*) **Power System State Estimation by Phase Synchronization and Eigenvectors** Richard Y. Zhang, University of Illinois at Urbana-Champaign (*Urbana, IL*) Iven Guzel, University of Illinois at Urbana-Champaign (*Urbana, IL*) **ABSCoRES: Applying Credit Scoring Methodologies for Risk Estimation in Energy Assets and Grid Management** Andres F. Ramirez, Lehigh University (*Fallbrook, CA*) Alberto J. Lamadrid, Lehigh University (*Fallbrook, CA*)
9:30 AM	Session H-B1 **Embracing Open Source and OSS Projects to Improve Energy Market Efficiency and Reliability** Alexandre Parisot, Linux Foundation Energy (*San Francisco, CA*) **Global-TEP: A New Global Solver for Transmission Expansion Planning with AC Network Model** Mahdi Mehrtash, Johns Hopkins University (*Baltimore, MD*) **Advanced Reliability Tool Set** Tamer Ibrahim, Electric Power Research Institute (*Knoxville, TN*) Eknath Vittal, Electric Power Reseach Institute (*Palo Alto, CA*) Stavros Konstantinopoulos, Electric Power Research Institute (*Palo Alto, CA*) Blaine Burton, Electric Power Reseach Institute (*Palo Alto, CA*) **Utilizing Locational Marginal Emission Rates to Achieve Decarbonization Goals** Emma Naden, Tabors Caramanis Rudkevich (*Newton, MA*) Aleksandr Rudkevich, Tabors Caramanis Rudkevich (*Newton, MA*) Richard Tabors, Tabors Caramanis Rudkevich (*Newton, MA*) Ninad Kumthekar, Tabors Caramanis Rudkevich (*Newton, MA*) Bo Li, Tabors Caramanis Rudkevich (*Newton, MA*)
11:30 AM	Lunch

Thursday, July 11, 2024

12:30 PM Session H-2

A Fast Learning-Based Unit Commitment Strategy with AC Optimal Power Flow for Large Grids with Direct Inclusion of Weather

Farnaz Safdarian, Texas A&M University (*College Station, TX*)
Joshua Peeples, Texas A&M University (*College Station, TX*)
Thomas Overbye, Texas A&M University (*College Station, TX*)

Trustworthy Deep Learning for Electricity Market Applications

Vladimir Dvorkin, University of Michigan (*Ann Arbor, MI*)
Ferdinando Fioretto, University of Virginia (*Charlottesville, VA*)

Leveraging Underutilized DER Edge Compute to Improve Market Efficiencies

Philip Court, Ecosuite (*Brooklyn, NY*)
Joel Santisteban, Ecosuite (*Brooklyn, NY*)
John Gorman, Ecosuite (*Brooklyn, NY*)

Privacy-Preserving Demand Response Enabled by Synthetic Data

Guangchun (Grant) Ruan, Massachusetts Institute of Technology (*Boston, MA*)
Morteza Vahid-Ghavidel, INESC-TEC (*Porto, Portugal*)
Audun Botterud, Massachusetts Institute of Technology (*Boston, MA*)

GAMSPy: A Pipeline Friendly General Algebraic Modeling Language

Adam Christensen, GAMS Development Corporation (*Fairfax, VA*)
Steven Dirkse, GAMS Development Corporation (*Fairfax, VA*)
Michael Bussieck, GAMS Software GmbH (*Braunschweig, Germany*)
Muhammet Soyturk, GAMS Software GmbH (*Braunschweig, Germany*)

3:00 PM Adjourn

CONFERENCE ABSTRACTS

Day 1 - Tuesday, July 9

Session T1 (Tuesday, July 9, 9:30 AM)

A MRI-BASED RESOURCE CAPACITY ACCREDITATION

Dr. Feng Zhao, Manager, ISO New England (Holyoke, MA)

This presentation introduces a Marginal Reliability Impact (MRI) based Resource Capacity Accreditation (RCA) framework. Under this framework, a resource's accreditation value will be based on its marginal reliability impact on system adequacy, which results in a better alignment of the resource's accredited capacity with its reliability contribution. An important feature of the design is that each MW of accredited capacity from different resources will have the same contribution to system adequacy, thus achieving substitutability among resource capacities. Also with MRI-based capacity demand curves, the design achieves substitutability between supply and demand capacities. As a result, a Forward Capacity Market (FCM) that trades MRI-based capacities provides a better representation of the resource adequacy problem, and therefore is expected to yield a more efficient result.

DEVELOPMENT OF A REGIONAL ENERGY SHORTFALL THRESHOLD

Dr. Jinye Zhao, Technical Manager, ISO New England (Holyoke, MA)
Stephen George, Director, ISO New England (Holyoke, MA)
Dr. Ke Ma, Lead Analyst, ISO New England (Holyoke, MA)
Dr. Hannah Johlas, Senior Energy Security Analyst, ISO New England (Holyoke, MA)

ISO New England is pioneering the development of a Regional Energy Shortfall Threshold (REST), establishing an acceptable level of regional energy shortfall risk during extreme weather conditions. The development of REST will utilize the Probabilistic Energy Adequacy Tool, which is capable of identifying weather events that could cause energy deficits as well as assessing the likelihood and severity of such events. REST will serve as an energy adequacy standard for extreme weather events, complementing the widely used 1-day-in-10-year resource adequacy criterion. This presentation focuses on ISO's current thinking regarding the selection criteria for extreme weather events, the metrics used to quantify energy adequacy risk and the frequency of REST evaluations.

STUDY OF DER RESPONSES USING TRANSMISSION AND DISTRIBUTION SYSTEMS CO-SIMULATION

Dr. Mingguo Hong, Principal Analyst, ISO New England (Holyoke, MA)
Dr. Xiaochuan Luo, Manager - Power System Technology, ISO New England (Holyoke, MA)
Dr. Tongxin Zheng, Chief Technologist, ISO New England (Holyoke, MA)
Pradip Vijayan, Manager - Transmission Planning, ISO New England (Holyoke, MA)
Eva Mailhot, Transmission Planning Engineer, ISO New England (Holyoke, MA)
Brad Marszalkowsky, Supervisor - Resource Ingtegration, ISO New England (Holyoke, MA)
Dr. Trevor Hardy, Power System Research Engineer, PNNL (Richland, WA)
Dr. Alok Kumar Bharati, Senior Power Systems Researcher, PNNL (Richland, WA)
Dr. Wei Du, Electrical Engineer, PNNL (Richland, WA)
Dr. Frank Tuffner, Staff Research Engineer, PNNL (Richland, WA)
Aaron Hanenkratt, Senior Engineer, National Grid (Boston, MA)
Dan Kopin, Manager of Innovation, Vermont Electric Power Company (Rustland, VT)

With the increasing penetration of distributed energy resources (DER) in power systems, it is critical to develop modeling capabilities that can accurately represent their impact on bulk power transmission system operations during network events, such as cloud transients and network faults, etc. While the Electromagnetic Transient (EMT) simulation is a great tool for achieving the purpose of such study, there are significant limitations in both model scales and simulation time. An alternative approach is to perform joint transmission and distribution systems (T&D) co-simulation in the phasor domain. ISO New England has teamed up with Pacific Northwest National Laboratory (PNNL), National Grid (NG) and Vermont Electric Power Company (VELCO) to conduct T&D co-simulation on realistic T&D planning models, to answer important questions concerning distribution voltage security during cloud transient and DER voltage ride-through responses following transmission faults. This presentation summarizes the project study efforts, discussing the benefits of T&D co-simulation, T&D network models, software platforms, main outcomes and future work.

OPTIMIZING ENERGY AND RESERVE SCHEDULES FOR POST-CONTINGENCY SCENARIOS: A SECURITY CONSTRAINED UNIT COMMITMENT APPROACH

Matthew Musto, Technical Specialist, New York ISO (Rensselaer, NY)
Kanchan Upadhyay, Senior Energy Market Engineer, New York ISO (Rensselaer, NY)

Dr. Edward Lo, Contractor, Hitachi Energy (San Jose, CA)

This presentation explores a Security Constrained Unit Commitment and Economic Dispatch (SCUC/ED) scheme to enhance energy and reserve schedules in power systems; considering preventative dispatch sensitivity factors for N-1 and N-2 contingencies. The co-optimization of energy and reserve schedules aims to improve system security and reliability, while also focusing on empirical testing of tradeoffs between transmission and generation operating points. The presentation will examine the effects of these methods on Energy and Reserve scheduling, Locational Marginal Operating Reserve Price (LMORP) and Locational Marginal Price (LMP) formulations, as well as their impacts on transmission congestion flows. The findings will provide insights into potential future research areas in this domain.

Session T2 (Tuesday, July 9, 12:30 PM)

OPTIMIZING LOCATIONAL MINIMUM INSTALLED CAPACITY REQUIREMENTS

John Meyer, Senior Market Solutions Architect, New York ISO (Rensselaer, NY)
Dr. Sushant Varghese, Energy Market Engineer, New York ISO (Rensselaer, NY)

The New York Independent System Operator, Inc. (NYISO) has been working on potential improvements to the software tools and process of optimizing the Locational Minimum Installed Capacity Requirements (LCRs) for least investment cost while maintaining reliability (Resource Adequacy) requirements for the entire New York Control Area (NYCA) system. These LCRs contribute to the calibration of capacity market demand curves and determine the minimum amount of capacity supply that needs to be secured in certain locations. The work includes assessing revisions to the high-level problem formulation and an update on the investigation of algorithms that leverage reliability simulation software to determine the LCRs.

HOURLY ELECTRICITY LOAD FORECASTING USING MACHINE LEARNING ALGORITHMS

Dr. Yinghua Wu, Senior Lead Data Scientist, PJM Interconnection (Audubon, PA)
Laura Walter, Senior Lead Data Scientist, PJM Interconnection (Audubon, PA)
Dr. Anthony Giacomoni, Manager - Advanced Analytics, PJM Interconnection (Audubon, PA)

PJM prepares hourly load forecasts during each hour looking ahead seven days. These forecasts are used as inputs to the five-minute forecasts used by PJM's Real-Time Security Constrained Economic Dispatch (RT-SCED), which is executed every five minutes, and Intermediate-Term Security Constrained Economic Dispatch (IT-SCED), which is run continuously throughout the operating day, that provide dispatch solution and commitment recommendations respectively. Accurate load forecasting plays an important role in maintaining the reliability and efficiency of the power grid. Members often use these forecasts, which are shared publicly, in planning their bidding strategies in the Day-Ahead and Real-Time energy markets. Given recent progress in machine learning technologies, it is highly desirable to survey a collection of the most representative and innovative methods that are suitable to time series predictions, such as gradient boosting, recurrent neural network and causal convolution. There are also different ways to formulate the problem to implement these new technologies. In this study, we combine industry knowledge with the latest state-of-the-art algorithms to explore practical and optimal solutions for hourly load forecasts.

