Reliability Challenges and Solutions: European Policy and Regulatory Framework and Lessons from the German Experience

Dr. Robert F. Ichord, Jr.
Senior Fellow Atlantic Council Global Energy Center
Presentation to Energy Bar Association International Energizer Panel
March 28, 2018
EU Policy and Regulatory Framework

- The Third Package, Proposed “Winter Package” and Climate/Clean Energy Targets
- ACER, ENSOE- E&G, and Key Market Issues
- Energy Security, Diversification and the Nordstream II Issue
Energiewende

- History of the Green Party and the Commitment to Clean Energy
- Chernobyl, Fukushima and the Nuclear Decision
- Energy Subsidies and the FIT Approach
- Political Economy Issues
Germany: Electricity Generation Mix
2010-2017 (Est.) TWh

Wind: 16.9%
Nuclear: 12.1%
Hydro: 3.3%
Solar: 6.4%
Biomass: 8.3%
Hard Coal: 15%
Lignite: 23.7%
Gas: 13.9%
Growth of Renewables and the Reliability Challenge

1. Proliferation of Small Solar Generators
2. Tapping the Huge Wind Potential
3. Transmission Constraints and Baseload Operation
German Wind, Solar and Biomass Generation
(2010-2017) TWh
Costs and Benefits of the Transition

- Renewable Charges and High Retail Tariffs
- Excess Capacity and Low Wholesale Prices
- Deterioration of Utility Finance and Value
- New Companies and Employment Opportunities
- High-Cost Emissions Reduction
- Expanded Exports and Tensions with Neighbors
Regulatory and Market Challenges

- Transition to Reverse Auctions and Possible Elimination of Priority Dispatch
- Reduce Grid Expansion Costs
- Large Scale Batteries for Grid Balancing
- Cross-border peak smoothing
- Compensation to Impacted Utilities
- Capacity and Reserve Market Issues
- Market Structure: EON and RWE deal
Balancing Security, Economic Competitiveness and Environment/Climate Change

- Nuclear Closures and Decommissioning Costs
- Future of Coal and Lignite
- Gas and Growing Dependence on Russia
- Exports and Industry Competitiveness
Integrating Intermittent Generation in Southeast Europe: Lessons Learned

William L. Polen
Senior Director
United States Energy Association

United States Energy Association
June 29, 2017
Contents

- Overview of USEA
- Southeast Europe Cooperation Initiative Transmission Planning Project (SECI)
- Renewable Energy Integration in Southeast Europe
- Smoothing Seams
- Energy Security
Overview of USEA

- Not for Profit voluntary membership association
- 150 members covering the breadth of the U.S. energy industry
  - Utilities, regulatory agencies, oil & gas, nuclear, finance, research universities, consultancies
- U.S. member committee of the World Energy Council
- Educational & information dissemination mission
  - Annual State of the Energy Industry; Energy Efficiency Forum; Energy Supply Forum; weekly briefings
- 25 years of cooperation with USAID
ETAG Objectives

Plan for robust, reliable cross border transmission interconnections as the backbone infrastructure for cross border trade and exchange of electricity generated by clean & innovative energy technologies

Develop technical rules, guidelines and network infrastructure assessments to accelerate integration of clean & innovative energy technologies

Improve security of supply in distribution systems by supporting: optimization planning; line loss reduction; asset management programs; smart grid technology; and region wide disaster preparedness and emergency response programs

Support utility commercialization, privatization and market transformation to improve overall network efficiency and support clean energy market development
Project Goals: SECI & BSTP

Promote National & Regional Transmission Planning Among TSOs

Harmonize Transmission Planning Principles, Methods and Methodologies

Identify Priority Investments in Transmission Systems & Interconnections
SECI Project Participants

- Albania – Transmission System and Market Operator
- Bosnia and Herzegovina – Independent System Operator in BiH
- Bosnia and Herzegovina – Electricity Transmission Company of BiH
- Bulgaria – NEK EAD, National Electricity Company
- Croatia – HEP Transmission System Operator LLC
- Kosovo – Transmission System and Market Operator (KOSTT)
- Macedonia – Macedonia Transmission System Operator
- Montenegro – AD Prenos
- Romania – Transelectrica
- Serbia – JP Elektromereza Srbije (EMS)
- Turkey – Turkish Electricity Transmission Company
- Italy – TERNÁ (observer)
- Slovenia – Elektro Slovenia (observer)
SECI: Preparation for Large Scale Wind Integration in Southeast European Power System

- Ambitious Renewable Energy Supply (RES) Targets in SEE, especially wind generation
- Study Reviewed RES: Targets, Existing Wind Studies, Legal/Regulatory Framework, Technical Standards for each SECI Country
- Conducted Regional Network Load Flow Analysis Assuming Large Scale Penetration of Wind Generation
SECI: Impediments to Large Scale Wind Integration

Limiting factors for larger WPP integration:

- Wind energy potential: 2
- Tariff system on RES: 1
- Complex WPP development: 5
- Lack of legislative framework: 4
- Available system reserve: 10
- Network absorption capability: 6
- Lack of investments: 1
SECI: Impediments to Large Scale Wind Integration
SECI: Critical Findings of Large Scale Wind Integration in Southeast European Power System Study

- Technical Standards for Balancing Reserves can be an Impediment to Wind Generation Development at the National Level
- Regional Provision of Balancing Reserves Requires 50% less Reserves than National Provision of Reserves
- Regional Provision of Balancing Reserves Opens 2,000 MW of Generating Capacity for Market Activities
- Regional Balancing Reserve Sharing Mitigates a Significant Technical Impediment to Wind Generation Development at the National Level
ENTSO-E Approved Reserve Sharing Mechanisms

Individual Dimensioning
- R = 150
- R = 100
- \( \sum = 250 \text{ MW} \)

Exchange of Reserves
- R = 170
- R = 80
- \( \sum = 250 \text{ MW} \)

Common Dimensioning
- R = 150
- \( \sum = 150 \text{ MW} \)

Sharing Reserves
- R = 150
- R = 30 + 70
- \( \sum = 220 \text{ MW} \)
Dealing with Seams

- Sufficient cross-border transmission capacity for energy & balancing markets
- Seams create opportunities for gaming
- Coordinated Auction Office
- Regulatory Action
Other Issues

- Impact on Tariffs – Social Stability
- Queue Management
- Complex Connection Procedures
- Interaction with Distribution Networks
- Energy Security
## Germany
March 24, 2018 6:50 PM

### Carbon Intensity
- **Low-carbon**
  - 603g (gCO₂eq/kWh)
  - 26%
- **Renewable**
  - 2%

### Electricity Production & Carbon Emissions by Source

<table>
<thead>
<tr>
<th>Source</th>
<th>0GW</th>
<th>20GW</th>
<th>40GW</th>
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<tr>
<td>wind</td>
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</table>
Accommodating a Changing Resource Mix:

A North American Bulk Power System Reliability Perspective

John Moura, Director, Reliability Assessment and System Analysis
Energy Bar Association International Energizer Panel
March 28, 2018
About NERC: Mission

To ensure the reliability of the North American bulk power system

- Develop and enforce reliability standards
- Assess current and future reliability
- Analyze system events and recommend improved practices
- Encourage active participation by all stakeholders
- Accountable as ERO to regulators in the United States (FERC) and Canada (NEB and provincial governments)
ENTSO-E: European Network of Transmission System Operators for Electricity

- 41 Transmission Operators
- 34 Countries
- 5 Synchronous Zones
- Recognized in EU Regulation
- 1,030 GW Installed Capacity
- 528 GW Peak Load
- Population: 532M
• Conventional generation retirements create BPS reliability concerns when Essential Reliability Services and fuel assurance mechanisms are not replaced

• Declining reserve margins projected to tighten operational reliability, particularly under extreme conditions

• Variable resources can be reliably integrated, but need to be cautiously planned and operated

• Fuel diversity is a means to fuel assurance, but solutions need to consider regional differences

• Finding solutions to the limited pipeline capacity problem should encompass wholesale electric market action as well as natural gas regulatory frameworks
What is BPS Reliability?