OPTIMIZING SYNCHRONOUS CONDENSERS IN PJM'S DAY-AHEAD ENERGY MARKET USING A HYBRID MULTIPLE CONFIGURATION RESOURCE MODEL

Dr. Anthony Giacomoni, Manager - Advanced Analytics, PJM Interconnection (Audubon, PA)
Dr. Danial Nazemi, Senior Operations Research Engineer I, PJM Interconnection (Audubon, PA)
Dr. Qun Gu, Principal Consultant, PowerGEM (Clifton Park, NY)
Dr. Boris Gisin, President, PowerGEM (Clifton Park, NY)

For three years, PJM, MISO and PowerGEM worked jointly on developing an advanced security constrained unit commitment (SCUC) algorithm to prepare for the full-scale implementation of a multiple configuration resource (MCR) model in their energy markets. In October 2023, PJM implemented the model in its Day-Ahead Market (DAM) for the optimization of synchronous condensers. This marked an important milestone as the first time the MCR model was implemented into production in PJM's energy markets. In the future, the MCR model will also be implemented for combined cycle units and possibly for hybrid resources as well. A synchronous condenser is a machine whose shaft is not attached to any driving equipment and is able to provide reactive power support. Presently, over 40 combustion turbines and hydro units in PJM have the ability to operate in both condensing mode and generating mode. In condensing mode, the units consume a small amount of real power, but they are able to provide synchronized reserves since they are synchronized to the grid and can quickly transition to generating mode. The optimization of multiple configurations is very challenging due to the additional integer variables, configuration- and component-level constraints, and complicated transition characteristics, which could all impact the solution time and may lead to performance challenges. The MCR model was implemented in the PROBE Day-Ahead software, which is currently a critical component of PJM's DAM clearing process. The MCR model has the ability to perform energy and ancillary service co-optimization for synchronous condensers with multiple configurations. The MCR model also supports PJM's market mitigation process. Benefits of the new model include enhanced modeling ability to match with resources' physical characteristics and improved market outcomes with increased social benefits. Prior to October 2023, the commitment decisions for synchronous condensers in the DAM were made using a heuristic and not a full configuration-based optimization. Often market operators noticed units were being sub-optimally committed in condensing mode and would require uplift payments. Using the MCR model, with the operational and economic characteristics of each operating mode of the unit and its transitions being considered and fully optimized in the unit commitment, PJM market operators now witness improved market outcomes with significantly reduced uplift payments. The MCR model has also proven to have minimal impact on computational performance. This presentation will describe the implementation of the MCR model for synchronous condensers in PJM's DAM. It will also quantify some of the benefits that optimizing synchronous condensers provides to the DAM.

STOCHASTIC NODAL ADEQUACY PRICING PLATFORM

Geoff Brigham, Manager - Research and Development, Midcontinent ISO (Carmel, IN)
Dr. Aleksandr Rudkevich, President and CEO, Newton Energy Group (Newton, MA)
Dr. F. Selin Yanikara, Energy Research Analyst, Newton Energy Group (Newton, MA)
Russ Philbrick, CEO and CTO, Polaris Systems Optimization (Shoreline, WA)
Dr. Richard Tabors, President, Tabors Caramanis Rudkevich (Newton, MA)
Dr. Bing Huang, Research Engineer, Midcontinent ISO (Carmel, IN)
Mojtaba Sepehry, Market Engineer, Midcontinent ISO (Carmel, IN)

The software system of the Stochastic Nodal Adequacy Pricing Platform (SNAP), supported by an ARPA-E grant, was developed as a probabilistic extension of production costing tools that supports the use of high-fidelity models with realistic representation of operational and grid constraints. SNAP calculates the economic value of the contribution of each individual resource to system adequacy. This includes generation, demand, and transmission resources. SNAP is able to accurately simulate the temporal and spatial relationships affecting system physics and economics. The ability to use high-fidelity models enables accurate calculation of dual variables and their use in defining reliability metrics that accurately represent the economic and engineering characteristics of all resources (including those behind the meter). In particular, the use of dual variables captures impacts of time-coupled resources and constraints such as storage and limited fuel supply. By bringing economic metrics directly into reliability analysis, we can supplement traditional reliability metrics with economically justified reliability criteria for use by system planning and operations. Demonstrated in the case analysis of MISO to be presented, the high-fidelity probabilistic models, rich with operational and engineering details, are computationally intensive. Using these models in the Monte Carlo fashion for probabilistic analysis has, in the past, been considered computationally intractable. In this presentation we will demonstrate that tractability can be achieved by combining parallel cloud computing technology with efficient math programming and multi-layered scenario reduction techniques. These techniques can be applied to multiple dimensions, such as weather scenarios, time, and random outages. SNAP provides the economic value of the contribution of every resource to system reliability. This includes generation, demand, and transmission resources.

Session T3 (Tuesday, July 9, 3:00 PM)

SHORT-TERM FORECASTING DURING EXTREME CLIMATE EVENTS

Amber Motley, Director - Short Term Forecasting, California ISO (Folsom, CA)

We continue to see increasing extreme climate events impact electric grid operations throughout the summer and winter seasons. One of the areas that is critical to reliable grid operations during extreme climate events is the short term load forecasting. The CAISO continues work to improve short term load forecasting models in the presence of extreme climate events and further integration of DER resources (including demand response and behind-the-meter solar). Amber Motley will discuss the short term demand forecasting evolutions that have occurred for the CAISO and Western Energy Imbalance Market balancing areas.

MODELING THE IMPACT OF REGULATION SERVICE ON BATTERY ENERGY STORAGE STATE OF CHARGE

Guillermo Bautista Alderete, Director - Market Performance and Advanced Analytics, California ISO (Folsom, CA)
Kun Zhao, Lead Quantitative Analyst, California ISO (Folsom, CA)

In recent years, the CAISO market has seen a large penetration of storage resources, expecting to reach a milestone of 10,000 MW by the end of 2024. Storage resources are energy-limited, requiring sophisticated modeling to efficiently manage their dispatch and state of charge over time. Given the characteristics of storage resources, they have become the primary technology supporting regulation services in the market. The provision of regulation impacts their state of charge: providing regulation up will deplete their state of charge, while providing regulation down will increase it. These impacts need to be considered in market optimization to come up with efficient energy dispatches. In 2023, CAISO implemented enhancements to the modeling of storage resources to consider the impact of regulation use on their state of charge. This model is based on the estimation of regulation use, which is then incorporated into the optimization with attenuation factors. This presentation will provide a review of the enhanced formulation of storage resources and discuss the market performance observed with the implementation of this approach.

ENERGY STORAGE RESOURCE MODEL

Khaled Abdul-Rahman, Vice President - Technology, California ISO (Folsom, CA)
Dr. George Angelidis, Executive Principal, California ISO (Folsom, CA)
Fan Zhang, Staff Enterprise Technology Engineer, BP (Houston, TX)
Yannick Degeilh, Senior Power Systems Engineer, California ISO (Folsom, CA)
Juan Alvarez Lopez, Power Systems Engineer, California ISO (Folsom, CA)

The Energy Storage Resource (ESR) model is the next evolution in modeling batteries to address the unique operational characteristics of these devices. It is fundamentally different from conventional models where the operating cost is modeled with an energy bid that spans the resource capacity, from charging (negative schedule) to discharging (positive schedule). The ESR model uses instead separate State of Charge (SOC) bids for charging and discharging that span the operational range of stored energy. This model provides the ability to represent the higher operating cost when charging at a high SOC or discharging at a low SOC, irrespective of the energy schedule, which is impossible with the conventional models.

FLEXIBILITY RESERVE PRODUCTS AND STRUCTURAL CHANGES TO UNIT COMMITMENT IN REAL-TIME MARKETS AND OPERATIONS

Dr. Mort Webster, Professor of Energy Engineering, Pennsylvania State University (University Park, PA)

Dr. Anthony Giacomoni, Manager - Advanced Analytics, PJM Interconnection (Audubon, PA)
Aravind Retna Kumar, Ph.D. Candidate, Pennsylvania State University (University Park, PA)
Shailesh Wasti, Ph.D. Candidate, Pennsylvania State University (University Park, PA)

The projected trends in the U.S. power system, increasing wind and solar generation and retiring fossil fuel generation, will increase the net load variability and forecast uncertainty over the next several decades. It is widely anticipated that systems will need additional ramping flexibility to respond rapidly to sudden changes in net load. One approach that has been implemented by some Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs), and considered by others, is to increase the lookahead horizon in their Real-Time Economic Dispatch (RTED). The longer lookahead enables pre-ramping of slower units to be prepared for potential rapid fluctuations in net load. However, in some regions, a shift to a multi-interval dispatch approach presents technical challenges and may take several years to implement. One alternative is to expand the use of new flexibility reserve and ramping products, which are easier to implement or modify on shorter time-scales. By introducing ramping products with several delivery times (e.g., ten minutes and sixty minutes), it may be possible to induce similar dispatching behavior to that of a multi-interval dispatch. However, products with a longer delivery time may require structural changes to the Real-Time Unit Commitment (RTUC) clearing engine, such as longer lookahead horizons. In this work, we apply a simulation model of the PJM Real-Time Energy Market that emulates critical intertemporal characteristics: simulating the RTUC and RTED on a rolling horizon basis throughout the operating day with changing forecasts throughout the day including forecast errors, and separate solutions of RTUC and RTED. Using this model, we explore the system-level impacts of several possible enhancements, including the implementation of flexibility ramp products with varying delivery times, combinations of multiple ramp products, extending the horizon of the RTUC, and modifying the generator types that can be committed in real-time. We will present the relative changes from alternative market designs in reliability metrics, system costs, and net revenues to different subclasses of resources as a measure of incentives for providing flexibility.

INTERREGIONAL TRANSMISSION OPERATIONAL COORDINATION

Dr. Yonghong Chen, Chief Scientist, National Renewable Energy Laboratory (Golden, CO)

Dr. Jose Daniel Lara, Senior Staff Researcher, National Renewable Energy Laboratory (Golden, CO)

This presentation will discuss challenges and opportunities on interregional coordination in the areas of interchange transaction, congestion management, reserve sharing and deliverability across multi-stage operational processes. It will then provide an overview of the interregional transmission operational coordination (IRTOC) project that currently focuses on congestion management, including Inter-regional transmission coordination in real time operations and operational planning, HVDC optimization (intra- and inter-regional), ancillary service deliverability (intra- and inter-regional). In addition, it will discuss the Sienna-Decomposition tool development to systematically study interregional coordination methods.

Day 2 - Wednesday, July 10

Session W-A1 (Wednesday, July 10, 9:30 AM)

AMBIENT-ADJUSTED RATINGS FOR IMPROVED MARKET EFFICIENCY: DESIGN AND IMPLEMENTATION

Dr. Kwok W. Cheung, CTO and Director - Global Management Solutions, GE Vernova (Redmond, WA)
Tory McKeag, Software Architect, GE (Bothell, WA)

Issued on December 16, 2021, FERC Order 881 requires transmission providers to implement ambient-adjusted ratings (AAR) to determine the maximum transfer capability of their transmission lines for near-term transmission services. Traditionally, static line rating (SLR) of a line is conservatively calculated under the almost worst-case operating conditions and are updated infrequently. These conservative assumptions may restrict the line capacity whenever the real weather condition is less stressful. More accurate assessment of transmission flow limits like AAR which is a limited form of dynamic line ratings (DLR) will positively impact the efficiency of market and system operations. DLR has the potential to expand practical line capacity, improve line utilization, reduce transmission congestion, and enhance market efficiency. In North America, independent system operators and transmission system operators are heavily involved in addressing the compliance of the order. This talk will discuss AAR within the framework of energy and market management systems. Various aspects of design and implementation of ARR will be addressed in detail.

IMPROVING GRID PERFORMANCE: INNOVATIVE SOLUTIONS FOR EVALUATING GRID-ENHANCING TECHNOLOGIES (GETS) IN GENERATION INTERCONNECTION AND TRANSMISSION PLANNING

Wonbae Choi, Principal Consultant, Grid Insights INC. (British Columbia, Canada)
Zemeng Wang, Principal Consultant, Grid Insights INC. (British Columbia, Canada)

This abstract introduces novel tools designed to improve the effectiveness of generation interconnection and planning procedures by offering a platform for assessing the most suitable placement of Grid-Enhancing Technologies (GET), such as power flow control devices using PowerGEM's TARA and PROBE-LT software. The aim is to assess grid reliability and economic benefits of GETs in a timely manner. 1) Background & Problem Statement: As outlined in FERC Order 2023 and reiterated in FERC Order 2023A, ISOs/Transmission Owners need to incorporate GETs into the new generation interconnection study process. Nevertheless, there is currently no established standard or framework for systematically showcasing the reliability and economic advantages of GETs or for strategically determining optimal locations for these devices. 2) Proposed solutions: Our proposed solutions offer a multifaceted approach to enhancing the efficiency of generation interconnection and planning processes while maximizing the benefits of GETs, particularly power flow controls. Key features of our solutions include: 1) Optimal Location Evaluation: Our tool incorporates advanced algorithms and modeling techniques to systematically evaluate potential placement locations for GET devices within the grid infrastructure based on the reliability assessment and economic analysis. By analyzing factors such as network topology, load distribution, and congestion patterns, the software identifies optimal locations where the deployment of GET devices, such as power flow control devices, can yield the greatest reliability and economic benefits. a) Reliability Assessment: The tool includes modules for conducting comprehensive reliability assessments, taking into account various scenarios and contingencies using PowerGEM's TARA software. By simulating the impact of different configurations of GET devices on system reliability metrics, our tool enables users to make informed decisions regarding the deployment of GET solutions. b) Economic Analysis: In addition to reliability considerations, our tool incorporates economic analysis using PowerGEM's PROBE-LT software to assess the cost-effectiveness of deploying GET devices. By quantifying the potential benefits in terms of reduced congestion costs, avoided infrastructure investments, and improved system efficiency, the tool provides valuable insights into the economic viability of implementing GET solutions. 2) Visualization and Reporting: To facilitate decision-making and stakeholder communication, our tool includes intuitive visualization tools and customizable reporting capabilities. Users can visualize the results of optimal location evaluations, reliability

assessments, and economic analyses through interactive maps, charts, and graphs, enabling them to effectively convey the benefits of proposed GET solutions to relevant stakeholders. By deploying our solutions, utilities, and grid operators can unlock significant operational efficiencies, enhance grid reliability, and facilitate the seamless integration of renewable energy sources. Our abstract outlines the technical capabilities, benefits, and potential impacts of our tools, demonstrating its relevance and significance in advancing the goals of modern grid management and optimization.

CONGESTION AND OVERLOAD MITIGATION WITH OPTIMAL TRANSMISSION RECONFIGURATION – EXPERIENCE IN THE MISO AND SPP FOOTPRINTS

Pablo A. Ruiz, CEO, NewGrid, Inc. and The Brattle Group (Somerville, MA)
Paola Caro, Principal Engineer, NewGrid, Inc. (Somerville, MA)
Rodica Donaldson, Vice President - Transmission Analytics, EDF Renewables (San Diego, CA)
German Lorenzon, Senior Engineer, NewGrid, Inc. (Somerville, MA)
Mitchell Myhre, Senior Manager - Business Planning and Regulatory Strategy, Alliant Energy (Madison, WI)
Ruchi Singh, Director of Engineering, ENGIE North America (Houston, TX)
Steve Leovy, Senior Transmission Engineer, WPPI Energy (Sun Prairie, WI)
Thomas J. Butz, Utility Planner - Senior, Minnesota Power (Duluth, MN)

Transmission needs have been increasing rapidly and become more variable, resulting in significant congestion management costs, renewable curtailments, frequent transmission overloads and stranded generation capacity during extreme events. In the longer timeframes, transmission needs have resulted in more challenges to schedule transmission and generation outages, delays in the testing of new generation, and inability to bring new generating plants online until transmission reinforcements are completed. Topology optimization software is a grid-enhancing technology that identifies reconfiguration options to re-route power flow around transmission bottlenecks, employing underutilized facilities. These reconfigurations provide cost savings to power customers and increases the transmission network performance from both reliability and market-efficiency perspectives. Even though it is a proven solution, reconfiguration use has remained limited. To facilitate the use of reconfigurations and provide another congestion management tool to transmission customers, the Midcontinent ISO (MISO) has implemented a process for market participants to submit reconfiguration proposals that show promise after initial analysis. The Southwest Power Pool (SPP) and the Electric Reliability Council of Texas (ERCOT) have similar process initiatives under discussion.

This presentation will demonstrate the reliability, cost-saving, environmental and curtailment-mitigation impacts of reconfigurations identified on behalf of market participants in MISO and SPP, as well as illustrate additional benefits that could be obtained if topology optimization opportunities were used proactively and consistently across RTO footprints.

GRID-ENHANCING TECHNOLOGY BENEFIT ASSESSMENT WITH ADVANCED OPF POWSYBL METRIX

Violette Berge, Vice President, Artelys Canada Inc. (Montreal, Canada)
Nicolas Omont, Vice President of Operations, Artelys (Paris, France)
Felipe Gonzales Venegas, Energy and Optimization Engineer, Artelys (Paris, France)
Gladys Leon Suros, Vice President, Artelys España (Valencia, Spain)

The energy transition requires heavy investments into the transmission grid. However, grid-enhancing technologies have the potential to defer, reduce them, or mitigate the impact of late implementation. To leverage their full potential, they need to be well represented in transmission expansion studies to minimize the gap between planning and operations and thus assess adequately their benefits. PowSyBl Metrix is a tool dedicated to grid reinforcement cost-benefit analysis in contexts with high penetration of variable renewable energy sources. It is tuned for the optimization of annual hourly scenarios. It can either simulate or optimize preventive and curative actions like load and generation curtailment, transmission switching, phase angle regulation and HVDC line set point adjustment while enforcing security constraints both on the base case (N) and contingency cases (N-k). It relies on a Security-Constrained DC Optimal Power Flow (SC-DCOPF) supported by a 100-time faster computation of sensitivity factors based on the Woodbury matrix identity and a specially tuned open-source Mixed Integer Programming solver. As a result, the solution is both very efficient and fully open-source as it does not rely on a commercial solver. PowSyBl Metrix can be used to compute the social welfare variation between different grid configurations in order to assess the benefits of a specific project: for example, with or without a new line or using or not using a grid-enhancing technology. It can also assess the potential of a grid-enhancing technology on the existing grid in terms of additional renewable hosting capacity. The presentation will introduce the main concepts of the tool and then give application examples.

<u>Session W-B1 (Wednesday, July 10, 9:30 AM)</u>

RELIABILITY ASSESSMENT OF POWER GRID OPERATIONS CONSIDERING CORRELATED DEPENDENCY FROM GAS PIPELINE DELIVERY OVER EXTREME WEATHER

Zhi Zhou, Principal Computational Scientist, Argonne National Laboratory (Lemont, IL)
Neal Mann, Energy Systems Engineer, Argonne National Laboratory (Lemont, IL)
David Sehloff, Energy Systems Engineer, Argonne National Laboratory (Lemont, IL)
Eric Tatara, Software Engineer, Argonne National Laboratory (Lemont, IL)
Sinem Perk, Program Manager, Argonne National Laboratory (Lemont, IL)
Mitchell Krock, Postdoctoral Appointee, Argonne National Laboratory (Lemont, IL)

Decarbonizing the electric grid intensifies the interaction between the grid and natural gas pipelines, which are increasingly vulnerable to extreme weather. This study develops a modeling workflow to assess the joint risks of extreme weather on both electricity and gas pipeline systems, impacted by weather-dependent grid and pipeline inputs. The approach incorporates climate change scenarios, using a probabilistic model to characterize uncertainty of future extreme weather events based on outputs from climate models. The model enables the evaluation of grid reliability, focusing on the probability of resource outage, the uncertainty of renewable generation, and, ultimately, the probability and expectation of load curtailment. The methodology is demonstrated through a case study using a synthetic grid and pipeline system resembling the real systems in the New England region.

PARALLEL COMPUTING FOR STOCHASTIC POWER SYSTEM CAPACITY EXPANSION PLANNING

Dr. Tomas Valencia Zuluaga, Postdoctoral Researcher, Lawrence Livermore National Laboratory and University of California, Berkeley (Berkeley, CA)
Dr. Shmuel Oren, Professor, University of California, Berkeley (Berkeley, CA)
Dr. Amelia Musselman, Systems Analyst, Lawrence Livermore National Laboratory (Livermore, CA)
Dr. Jean-Paul Watson, Senior Research Scientist, Lawrence Livermore National Laboratory (Livermore, CA)

The penetration of renewable, intermittent, and decentralized generation resources is rapidly increasing the sensitivity of the power grid to the weather. Simultaneously, the frequency and intensity of extreme events are increasingly deviating from their historical meteorological behavior. Conventional modeling tools for generation and transmission expansion planning, based on historical data, are inadequate to inform investment

decisions for a resilient and decarbonized power grid under this changing landscape. Incorporating climate projections into expansion planning tools can improve the relevance of these tools to decision makers but the results are only meaningful if the variability associated with these projections is also considered. Stochastic programming is well-suited for this purpose, but often leads to computationally challenging optimization problems. We propose a nodal stochastic joint generation, storage and transmission expansion planning model that incorporates the output from high-resolution global climate models through load and generation availability scenarios. We implement our model in Pyomo and perform computational studies on a realistically-sized test case of the California electric grid in a high performance computing environment. Through model reformulations and algorithm tuning, we solve this large problem using a variant of the Progressive Hedging Algorithm. Our software utilizes the parallelization capabilities and overall versatility of mpi-sppy, exploiting its hub-and-spoke architecture to concurrently obtain inner and outer bounds on an optimal expansion plan. Initial experiments show that instances with 360 representative days on a system with almost 9,000 buses can be solved to within 5% of optimality in under 4 hours of wall clock time using Gurobi, highlighting the potential of decomposition methods like this one to enhance the development of more powerful and relevant electricity grid planning software.