- The ability of the BPS to meet the electricity needs of end-use customers at all times.

- **Adequacy** — The ability of the bulk power system to supply the aggregate electrical demand and energy requirements of the customers at all times.

- **Operating Reliability** — The ability of the bulk power system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.
Development of Adequacy Plans

Establish and Administer Resource Adequacy

Integrated Resource Plan

Capacity, Energy, Ancillary Service Markets

Independent Assessment

States
Provinces
ISO/RTOs

Regulated Utilities
Coop/Muni

Wholesale Electricity Markets

NERC
Regions
Less Synchronous Generation
Capacity Retirements Since 2012

- Continuing trend irrespective to environmental initiatives
- Replacement capacity has less spinning mass, contributing to lower system inertia

NERC-Wide Actual and Projected Conventional Generation Retirements
Frequency Excursion - Interconnection-wide Phenomena
More Gas-Fired Generation
• NERC-wide, on-peak natural gas-fired capacity increased to 442 GW, up from 280 GW in 2009.

• 32 GW of Tier 1 gas-fired capacity planned during the next decade.

<table>
<thead>
<tr>
<th>Assessment Area</th>
<th>2022 (%)</th>
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<tbody>
<tr>
<td>FRCC</td>
<td>78.1%</td>
</tr>
<tr>
<td>WECC-CAMX</td>
<td>68.2%</td>
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<tr>
<td>Texas RE-ERCOT</td>
<td>63.3%</td>
</tr>
<tr>
<td>NPCC-New England</td>
<td>52.3%</td>
</tr>
<tr>
<td>WECC-SRSG</td>
<td>51.8%</td>
</tr>
<tr>
<td>WECC-AB</td>
<td>51.8%</td>
</tr>
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</table>
2015 Aliso Canyon Out of Service and Resulting Electric Reliability Concerns

Potential Impacted Generation
LA Basin:
- 9,800 MW natural gas generation
- ~95% of total local capacity

Rest of Southern California:
- >15,000 MW natural gas generation

Maximum Import Capacity
- 5,500 MW DC capacity
- 14,900 MW AC capacity
- 20,400 MW total*

* Typically limited to 17,000 - 18,000 MW
Reported GADS Outages of Natural Gas Generation Due to “Lack of Fuel” (2012-2015)
Pipeline and other natural gas infrastructure are not expanded or built without long-term firm service arrangement.

Source: ANL
Top-20 Gas Pipelines by Peak-Day Delivery Arrangement

Red pipelines mean there were no interruptible flows on-peak

Source: ANL
Active Interstate Pipeline Restrictions

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>December 2017</th>
<th>January 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
<td>23</td>
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<tr>
<td>Dominion DTI</td>
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<tr>
<td>Dominion Cove Point</td>
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<tr>
<td>Transco</td>
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<td>Texas Eastern</td>
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<tr>
<td>Tennessee</td>
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<td>Columbia</td>
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<td>NGPL</td>
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<tr>
<td>Eastern Shore</td>
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<td></td>
</tr>
<tr>
<td>Northern Border</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panhandle Eastern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas Gas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LEGEND**

- **No Restrictions**
- **Scheduling Operational Flow Order**
- **Non-Firm Restriction**
- **Rateable Take**
- **Force Majeure**

Source: PJM
This chart is the ISO’s best approximation of usable oil discounting for unit outages, reductions, or emissions.
More Variable Resources
Solar PV continues to expand at a rapid pace

Visibility is needed to plan and operate the bulk power system

Over 100 GW by 2022 when considering utility-scale PV
Solar Irradiation in Germany Similar to that of Alaska

~1,500 kWh/m²/a

>2,000 kWh/m²/a

~1,000 kWh/m²/a
**Three Key Considerations**

*Reliably integrating these resources into the bulk power system will require significant changes to traditional methods used for system planning and operation.*

<table>
<thead>
<tr>
<th>Forecasting</th>
<th>Flexibility</th>
<th>Transmission</th>
</tr>
</thead>
</table>
| • Variable Fuels Must Be Used When Available  
• Forecast is only information; operator must make informed decisions  
• “It’s the ramps, not the ripples”  
• Methods for calculating expected on-peak capacity | • More Ancillary Services  
• Larger Balancing Authorities  
• Flexible Resources  
• Storage  
• PHEV  
• Leverage fuel diversity of other variable resources | • Interconnect variable energy resources in remote areas  
• Construct/site/permit transmission to deliver power across long distances |
“Duck” Curve Emerges 4-Years Early

Typical Spring Day

Net Load 11,663 MW on May 15, 2016

Actual 3-hour ramp 10,892 MW on February 1, 2016
High levels of variable generation will require **significant transmission additions** and reinforcements.

- **Challenge**
  - Interconnect variable energy resources in remote areas
  - Smooth the variable generation output across a broad geographical region
  - Deliver ramping capability and ancillary services.
  - Construct/site/permit transmission to deliver power across long distances.

Source: EPRI & NREL

Legend
- Demand Centers
- High Wind Availability
New Transmission Needed to Accommodate Resource Transition (Germany)

Power plants (>100 MW):
- Nuclear
- Lignite
- Hard coal
- Oil
- Natural gas
- Gas (various resources)
- Hydropower
- Renewable energy
- Wind installed
- >= 1,000 MW
- Wind expected
- Solar installed
- >= 1,000 MW
- Solar expected

Wind energy:
- 43 projects
- 350 km AC new
- 2150 km DC new
- 2,550 km AC optimisation
- ca. 450 km approved / 180 km = 7.6% / 3%

>5,500 km of priority lines by 2024
In Closing...
• Bulk power system reliability must be maintained, regardless of the generation mix;
• Maintaining a diverse resource mix increases resilience, flexibility, and reliability
• All generation must contribute to system reliability within their physical capabilities; and
• Industry standards and criteria must be fair, transparent and performance-based.
• Reliability challenges are bigger than any one organization and time is needed to engineer the solutions
Questions and Answers
State of Play on Renewable Energy

Timothy Burdis
Lead Strategist – State Government Policy
PJM Interconnection

Energy Bar Association
March 28, 2018
What is PJM?
PJM as Part of the Eastern Interconnection

<table>
<thead>
<tr>
<th>Key Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Member companies</td>
<td>1,000+</td>
</tr>
<tr>
<td>Millions of people served</td>
<td>65</td>
</tr>
<tr>
<td>Peak load in megawatts</td>
<td>165,492</td>
</tr>
<tr>
<td>MW of generating capacity</td>
<td>178,563</td>
</tr>
<tr>
<td>Miles of transmission lines</td>
<td>84,042</td>
</tr>
<tr>
<td>2017 GWh of annual energy</td>
<td>773,522</td>
</tr>
<tr>
<td>Generation sources</td>
<td>1,379</td>
</tr>
<tr>
<td>Square miles of territory</td>
<td>243,417</td>
</tr>
<tr>
<td>States served</td>
<td>13 + DC</td>
</tr>
</tbody>
</table>

21% of U.S. GDP produced in PJM

As of 2/2018
PJM’s Role as a Regional Transmission Organization

PLANNING
Planning for the future like...

OPERATIONS
Matches supply with demand like...

MARKETS
Energy Market Pricing like...

Urban Planning

Air Traffic Control

Stock Market
Market & Policy Developments

The Present
State Renewable Portfolio Standards (RPS) require suppliers to utilize wind and other renewable resources to serve an increasing percentage of total demand.