EXTREME WEATHER IMPACTS AND CONSIDERATIONS ON THE TRANSMISSION PLANNING PROCESS

Dr. Eknath Vittal, Sr. Principal Technical Leader, Electric Power Research Institute (Palo Alto, CA)
Dr. Parag Mitra, Principal Technical Leader, Electric Power Research Institute (Palo Alto, CA)
Dinesh Dhungana, Technical Leader, Electric Power Research Institute (Palo Alto, CA)

As the impacts of extreme weather become more pronounced, proactive planning of the transmission system is required. Given the focus of FERC Order No. 896 and the under development NERC TPL-008 standard, new methods, tools, are processes are required to understand and plan system to ensure resilience against extreme weather events. The focus of Order No. 896 and TPL-008 are extreme heat and extreme cold events. Analysis of these types of extreme events is very challenging in the context of transmission planning. Extreme temperature events can take place over very different spatial and temporal regions ranging across multiple states, and occurring over a period of hours to multiple weeks. Identifying, building, and studying snapshot conditions reflective of those extreme conditions poses many challenges. This presentation will discuss advanced methods and tools developed by EPRI to support the follow: 1) Selection of network conditions for snapshot analyses for robust scenario representation 2) Probabilistic approaches for modeling generator unavailability 3) Contingency assessment under stressed network conditions. All three of these aspects will be critical to enable to the studies that are required to ensure robust and resilient system planning decisions are made. This presentation will highlight progress and underdevelopment applications that facilitate the analysis of extreme event impacts in the transmission planning space.

DYNAMIC ASSESSMENT AND DETERMINATION OF CONTINGENCY RESERVES

Miguel Ortega-Vazquez, Senior Principal Team Lead, Electric Power Research Institute (Palo Alto, CA)

Contingency reserve is an important service used by system operators to respond to outages of bulk power assets and other large unforeseen events. While keeping large amounts of reserve protects the power system against supply deficits that might arise from different contingencies (and thus reduces the probability of load-balance violations), this reserve provision is costly. In the US, system operators set these requirements to comply with reliability standards (e.g., NERC BAL-002), and even increase them at their discretion to further system reliability. However, such methods are based on fixed MW amounts and disregard the dynamic nature of system's risk (i.e., the expectation of not having sufficient reserves to maintain power balance if a contingency occurs), as well as the large impacts that adverse weather conditions have on assets' reliability. Such heterogeneous risk distribution exposes the system in critical time periods in which the system is heavily stressed and adverse weather conditions increase the likelihood of outages. This work proposes a method/tool that dimensions dynamic contingency reserves to a) meet a desired deterministic criterion (e.g., NERC standard), b) augment the MW held as reserve to mitigate risk in periods in which credible contingencies would result in load balance violations, c) explicitly account the impact that adverse weather conditions have on power system assets', and d) ensure deliverability of reserves in post-contingency states.

Session W-A2 (Wednesday, July 10, 12:30 PM)

SIMULATION PLATFORM WITH INTEGRATING SECURITY CONSTRAINED UNIT COMMITMENT, DER AGGREGATION, AND DISTRIBUTION SYSTEM MODELS

Brent Eldridge, Electrical Engineer, Pacific Northwest National Laboratory (Bel Air, MD)

Dr. Eran Schweitzer, Electrical Engineer, Pacific Northwest National Laboratory (Portland, OR)
Dr. Jesse Holzer, Mathematician, Pacific Northwest National Laboratory (Richland, WA)
Dr. Matt Cornachione, Post Doctorate RA, Pacific Northwest National Laboratory (Portland, OR)
Dr. Alok Bharati, Senior Power Systems Researcher, Pacific Northwest National Laboratory (Richland, WA)
Dr. Abhishek Somani, Electrical Engineer, Pacific Northwest National Laboratory (Denver, CO)

FERC Order 2222 mandated that all ISOs in the United States implement participation models for aggregators of distributed energy resources (DERs). These aggregations, consisting of multiple individual DERs, are modeled as a single resource at the transmission system level. Anticipated increases in such aggregations poses several challenges: inaccurate resource injections that cause inaccurate transmission power flow and jeopardize system reliability constraints, over- or under-voltage conditions in distribution systems, and economic incentives for aggregators to deviate from their dispatch schedules. In this presentation, we describe a simulation platform developed to investigate these challenges. The platform's capabilities enable an integrated co-simulation of transmission-level security-constrained unit commitment (SCUC), aggregator dispatch of DERs, identification of distribution system violations, and accurate power flow delivered at the transmission and distribution (T&D) interface. We compare results with initial SCUC solutions where DER aggregations are assumed to be a single transmission-connected resource.

STANDARDIZING AND AUTOMATING DER COMPANY REGISTRATION AND CONNECTIVITY ESTABLISHMENT FOR UTILITIES AND OTHER CENTRALIZED SYSTEMS

Daniel Roesler, CTO and Working Group Maintainer, UtilityAPI and LFEnergy's Carbon Data Specification Consortium (Oakland, CA)

The Linux Foundation Energy (LFEnergy) has established the open standards group Carbon Data Data Specifications Consortium (CDSC) to develop specifications to standardize access to and the format of customer usage and grid power systems data. With these new standards, companies and DERs will be able to automate connectivity with grid systems, participate in grid programs, calculate carbon emissions, and analyze the impact of energy efficiency and DER projects and programs. As part of this initiative, the Customer Data working group (CDSC-WG1, customerdata.carbondataspec.org) has developed draft specifications for standardizing and automating DER company registration and connectivity establishment with utilities and other central grid entities. The specifications are intended to provide open, free standards for utilities and other central grid entities to implement to enable scalable, automated registration and secure connectivity establishment of DER companies and other behind-the-meter entities to central grid infrastructure. By standardizing and automating registration and connectivity establishment, these specifications will unlock wide-scale deployment, adoption, and connectivity of grid-enhancing behind-the-meter technologies. These specifications are designed to be universally applicable as the registration and onboarding step for other DER control and communication protocols, so that those standards can focus on their core protocols and communication and not have to worry about the registration and onboarding process for behind-the-meter companies. This presentation will provide an overview of these new specifications and how they can be used to enable deployment and adoption of grid-enhancing technologies. The presentation will be given by CDSC-WG1 maintainer Daniel Roesler, Founder & CTO of the utility data services company, UtilityAPI. The CDSC working groups have active participation from large technology firms (Google, Microsoft, Apple, etc.), DER technology companies (OhmConnect, UtilityAPI, WattTime, etc.), utilities and grid infrastructure (APS, MISO, etc.), and European cleantech companies (Electricity Maps, CarbonLaces, FlexiDAO, etc.). Other companies, utilities, infrastructure providers, and policymakers are encouraged to join the working groups and contribute feedback to these new specifications.

INCREASING DER OPERATIONAL DATA AND TELEMETRY

Brett Busold, Engineering Technologist - Senior, American Electric Power (New Albany, OH)

This presentation outlines the need for increased real-time DER data and associated telemetry to support the balancing and operating of the DER-enabled grid. Historically, the data collected for DERs was inconsistent and limited to only large DERs (generally larger than 500kW). There was an internal need to establish minimum requirements for a broader range of DERs to ensure reliable operation of the Distribution Wires while also limiting the amount of unnecessary SCADA data and infrastructure. This presentation is a result of the ongoing workshops, research, development, and documentation done to outline the real-time data needs of operators for situational awareness, data needs of the DERMs for proper functionality, and the increased real-time telemetry that would support collecting the necessary real-time information.

A REAL-TIME ECONOMIC DISPATCH APPROACH FOR WHOLESALE ENERGY MARKET WITH MULTI-TRANSMISSION-NODE DER AGGREGATIONS

Dr. Zhentong Shao, Postdoctoral Student, Stevens Institute of Technology (Hoboken, NJ)
Weilun Wang, Ph.D. Student, Stevens Institute of Technology (Hoboken, NJ)
Dr. Brent Eldridge, Operations Research Scientist, Pacific Northwest National Laboratory (Richland, WA)
Dr. Abhishek Somani, Senior Economist, Pacific Northwest National Laboratory (Richland, WA)
Dr. Lei Wu, Professor, Stevens Institute of Technology (Hoboken, NJ)

Enabling the integration of distributed energy resources (DERs) into the wholesale market, as prompted by FERC Order 2222, introduces substantial operational complexities. This paper advances a real-time economic dispatch (RTED) framework to facilitate multi-transmission-node DER aggregation (DERA), optimizing their participation in energy market operations. We enhance the modeling of multi-transmission-node DERAs by implementing distribution factors (DFs) to capture individual nodal DERs' behavior across the transmission network. Our methodology introduces an innovative DF updating strategy, incorporating a custom K-Nearest Neighbors (KNN) method and a discrete PI controller, alongside transmission sig- nals that enforce a sufficient guarantee for transmission security. These enhancements aim to optimize the economic efficiency and security of the DF-based RTED model, addressing the critical challenges of multi-transmission-node DER integration. The proposed method is tested on modified 24-bus and 118-bus systems via a rolling RTED process with real load data. The test results show that the proposed framework demonstrates marked improvements in minimizing social welfare costs and ensuring transmission network security.

<u>Session W-B2 (Wednesday, July 10, 12:30 PM)</u>

POWERGEM TARA WORST CLUSTER TRLIM ANALYSIS FOR SYSTEM-WIDE BUS INJECTION CAPABILITY AND HEATMAP TO ADDRESS FERC ORDER 2023

John Condren, Principal Consultant, PowerGEM (Clifton Park, NY)
Seungwon An, Senior Engineer, PowerGEM (Clifton Park, NY)
Boris Gisin, President, PowerGEM (Clifton Park, NY)

For over 10 years, PowerGEM has worked with PJM, MISO and CAISO to automate generation deliverability processes. The implemented generation deliverability solutions

provide a systematic transparent method to evaluate firm capacity deliverability accounting for uncertainties in generation dispatch utilizing the worst-case dispatch scenario concept. PowerGEM recently developed a new Worst Cluster TrLim analysis function providing a high performance general generation deliverability solution. This solution also utilizes the worst case dispatch approach and may be used for any region, even if it does not currently have an established generation deliverability procedure. This presentation will provide an overview of Worst Cluster Trlim and Heatmap functionality offered by PowerGEM. Comparing to another commonly used FCITC (First Contingency Incremental Transfer Capability) approach, the developed solution provides a more conservative approach, assuring that prospective generation is always deliverable irrespective of the initial dispatch in the seed load flow model. This is in contrast to the FCITC approach, which cannot assure that MW of a prospective bus injection are deliverable. The new Worst Cluster TrLim released in 2023 represents an ISO-agnostic general generation deliverability solution and may be used within any US region. Worst Cluster TrLim can rapidly compute bus injection capability for a large list of prospecting buses in the region. Computed results can be saved to directly create heat maps that may be posted as a web solution as requested by FERC Order 2023. A desktop Heatmap application is also available for more detailed drill down analysis of flowgates impacted by a prospective bus injection as well as reporting of existing generators or other proposed projects which affect each flowgate.