**State RPS Targets**

- NJ: 23.85% by 2021
- MD: 25% by 2020
- DE: 25% by 2026
- DC: 50% by 2032
- PA: 18%** by 2020
- IL: 25% by 2026
- OH: 12.5% by 2026
- NC: 12.5% by 2021
- MI: 10% + 1,100 MW by 2015
- VA: 15% by 2025
- IN: 10%** by 2025

- Minimum solar requirement
- ** Includes non-renewable “alternative” energy resources
Existing Installed Generation
(CIRs, December 31, 2017)

- Natural Gas, 67,280 MW
- Nuclear, 33,992 MW
- Oil, 9,734 MW
- Solar, 373 MW
- Hydro, 8,371 MW
- Wind, 1,130 MW
- Waste, 962 MW

As of Jan 31, 2017
2005-2017 PJM Average Emissions

- **CO\textsubscript{2}** (lbs/MWh)
- **SO\textsubscript{2} and NO\textsubscript{x}** (lbs/MWh)

- **Carbon Dioxide**
- **Sulfur Dioxides**
- **Nitrogen Oxides**

Bar and line chart showing the average emissions from 2005 to 2017, with notable decreases over the period.
The chart illustrates the PJM Wholesale Cost over a 6-year period from 2011 to 2016. The costs are broken down into four categories: Other, Transmission, Reliability (Capacity), and Energy. Each year, the total cost and the breakdown for each category are shown. For example, in 2011, the total cost was $61.65, with contributions from Other ($1.89), Transmission ($4.34), Reliability (Capacity) ($9.49), and Energy ($45.94). Similar breakdowns are shown for each subsequent year, with the total costs increasing to $70.40 in 2014 and $47.49 in 2016.
Market & Policy Developments

The Future
PJM Wind & Solar to Meet Existing RPS Requirements

116 GWh of Energy (13% of PJM load) by 2031
- 29,000 MW of Wind,
- 8,100 MW of Solar

- PJM Wind
- PJM Solar
Queued Generation Fuel Mix - Requested Capacity Injection Rights (December 31, 2017)

- Natural Gas, 57,778 MW
- Nuclear, 162 MW
- Solar, 10,882 MW
- Storage, 69 MW
- Wind, 2,793 MW
- Wood, 66 MW
- Biomass, 4 MW
- Coal, 198 MW
- Diesel, 9 MW
- Hydro, 77 MW
- Methane, 48 MW

**NOTE:** Nameplate Capacity represents a generator’s rated full power output capability.
Cleared Installed Capacity

- **Coal**
- **Gas**
- **Nuclear**
- **Renewables**

*Includes solar & wind at nameplate, hydro and wood.*
Increasing Demand Resources in the Capacity Market

- Price Responsive Demand
- Energy Efficiency
- RPM & FRR Demand Response
- Cleared & Committed Demand Response

Declining Electricity Demand Growth

PJM RTO Summer Peak Demand Forecast

Load (MW)

2013 Load Forecast
2014 Load Forecast
2015 Load Forecast
2016 Load Forecast
2017 Load Forecast

Year


190,000
180,000
170,000
160,000
150,000
140,000
130,000
120,000
Integrating Renewables
Regional markets reduce Variable Energy Resource integration costs

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Impact to Integration Cost</th>
</tr>
</thead>
</table>
| Larger balancing areas                           | • Reduces overall increase in variability  
• Less regulation and ramping service required  |
| Faster markets, i.e., shorter scheduling intervals (5-15 minutes) | • Less regulation required to accommodate intra-hour variations |
| Larger geographic area                           | • Increases weather diversity and reduces overall variability                               |
| Centralized wind power forecasting               | • Cost-effective approach to reduce scheduling impacts                                     |
| Regional / Interregional Transmission Planning   | • Cost-effective upgrades to ensure grid reliability and mitigate congestion                 |
PJM Initiatives to Address Impacts

Energy Markets / Operations
- Implemented a centralized wind power forecast service
- Solar power forecast is in progress
- Implemented changes to improve wind resource dispatch / control
- Demand Response / Price Responsive Demand improves operational flexibility
- Frequency Regulation – “pay for performance” rewards better performing resources (like storage)
- Interchange Scheduling – compliant with FERC Order 764 (15-minute intervals)