UNLOCKING GRID POTENTIAL: A HOLISTIC EVALUATION OF TRANSMISSION HOSTING CAPACITY

Swaroop Guggilam, Principal Engineer, Electric Power Research Institute (Knoxville, TN)
Sujit Tripathy, Senior Engineer, Electric Power Research Institute (Knoxville, TN)
Deepak Ramasubramanian, Senior Technical Leader, Electric Power Research Institute (Knoxville, TN)
Vikas Singhvi, Program Manager, Electric Power Research Institute (Knoxville, TN)
Jens Boemer, Technical Executive, Electric Power Research Institute (Seattle, WA)
Anish Gaikwad, Deputy Director, Electric Power Research Institute (Knoxville, TN)

The power grid is undergoing a dynamic transformation fueled by the integration of renewable energy sources to achieve clean energy goals. However, understanding the grid's capacity to accommodate this transition without necessitating extensive upgrades or causing operational challenges is crucial. Here is where transmission hosting capacity analysis can play a role. This analysis provides an overview of where new-generation resources can connect to the network and where system enhancements may be required.

However, the evaluation is complex and multi-faceted. To address this pressing need, efficient and reliable analytical methods and software tools are essential. These tools must assess the interplay between retiring conventional generation, meeting transmission planning standards, and the surge in renewable or distributed energy resources. Additionally, they should account for other generation interconnection requests and consider varying operating conditions. As mandated by the FERC ORDER 2023, an interactive transmission hosting capacity map, often referred to as a "heatmap," is a valuable output. One such robust software solution is the Transmission Hosting Capacity Tool (THCT) developed by EPRI. THCT employs a comprehensive ac network model while incorporating diverse generator retirement profiles. It uniquely combines criteria such as voltage limits, congestion thresholds (flow limits), and short-circuit strength limits to determine transmission hosting capacity at multiple locations at the same time. Furthermore, THCT generates a heat map overlay, providing developers, utilities, and stakeholders with actionable insights. This transparency improves the decision-making process about where new-generation resources can integrate while ensuring grid reliability. The scope and goal of this presentation are to discuss and delve into the ongoing efforts at EPRI's forefront around transmission hosting capacity. We would showcase the capabilities of the THCT tool and provide examples of its use in real utility/system operators' networks. Finally, discuss existing challenges and chart a course toward a resilient energy future.

A Novel, Unique, and Proven Approach to Performing Near Real Time Probabilistic Power System Risk Analyses as an Immediately Available Solution for Unlocking Existing Grid Capacity by Facilitating the Safe Encroachment into N-1 Power System Engineering

Barry Bragger, General Manager - North America, Infinigrid, Inc. (Boynton Beach, Florida)
Arne Brufladt Svendsen, Chief Technical Officer, Infinigrid (Bergen Norway)
Martin Groh, Principal Software Developer, Infinigrid (Oslo Norway)
Robert Nyiredy, Chief Executive Officer, Infinigrid (Oslo, Norway)
Mathieu Milenkovic, Lead Physicist and Mathemetician, Infinigrid (Oslo Norway)

The worldwide power system is a "symphony of complexity" that must be in constant balance and "play in perfect harmony" to reliably keep the lights on. Today more than ever change is causing ever-increasing system congestion that poses serious challenges to our green transition and to the electrification of our society. To facilitate the transition to the Grid-of-the-Future massive investments must be made. Some estimates of the required investment are upwards of $3.1 trillion USD by 2030 (Rystad Energy).

Notwithstanding the monetary enormity of this investment, realistically there is not enough time until 2030 to effect such massive change, yet capacity challenges exist today. Proven intermediate-term solutions that can be brought online quickly and economically must be implemented to improve the utilization of existing capacity in our existing grid. Such solutions must create new flexibility and extra capacity within today's grid to buy us the time to build the system infrastructure to fully adapt to today's green electrification and to keep the "music playing." Fundamentally, the problem is simple. Data Centers for AI, Cryptocurrency Mining, EVs for ICE transition, etc. are rapidly increasing system load today, yet it often takes years or even decades to upgrade power system infrastructure. The obvious and immediate solution is to operate our existing power system closer to its technical limits, however forcing additional capacity inside of N-1 engineering security criteria decreases grid reliability. Therefore, such actions must be undertaken safely and with careful consideration for the reliability of the overall power system. To be successful there must be a way for system operators to quantify their system risk in a reliable probabilistic manner, in near real time, to understand system risk baselines and to rationally assess what the risks are or may be to exceeding "acceptable risk" in a dynamic environment with substantial variables. That is for present system operation. For future power system design it is equally important to have a similar tool to perform probabilistic analyses for power system states going forward. TSO/DSOs would then have available to them new tools to safely assess the risks associated with both operating and designing power systems closer to technical limits. Heretofore, the complexities of analyzing large, complex meshed power systems probabilistically and in near real time was mathematically daunting as myriad influencing factors must be included to achieve satisfactory results. Previous attempts required simplifications that fit complex analyses into a size suitable for then available theoretical models. As a result, this complex task has remained all but unsolvable – until now. By using a novel and unique mathematical method based on segmented Markov models built together within unit models we can simulate large complex power systems in near real time without diminishing the reliability of our probabilistic predictions. Our new proprietary model segmentation – which solves the "dimensionality challenge" – creates a new world of possibilities to build and analyze large complex models while maintaining an original level of detail without loss of information. Our methodology allows for all influencing factors (such as the component reliabilities of all primary and secondary equipment, branch reliability, system reliability, load flows, all generation, spinning reserve, power demand, load priority, system protection, etc.) to be modeled. This presentation will demonstrate the methodology, analysis results, and use cases addressed by the newly developed simulation program, Promaps Realtime. The mathematical framework and the accompanying software has been tested for real time probabilistic risk analysis at TSO/DSOs in Europe. With this mathematical framework and our tested simulation tool we can demonstrate that one important "key" to gaining the needed capacity in our power system is here today.

AN ANALYSIS ON MARKET-TO-MARKET COORDINATION

Dr. Alinson Santos Xavier, Computational Scientist, Argonne National Laboratory (Lemont, IL)
Weihang Ren, Graduate Student, University of Florida (Gainesville, FL)
Dr. Fengyu Wang, Assistant Professor, New Mexico State University (Las Cruces, NM)
Dr. Yongpei Guan, Professor, University of Florida (Gainesville, FL)
Dr. Feng Qiu, Group Leader, Argonne National Laboratory (Lemont, IL)

The growing usage of renewable energy resources has introduced significant uncertainties in energy generation, posing challenges for Regional Transmission Operators (RTOs) in managing transmission congestion. The cost of real-time congestion for the Midcontinent Independent System Operator (MISO), for example, surged to $3.7 billion in 2022, more than tripling since 2020. To mitigate congestion that affects neighboring regions, RTOs employ a market-to-market (M2M) process, in which they exchange real-time security-constrained economic dispatch solutions and communicate requests for congestion relief. While this method provides some economic benefits, it still struggles with issues like power swings and time delays. In this presentation, we analyze the M2M process to better understand its efficacy and identify potential improvements. We develop an open-source version of the M2M process using UnitCommitment.jl and test it across a comprehensive set of multi-area benchmark instances. To evaluate the potential impact of M2M enhancements, we develop a centralized model that provides a lower bound on congestion costs and compare it against current practice. Additionally, we identify scenarios where the existing M2M process fails to provide solutions. Finally, we explore enhancements and alternative strategies to narrow the efficiency gap in multi-area congestion management.

<u>Session W-A3 (Wednesday, July 10, 3:00 PM)</u>

BIDDING STRATEGIES FOR BATTERY ENERGY STORAGE ADDRESSING UNCERTAIN MARKET CLEARANCE PATTERNS

Dr. Yongpei Guan, Professor, University of Florida (Gainesville, FL)
Weihang Ren, Ph.D. Student, University of Florida (Gainesville, FL)

Charging during the off-peak hours and discharging during the peak hours could be profitable for the battery energy storage owners to participate in the wholesale electricity energy markets. Meanwhile, this promotes the investment in battery energy storage, accommodating renewable generation intermittency, reducing fossil energy production, and finally achieving 100% clean energy production for the whole society. Albeit the overall benefit, the operational practice at different wholesale markets, in particular, the uncertain market clearance patterns, causes potential inconvenience and challenges for the owners to submit energy bidding offers, which affects the overall performance of market participation activities in terms of total profit. In this paper, we first explore innovative bidding strategies to maximize the expected profit of the battery energy storage owners under market clearance uncertainty. More specifically, we explore four different models to derive optimal bidding strategies for three different market clearance settings for battery energy storage. Then, we propose an innovative general network-flow model that is capable of addressing all three different common market clearance settings. The final case studies for the proposed models are implemented based on the CAISO data and the results show the advantages of our developed innovative network-flow model for the battery energy storage bidding, through both one-time and rolling-horizon validations.

INTEGRATING BATTERY STORAGE INTO ELECTRICITY MARKETS: ACCOUNTING FOR DEGRADATION COSTS AND PARTICIPATION MODELS IN THE IESO WHOLESALE MARKETS

Dr. Nitin Padmanabhan, Senior Research Engineer, Electric Power Research Institute (Ontario, Canada)
Bo Yuan, Ph.D. Student, Cornell University (Ithaca, NY)
Erik Ela, Technical Executive and Program Manager, Electric Power Research Institute (Palo Alto, CA)
Sasoon Assaturian, Senior System and Sector Development Advisor, Independent Electricity System Operator (Toronto, Ontario)

Effectively integrating battery storage into electricity markets is challenging, mainly due to the difficulty in precisely calculating its marginal operation costs, which are influenced by usage-based battery degradation costs. Current market frameworks that allow battery storage participation often fail to clearly account for distinct physical and operational traits like state of charge (SoC) and degradation, in the storage bids and offers. Moreover, existing market auction models typically overlook the lifetime loss of ESRs due to deep cycling, which significantly impacts operational costs and may require a fundamental re-evaluation of contemporary market auction models, particularly as the use of storage-based resources expands. To address this gap, EPRI has developed a novel offer generation module that incorporates degradation costs into the storage bidding strategy. Furthermore, the developed bidding strategies (bid/offers) are used in a study to evaluate the storage participation impacts on market operations and reliability, comparing two SoC management frameworks – (i) Self SoC management, (ii) ISO SoC management. The Independent Electricity System Operator (IESO) of Ontario, Canada, is, like other system operators across North America, evaluating ways in which these ESRs can participate in wholesale electricity markets. The “participation model” of the resource includes characteristics of the way in which the resource interfaces with the market operator, the bidding and physical parameters, and the way the resource is modeled in the market clearing software. There are two different participation model options: (i) Interim storage model, which represents the storage as two separate independent resources (modeled as a dispatchable load and a dispatchable generator, with SoC managed by the resource through submitted bids/offer), (ii) Enduring storage model, which represents the storage as one single resource (modeled considering full output from charge to discharge and with SoC managed by the IESO). EPRI is working with IESO to investigate the potential benefits of advanced participation model options for storage resources. Our presentation will unfold the intricacies of the offer generation module, compare the efficacy and consequences of different storage participation models through case studies, and share insights from our analysis on the broad implications for system reliability, economic efficiency, and the profitability of storage assets at high penetration levels. We aim to provide empirical guidance on the practicality of these models, fostering informed decision-making for market integrations of storage solutions.

ENERGY STORAGE PARTICIPATION ALGORITHM COMPETITION (ESPA-COMP) DESIGN AND PILOT RESULTS

Dr. Matthew Cornachione, Research Associate, Pacific Northwest National Laboratory (Richland, WA)
Dr. Brent Eldridge, Electrical Engineer, Pacific Northwest National Laboratory (Richland, WA)
Dr. Brittany Tarufell, Economist, Pacific Northwest National Laboratory (Richland, WA)
Dr. Jesse Holzer, Mathematician, Pacific Northwest National Laboratory (Richland, WA)
Liping Li, Electrical Engineer, Pacific Northwest National Laboratory (Richland, WA)
Dr. Arun Veeramany, Data Scientist, Pacific Northwest National Laboratory (Richland, WA)
Dr. Kostas Oikonomou, Electrical Engineer, Pacific Northwest National Laboratory (Richland, WA)

Dr. Abhishek Somani, Electrical Engineer, Pacific Northwest National Laboratory (Richland, WA)

Existing ISO market structures were designed around the operational constraints of conventional generators, and system operators are currently investigating potential reforms to better integrate renewables, battery energy storage systems (BESS), and other new technologies. Recognizing this need, we developed a novel simulation platform designed to compare and assess potential benefits of new market design policies, with a primary focus on BESS. Our platform's key features include a configurable market clearing engine, a lithium-ion battery state-of-charge and degradation model, and user-submitted algorithms for generating storage offers. This platform was used to host the Energy Storage Participation Algorithm Competition (ESPA-Comp), a pilot project where competing teams submit algorithms to offer storage resources into the simulated market. Participants are evaluated based on their resource's profitability in the simulated environment. We applied a simplified WECC topology with high renewable capacity. Two distinct market designs were analyzed: the conventional two-settlement market and a multi-settlement market. In this presentation, we will describe the architecture of the platform, share results and insights from the pilot competition, and explore potential innovative use cases for the platform.

EVALUATING BENEFITS OF LONG DURATION ENERGY STORAGE

Aleksandr Rudkevich, CEO, Newton Energy Group LLC (Newton, MA)
Ninad Kumthekar, Director, Tabors Caramanis Rudkevich (Newton, MA)
Joseph Silvers, Senior Analyst, Tabors Caramanis Rudkevich (Newton, MA)
Sydney Swearigen, Analyst, Tabors Caramanis Rudkevich (Newton, MA)
Richard Tabors, President, Tabors Caramanis Rudkevich (Newton, MA)
Russ Philbrick, CEO, Polaris Systems Optimization (Shoreline, WA)

Long Duration Energy Storage (LDES) will play a critical role in successful decarbonization of the electric sector of the world economy. LDES is needed to manage weather driven energy needs and resources across time and will significantly reduce the investment in energy production and transmission. LDES benefits accrue at multiple time scales ranging from hours, days, seasons and years. An adequate evaluation of these benefits is a challenging analytical task as it requires a use of multiple modeling techniques: (1) System Expansion Modeling to size and site LDES based on its impact on future generation and transmission; (2) Operational Scheduling to ration use of storage inventory over time across weeks, months and seasons; and (3) Energy and Ancillary Services Modeling emulating storage operations at daily, and intra-day timescales. In this presentation, we discuss the coordination of these three models to assess LDES within a large regional electricity market. Our methodology uses sequentially optimized and coordinated decision cycles. From this, we provide a range of simulated metrics assessing benefits of a large-scale LDES at various time scales.

A Theoretical Framework for Monitoring and Mitigating Energy Storage Market Power in Real-Time Markets

Ningkun Zheng, Ph.D. Student, Columbia University (Pittsburgh, PA)
Zhiyi Zhou, Ph.D. Student, Xi'an Jiaotong University (Shaanxi, China)
Dr. Bolun Xu, Assistant Professor, Columbia University (New York, NY)

In this presentation, we address the critical issue of energy storage systems market power exercising in real-time markets. We address the significant issue of market power exercised by energy storage systems in real-time electricity markets. We introduce a dynamic programming framework designed to analyze the strategic bidding behaviors of energy storage operators and assess their potential impacts on market prices. The key of our approach is an analytical methodology that determines the marginal state of charge value function, serving as a robust benchmark for evaluating strategic bids. This framework not only establishes an upper bound for economic withholding but also enhances the effectiveness of market power monitoring tools. Using historical data from the New York Independent System Operator, we validate our theoretical model and demonstrate its practical application. Our findings emphasize the importance of precise price sensitivity estimation in optimizing energy storage operations and maintaining competitive market conditions. This presentation will highlight how these insights can assist system operators and market regulators in developing more robust mechanisms to detect and counteract market power abuses, thus facilitating a fair and competitive market environment.

Session W-B3 (Wednesday, July 10, 3:00 PM)

Completing ISO Markets

Dr. Richard P. O’Neill (Silver Spring, MD)

Since the inception of ISO market, demand has been forecasted and placed in the market as a fixed point. Over time detailed participation models for generation have been developed, demand is still a point forecast. With bid-in demand, greater market efficiency and greater reliability is possible with better entry and exit signals. Average Incremental

Cost (AIC) pricing is consistent with the dispatch algorithm and transparent that is, free of uplift or make-whole payments and lowers capacity market prices. With bid-in demand and AIC pricing the market is more efficient, more reliable, and more sustainable.

Average Incremental Cost Pricing for the Alternating Current Unit Commitment Problem

Dr. Manuel Garcia, Scientist, Los Alamos National Laboratory (Los Alamos, NM)

Unit Commitment (UC) problems that consider the Alternating Current (AC) model of the transmission network have long been considered intractable to solve at scale by the power system community. Recently, the Grid-Optimization (GO) Competition held by the Advanced Research Project Agency-Energy (ARPA-E) has facilitated the development of the first algorithms to solve large-scale ACUC problems. This new capability opens a path towards the explicit consideration of the AC transmission network model in UC problems used to clear day-ahead electricity markets. This calls for the analysis of electricity market structures that accommodate both the continuous non-linearity of the AC transmission network and the discrete non-linearity of the UC problem simultaneously. This presentation provides simple examples illustrating the deficiencies of the traditional marginal pricing structure in the context of the ACUC problem. These examples highlight the need for not only reactive power prices, but also prices that capture incremental costs. An Average Incremental Cost (AIC) pricing structure is proposed that is designed around the ACUC problem. An AIC one-pass pricing problem is also proposed that represents a continuously constrained variant of the ACUC problem and allows for the computation of Locational Incremental Prices (LIPs) for both real and reactive power as the local optimal Lagrange multipliers of the power balance constraints. To avoid degeneracy, the pricing problem includes a small parameter $\epsilon > 0$. Under certain assumptions we provide a theoretical result stating that market participants are shown to realize profit that converges to a non-negative value as ϵ approaches zero, practically ensuring profitability for small values of ϵ. Additional simple and important examples are presented that provide intuition and insights into the proposed prices. Examples illustrate the basic concept of AIC pricing, the derived profitability results, the possible existence of multiple LIPs, and the improved incentives provided by LIPs as compared to traditional Locational Marginal Prices (LMPs). We additionally indicate many directions for future work including analysis of larger test cases.

A FAST LEARNING-BASED UNIT COMMITMENT STRATEGY WITH AC OPTIMAL POWER FLOW FOR LARGE GRIDS WITH DIRECT INCLUSION OF WEATHER

Dr. Farnaz Safdarian, Senior Research Engineer, Texas A&M University (College Station, TX)
Dr. Joshua Peeples, Assistant Professor, Texas A&M University (College Station, TX)
Dr. Thomas Overbye, Professor, Texas A&M University (College Station, TX)

We proposes a strategy to solve a fast, learning-based and computationally feasible unit commitment (UC) with ac optimal power flow (OPF) and direct inclusion of weather measurements for large grids. Through the proposed approach, we determine the on/off status of generating units and their dispatch. One of the main challenges is that UC with ac OPF is computationally intractable for large grids over long periods. The other challenge is that the status of all units are related and not independent. We leverage multi-label machine learning classifiers and scenario reduction to predict the status of each generator. The proposed strategy considers load and weather changes at different times of the year and the availability of the resources in addition to weather changes. The results show the UC is predicted with high classification performance metrics and feasible ac OPF results are achieved. The code for this work is made publicly available.

RECENT ADVANCES IN SOLVING LARGE-SCALE SECURITY-CONSTRAINED UC ACOPF

Dr. Andy Sun, Associate Professor, Massachusetts Institute of Technology (Cambridge, MA)

We will present some recent progress in solving large-scale UC ACOPF problems in real-time, day-ahead, and weekly planning based on the ARPA-E GO competition challenge 3. The new algorithms are capable in handling networks of more than 20,000 buses in 10 min, 2 hour, or 4 hours. The solutions obtained are highly feasible and achieve global optimality gap of less than 1% on average. We will discuss potential applications in the ISO/RTO day-ahead and real-time markets.

AC UNIT COMMITMENT IN THE GRID OPTIMIZATION COMPETITION CHALLENGE 3

Jesse Holzer, Senior Mathematician, Pacific Northwest National Laboratory (Richland, WA)

Unit Commitment (UC) problems are typically solved in the day head planning process using a DC power flow model accounting for real power only. How much better would the planned solution be if the UC model used AC power flow to account for voltage and reactive power? Can solvers handle the complexity of the resulting AC-UC problem? The Grid Optimization (GO) Competition Challenge 3 aimed to address these questions by posing an AC-UC problem and evaluating the solvers that competition entrants developed by running them on a set of problem instances. This presentation shows competition results demonstrating that the GO solvers successfully solved the AC-UC problems that we posed. We also demonstrate the use of two GO solvers to solve an AC-UC problem in a decomposed fashion, with one solver providing the UC solution followed by the other solver cleaning up the AC solution. This decomposition enables us to take advantage of the different strengths of the different GO solvers, with some performing better than others for UC or AC optimal power flow separately.

Session H-A1 (Thursday, July 11, 9:30 AM)

SOFTWARE FOR SYSTEM MODEL VALIDATION

Dr. Eric H. Allen, Director of Engineering, SmartGridz, Inc. (Sudbury, MA)
Dr. Jeffrey Lang, Chair Professor, Massachusetts Institute of Technology (Cambridge, MA)
Marija Ilic, Adjunct Professor and Senior Research Scientist, Massachusetts Institute of Technology (Cambridge, MA)

Accurate powerflow models are an essential foundation for all types of power system analyses. The NERC MOD-033 standard for system model validation was established to achieve that end. Software for performing system model validation is relatively scarce and limited, however. In this presentation, we show how optimization software can simultaneously achieve the goals of system model validation and greatly reduce the time and labor required.

A DAY-AHEAD CONTINGENCY PLANNING SOLUTION THAT CAPTURES THE PHYSICS OF ELECTRIC AND GAS NETWORKS

Dr. Wallace Kenyon, Director of Product, encoord Inc. (Denver, CO)
Will Frazier, Data Lead, encoord Inc. (Boulder, CO)
Dr. Carlo Brancucci, CEO, encoord Inc. (Denver, CO)

The day-ahead dispatch of electric generators is primarily determined with unit-commitment, economic dispatch optimization models that rely on two foundational assumptions; the electric transmission system can handle the resultant power flow, and the gas system can meet the demand of the gas-fired generators at the determined dispatch. Generally, these assumptions are sound. But electric line outages, and low pressures on the gas system, can and will occur, and the physical ramifications of these contingencies impact the reliability of the power system. Assessing these reliability concerns requires integrated conting0ency planning interfacing generation optimizations with physical electric and gas transmission simulations

POWER SYSTEM STATE ESTIMATION BY PHASE SYNCHRONIZATION AND EIGENVECTORS

Dr. Richard Y. Zhang, Assistant Professor, University of Illinois at Urbana-Champaign (Urbana, IL)
Iven Guzel, Ph.D. Student, University of Illinois at Urbana-Champaign (Urbana, IL)

To estimate accurate voltage phasors from inaccurate voltage magnitude and complex power measurements, the standard approach is to iteratively refine a good initial guess using the Gauss-Newton method. But the nonconvexity of the estimation makes the Gauss-Newton method sensitive to its initial guess, so human intervention is needed to detect convergence to plausible but ultimately spurious estimates. This paper makes a novel connection between the angle estimation subproblem and phase synchronization to yield two key benefits: (1) an exceptionally high quality initial guess, known as a spectral initialization; (2) a correctness guarantee for the estimated angles, known as a global optimality certificate. These are formulated as sparse eigenvalue-eigenvector problems, which we efficiently compute in time comparable to a few Gauss-Newton iterations. Our experiments on the Polish 3k-bus and the PEGASE 13k-bus models show, where voltage magnitudes are already reasonably accurate, that spectral initialization provides an almost-perfect single-shot estimation of n angles from 2n moderately noisy bus power measurements (i.e. n pairs of PQ measurements), whose correctness becomes guaranteed after a single Gauss-Newton iteration. Surprisingly, with inaccurate voltage magnitude measurements, it is possible for spectral initialization to estimate the voltage angles more accurately than the maximum likelihood estimator.

ABSCoRES: APPLYING CREDIT SCORING METHODOLOGIES FOR RISK ESTIMATION IN ENERGY ASSETS AND GRID MANAGEMENT

Dr. Andres F. Ramirez, Postdoctoral Scientist, Lehigh University (Fallbrook, CA)

Dr. Alberto J. Lamadrid, Associate Professor, Lehigh University (Fallbrook, CA)

This research aims to apply credit scoring methodologies to estimate risk scores for energy assets, to counteract information asymmetries. We illustrate our methodology for a system reduction of the New York Independent System Operator (NYISO). Leveraging operational variables from the Security-Constrained Unit Commitment (SCUC) and Security-Constrained Economic Dispatch (SCED) optimization models, combined with the physical characteristics and constraints, our methodology—named ABSCoRES—estimates the likelihood of deviations from expected conditions, serving as a measure for the efficiency of individual assets, and as aggregate for the risk in the electricity system. Our objectives include providing energy market participants with confidential information about their contribution to the energy grid's risk and the ability to compare their performance to regional or national averages through risk-scoring ratings. Our methodologies involve state-of-the-art credit scoring mechanisms and machine learning techniques. Results from our study indicate an accurate representation of generator efficiency and system dynamics. Furthermore, we outline plans to transition the research into a Software as a Service (SaaS) product, which can provide potential cost reductions and efficiency improvements in energy systems and serve as a platform for innovating in services to manage risk. Future directions include exploring dynamic reserve estimation and using scores as part of monitoring and tracking greenhouse gas emissions.

Session H-B1 (Thursday, July 11, 9:30 AM)

EMBRACING OPEN SOURCE AND OSS PROJECTS TO IMPROVE ENERGY MARKET EFFICIENCY AND RELIABILITY

Dr. Alexandre Parisot, Director of Ecosystem AI and Energy Systems, Linux Foundation Energy (San Francisco, CA)

The nonprofit Linux Foundation hosts and nurtures industrial-grade Open Source Software (OSS) projects related to the energy sector within its Linux Foundation Energy (LFE) subfoundation. This presentation will highlight examples of projects that are most relevant to improving market efficiency and reliability in bulk power systems, such as: TROLIE, an open API specification for the exchange of ratings and ratings-related information to support organizations working to comply with FERC Order 881, including a conformance program and open commons for compliant implementations; Dynawo, an hybrid C++/Modelica open source suite of simulation tools for power systems, and PowSyBl, a set of Power System Blocks in Java, dedicated to grid analysis and simulation; OperatorFabric, a smart assistant for system operators; OpenSTEF, a AI powered platform for short term load forecasting; The Carbon Data Specification Consortium (CDSC), a standard specification that will help to define the raw data to track the carbon intensity of consumed energy and the carbon emissions associated with power systems, to guide grid decarbonization, and decision-making. The presentation will also touch on initiatives utilizing generative AI to make openly available realistic synthetic datasets for applications such as developing topology optimization tools and techniques. By presenting these open source projects, we aim to raise awareness so that stakeholders can embrace them as part of their business and modernisation strategy, and also to demystify open source and address common misconceptions which prevent energy sector stakeholders from fully using its potential, unlike many other sectors like telecommunications, healthcare, finance, and the automobile industry. For instance, open source is commonly used to build successful commercial products, with one example being TROLIE, which is being integrated by vendors such as GE Vernova into products for utilities. Open source is also a great way to leverage publicly supported R&D efforts to impact and improve operational tools in the industry: Dynawo and PowSyBl illustrate how two large scale collaborative R&D projects supported by public funds from the European Commission (PEGASE and ITESLA) can spur tools that are being deployed in utility operations (in this case, that of the Transmission System Operator of France, RTE). Open specifications and standards can speed up the development of interoperability and data exchange frameworks, and the CDSC initiative perfectly illustrates this in support of carbon data accounting. Open source provides a cross-industry, community-driven collaboration platform which allows stakeholders with similar interests and challenges to come together and pool their resources while speeding up innovation. OperatorFabric, OpenSTEF and the other projects such as the open synthetic dataset initiative mentioned above illustrate this very well. As demonstrated in many other sectors, open source is a proven approach to speed up innovation, increase transparency and lower costs for software-based solutions. Given the current challenges and needs to improve market efficiency and reliability through digitalization and innovation in software, we believe that it is underutilized by our sector and aim to engage with stakeholders from utilities, system operators, policymakers, regulators, research institutions and solution providers/vendors and explore better ways to leverage the potential of open source.

GLOBAL-TEP: A NEW GLOBAL SOLVER FOR TRANSMISSION EXPANSION PLANNING WITH AC NETWORK MODEL

Dr. Mahdi Mehrtash, Assistant Professor, Johns Hopkins University (Baltimore, MD)

Global-TEP: A New Global Solver for Transmission Expansion Planning with AC Network Model Abstract._The transition to a decarbonized power system presents new challenges, needs, and opportunities for transmission systems. This is especially true because most ISOs and RTOs still rely on traditional transmission expansion planning (TEP) methods that do not adequately consider some factors that drive new transmission expansion, such as the need for new transmission infrastructure to support deep decarbonization objectives. We propose a new global solver, named Global-TEP, for the TEP problem with an AC network representation (ACTEP), which is a mixed-integer nonlinear programming problem. The proposed solver is based on second-order cone relaxation, enhanced relaxation tightening constraints, and optimization-based/feasibility based bound tightening techniques. Multiple enhanced relaxation tightening constraints are incorporated into the mixed-integer second-order cone relaxation of TEP in order to obtain a very strong relaxation as the lower bounding problem. In addition, a novel feasibility-based bound tightening technique is proposed to tighten the bounds of decision variables in a considerably short runtime. Finally, introducing a novel application of optimization-based bound tightening technique, Global-TEP is constructed that can solve the ACTEP problem efficiently with a guaranteed optimality gap. As illustrated by numerical case studies, Global-TEP is more scalable, more flexible, and much faster than the available global solvers. HVDC transmission lines may provide an economic option for moving large quantities of energy over long distances, but current TEP models do not properly account for the benefits of high-voltage alternating current (HVAC) and HVDC candidates. Furthermore, Current TEP methods largely overlook considerations related to reactive power and voltage stability. FACTS devices, such as phase-shifting transformers or reactive power compensators (VAr compensators), can be deployed to alleviate congestion at a lower cost than installing new transmission lines. We further extend the Global-TEP solver by adding the capability of considering HVDC lines and FACTS devices while reaching global optimality.

ADVANCED RELIABILITY TOOL SET

Dr. Tamer Ibrahim, Senior Engineer, Electric Power Research Institute (Knoxville, TN)
Eknath Vittal, Senior Principal Technical Leader, Electric Power Reseach Institute, (Palo Alto, CA)
Dr. Stavros Konstantinopoulos, Staff Level IV, Electric Power Research Institute (Palo Alto, CA)
Blaine Burton, Senior Technical Leader, Electric Power Reseach Institute (Palo Alto, CA)

As the power system undergoes transformational changes new planning and study tools must be developed. Advanced Reliabilty Tool Set (ARTS), developed by EPRI, aims to facilitate the transmission planning process by introducing automation across multiple steps of the process. Planning assessments require constant updates and validation of contingency definitions based on changes and upgrades to the network topology. The new contingency definitions must be evaluated annually to assess stability impacts. In addition to defining and evaluating contingency events, significant efforts must be devoted to identifying the critical initial conditions of the system that will impact reliability and stability. This tool maps planning cases to EMS data to update the planning cases with the substation topology data available in the EMS data. Then all TPL contingencies are generated for the planning cases in for the original planning case. The tool also can be used for post-processing of the dynamic analysis to identify the most critical contingencies.

UTILIZING LOCATIONAL MARGINAL EMISSION RATES TO ACHIEVE DECARBONIZATION GOALS

Emma Naden, Associate, Tabors Caramanis Rudkevich (Newton, MA)
Dr. Aleksandr Rudkevich, Principal, Tabors Caramanis Rudkevich (Newton, MA)
Dr. Richard Tabors, President, Tabors Caramanis Rudkevich (Newton, MA)
Ninad Kumthekar, Director, Tabors Caramanis Rudkevich (Newton, MA)
Bo Li, Analyst, Tabors Caramanis Rudkevich (Newton, MA)

Tracking, reporting and, ultimately, reducing carbon emissions is becoming an increasingly important goal for many stakeholders in the electricity industry, ranging from large electricity consumers to policy makers. Accurately accounting for carbon emissions requires going beyond the simple counting of megawatt-hours. Attributing carbon emissions accurately is further complicated in interconnected power systems like those operated by Regional Transmission Organizations, where load in one state may be served by generation located in another state. In an interconnected power system, an incremental injection or withdrawal of electricity at a given node will result in a systemwide change in economic dispatch and, therefore, in carbon emissions. This change in systemwide emissions in response to a marginal increase or decrease in demand at a given node is called the Locational Marginal Emission Rate (LMER). We will describe a carbon accounting methodology based on LMERs that provides a mathematically sound way to quantify the carbon footprint of loads, generators, and constrained transmission facilities within a power system. We demonstrate how the methodology can be used to achieve the policy goals of a single state within an RTO.

Session H-2 (Thursday, July 11, 12:30 PM)

TRUSTWORTHY DEEP LEARNING FOR ELECTRICITY MARKET APPLICATIONS

Dr. Vladimir Dvorkin, Assistant Professor, University of Michigan (Ann Arbor, MI)
Dr. Ferdinando Fioretto, Assistant Professor, University of Virginia (Charlottesville, VA)

While deep learning gradually penetrates operational planning in power systems, its inherent prediction errors may significantly affect electricity pricing. In this talk, we will discuss how prediction errors (e.g., in wind power forecasting) propagate into electricity prices, revealing notable pricing errors and their spatial disparity in congested electricity grids. To mitigate these errors, we propose to embed electricity market-clearing optimization as a layer in deep learning models. Differentiating through this layer allows for balancing between prediction and pricing errors, as oppose to minimizing prediction errors alone. This layer implicitly optimizes fairness and controls the spatial distribution of price errors across the system. Such a price-informed deep learning is showcased in the nexus of wind power forecasting and short-term electricity market clearing.

LEVERAGING UNDERUTILIZED DER EDGE COMPUTE TO IMPROVE MARKET EFFICIENCIES

Philip Court, Co-founder and CTO, Ecosuite (Brooklyn, NY)
Joel Santisteban, Co-founder and CEO, Ecosuite, (Brooklyn, NY)
John Gorman, Analyst, Ecosuite (Brooklyn, NY)

Using software and AI for the purposes of improving market efficiencies seems like an obvious thing to do, given access to sufficient real time data, many teams could build what's needed to provide this service. What might be less obvious is the opportunity to achieve this without the need to deploy any new dedicated infrastructure (i.e. without the need for new sensors, new compute resources or communications infrastructure). This presentation will take you through the approach and open source infrastructure that Ecosuite is using to make this possibility a reality. In short, we will show how using DER edge compute resources it is possible to publish real time and future situational knowledge that can be used for the purposes of improved market efficiencies.

DEEP LEARNING-BASED TRANSMISSION LINE SCREENING FOR UNIT COMMITMENT

Mr. Farhan Hyder, Graduate Research Assistant, Rochester Institute of Technology (Rochester, NY)
Sriparvathi Shaji Bhattathiri, Graduate Research Assistant, Rochester Institute of Technology (Rochester, NY)
Abigail Broscius, Student, Rochester Institute of Technology (Rochester, NY)
Dr. Bing Yan, Assistant Professor, Rochester Institute of Technology (Rochester, NY)
Dr. Michael E. Kuhl, Professor, Rochester Institute of Technology (Rochester, NY)

Solving the transmission-constrained unit commitment (TC-UC) problem efficiently for high-quality solutions is one of the biggest challenges faced by independent system operators today. One way to achieve this is by removing superfluous network constraints from the problem. Several approaches have been used to identify such constraints. However, these methods are either too conservative or fail to maintain solution feasibility. In this work, a deep learning-based approach is developed to identify the subset of transmission lines that can be safely removed from the TC-UC problem. The idea is to capture the temporal relationship between past line loading levels, nodal demands, and future line loading levels to identify superfluous network constraints. To achieve this, a novel regression-based classification approach is developed, where the regression model is used to predict line loading levels, and different thresholds are applied to classify transmission line capacity constraints as necessary or not for the TC-UC problem. In addition, different classification thresholds are applied for peak and off-peak hours, and the location of the transmission line is also considered while choosing the classification threshold. The major advantage of this approach is that once trained, the model can be used under different classification thresholds. Numerical results show that the proposed approach significantly improves computational efficiency without compromising the solution quality.

PRIVACY-PRESERVING DEMAND RESPONSE ENABLED BY SYNTHETIC DATA

Dr. Guangchun (Grant) Ruan, Postdoctoral Fellow, Massachusetts Institute of Technology (Boston, MA)
Dr. Morteza Vahid-Ghavidel, Researcher, INESC-TEC (Porto, Portugal)
Dr. Audun Botterud, Principal Research Scientist, Massachusetts Institute of Technology (Boston, MA)

In modern electricity market, demand response programs (DRPs) typically involve the collection and analysis of energy usage data from smart meters, as well as information about user behaviors and preferences. These data are used to develop pricing strategies that incentivize users to reduce energy consumption during peak periods. Privacy concerns arise because these data may contain sensitive user information such as home address, household size, and energy usage patterns. It is widely recognized that these data sets can expose behavioral trends, potentially enabling actions like theft, targeted marketing, or even surveillance of individuals. Additionally, increased concerns regarding privacy in the energy industry have emerged due to recent data breaches and unauthorized exploitation of personal data. Synthetic data is an emerging resource to protect privacy in DRPs, which can be generated according to the aggregate statistics collected from smart meters. It is promising to construct these data using advanced deep learning techniques such as diffusion models. In this paradigm, the noises are automatically added to the synthetic data without affecting statistically different results for demand response decisions. We should analyze the trade-off between privacy loss and decision accuracy, ensuring that the synthetic data is as close as possible to the original data while still protecting the individual privacy. Following the differential-privacy framework, we will employ the chance-constrained linear decision rules and specified feasibility constraints within the differentially private optimization. Analogous to decision-making in uncertain conditions, we recognize a balance between achieving feasibility and minimizing the anticipated cost associated with maintaining privacy. Furthermore, we demonstrate a consistent correlation between the parameters of differential privacy and the incurred cost of privacy within the stochastic framework. In electricity market, the objective of applying differential privacy in DRPs is to enable more efficient and privacy-preserving energy management and to achieve more sustainable and cost-effective market clearing outcomes. The following objectives can be achieved as well: 1-Increase the volume and effectiveness of DRPs in electricity market by collecting and analyzing a limited amount of real data from smart meters. 2-Protect the privacy of individual users by using differential privacy techniques to add random noise to the data and generation of synthetic datasets. 3-Ensure the effective trade-off through a sensitivity analysis of the privacy and accuracy of the synthetic data.

GAMSPy: A Pipeline Friendly General Algebraic Modeling Language

Dr. Adam Christensen, Member of Technical Staff, GAMS Development Corporation (Fairfax, VA)
Dr. Steven Dirkse, President, GAMS Development Corporation (Fairfax, VA)
Dr. Michael Bussieck, President, GAMS Software GmbH (Braunschweig, Germany)
Muhammet Soyturk, Software Development, GAMS Software GmbH (Braunschweig, Germany)

Algebraic modeling languages (AMLs) such as GAMS, AMPL and more recently Julia/JuMP have been a cornerstone in the fields of optimization and economics. These tools are popular because they are able to effortlessly link the worlds of algebra and computer science -- that is, the syntax of the AML closely approximates that of handwritten algebra but its execution is automated and scalable. This pedagogical link supports the developer during all phases of software development from original model formulation to performance debugging and final output. The syntax also is important when transferring modeling knowledge between parties (i.e., external code review, developer transitions, etc.). Recent years have seen sophisticated computing tools enter the mainstream. Open source software languages/packages such as Anaconda, Python, Numpy, and Pandas make it easy to work with large data structures efficiently in deployable environments. Modern infrastructure tools such as Docker and Kubernetes make it easy to isolate workflows and scale compute resources via any number of cloud platforms. All of these compute resources mean that data assets are arriving at optimization model instances from an ever diversifying number of start points. All of this creative data pipelining requires new and creative technical solutions from AML developers. In response to many of these pipelining challenges, several developers have begun offering Python-based APIs that are deployable by standard package indexing systems. Design philosophies will differ across AML developers, but generally these Python tools leverage Numpy/Pandas for high performance data storage, the syntax of which often benefits from Python's object-oriented programming framework. However, syntactical challenges begin when expressing model algebra in a pure object-oriented context; it is often necessary to build Python loop structures to add algebraic objects to other container objects; many of these loop structures require complicated if/else conditions to effectively handle sparse data. The native Python loops and the general object oriented framework can lead to performance problems associated with model generation, additionally, the object-oriented syntax can often break the pedagogical link between the necessary computer programming and the underlying algebra -- a key feature and benefit of AMLs. In this work we present a Python package called GAMSPy that leverages the flexible nature of Python to construct a true Python-AML. The GAMSPy design philosophy rests on the original benefits of AML languages, specifically that the syntax mirrors algebra. Its set-driven nature, a common element among AMLs, is accomplished with extensive Python operator overloading. Execution of the algebra relies on a GAMS subsystem to avoid the performance and pedagogical pitfalls of object-oriented frameworks. Relying on a performant execution subsystem is similar in design philosophy to other popular Python packages such as Numpy/Pandas. This modularized “mini-GAMS" subsystem is also deployed through a standard package manager making it possible to install GAMSPy and resolve all of its necessary dependencies with one line -- pip install gamspy. All of the GAMS supported solvers have been modularized for easy/memory efficient installation into a Python environment. Documentation and example model libraries with both GAMSPy and original GAMS code are available for users interested in developing in GAMSPy. This presentation will cover a number of real-world inspired examples that illustrate how to bring data into a Python environment and how to effectively clean and use it in an optimization model. We leverage the GAMS Transfer API in order to resolve data issues and incorrect logical links before passing the pristine data onto GAMSPy where model algebra is added. Ultimately, the model is solved and post-processing occurs directly in Python.

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