Transmission Planning
- Light load criteria implemented to improve grid reliability
- Expansion planning considers public policy impacts (i.e., RPS)
- Grid interconnection – enhanced standards for new inverter-based resources (wind and solar)

Evaluating Potential Grid Impacts
- PJM Renewable Integration Study (PRIS) - assessed grid impacts

Advanced Technology Research Program (ATRP)
- Pilot programs to evaluate new technologies and remove barriers to participation in PJM markets and operations.
Dr. Robert F. Ichord, Jr. is a non-resident Senior Fellow at the Atlantic Council’s Global Energy Center where he is spearheading an initiative on Transforming the Power Sector in Developing Countries. He is also CEO of Ichord Ventures LLC, an energy consulting company working with both the public and private sectors. Prior to retiring from the US Senior Executive Service in 2016 he was Deputy Assistant Secretary for Energy Transformation in the Energy Resources Bureau of the State Department, where he guided US international policy and programs on electricity and renewable energy. He also served for 33 years with the US Agency for International Development, heading energy project offices in the Asia, Near East, and Europe and Eurasia Bureaus.
WILL POLEN
Senior Director
United States Energy Association
Biography:

Mr. Polen is USEA’s Senior Director. Mr. Polen possesses 20 years of experience directing cooperative programs with the U.S. Agency for International Development (USAID), U.S. Trade and Development Agency, U.S. Department of Energy (USDOE), and U.S. Department of State supporting market transformation, energy trade and investment and technology transfer in the E&E region.

In his capacity as Senior Director, he manages two major USAID funded regional transmission planning projects that have leveraged several hundred million dollars in transmission network investment: Southeast Europe Cooperation Initiative Transmission Planning Project and the Black Sea Regional Transmission Planning Project.

He is also responsible for implementing USEA’s Utility Partnership Program for E&E, which has supported more than 20 twinning arrangements between U.S. electric power and natural gas utilities and their counterparts in E&E, including Ukraine, Russia, Armenia, Georgia, Kyrgyzstan, Kazakhstan, Moldova, Albania, and Kosovo, focused on utility commercialization, privatization and electricity market transformation.

Mr. Polen is a frequent traveler to the E&E region and possesses an extensive network of contacts with electric utilities and regulatory authorities in E&E. He has established USEA project offices in Moscow, Kiev, Yerevan, Tbilisi, and Astana. He currently manages a staff of four professionals in USEA’s Washington, DC headquarters.

Mr. Polen graduated from the University of Delaware in 1986 with a Bachelor of Arts in International Relations and from The American University in 1988 with a Master of Arts in International Development.
John Moura is the Director of Reliability Assessment and System Analysis for the North American Electric Reliability Corporation (NERC), where he joined in 2008. John leads the Electric Reliability Organization’s efforts to independently assess and report on the overall reliability, adequacy, and associated risks of the interconnected North American bulk power system. John leads the development of NERC’s annual long-term and seasonal reliability assessments, as well as NERC’s efforts in evaluating reliability impacts of potential environmental regulations, high-levels of variable generation, and an increasing dependence on natural gas. He is the co-author of numerous NERC special reports and several technical publications. In addition, John is actively engaged in multiple groups and committees across North America focused on the power system risk and vulnerability analyses, loss of load studies, probabilistic resource adequacy modeling, and interconnection-wide power system modeling. John earned his bachelor degree from Rutgers University.
Timothy C. Burdis

**Timothy C. Burdis** is a lead strategist within the State Government Policy Department at PJM Interconnection. He assists in outreach and strategy development for state government engagement; focusing on policy assessment, market design and transmission planning. He is responsible for PJM’s engagement with the Organization of PJM States, Inc. (OPSI).

Before his current post, Mr. Burdis worked on PJM emerging markets; responsible for the planning and integration management of changes to the wholesale electricity market. He specialized in changes brought about by state policy, renewable energy and infrastructure investment. He was also responsible for conducting industry research and analysis impacting electricity markets, and facilitating PJM’s corporate strategic planning process.

Additionally, Mr. Burdis served as director of business development & external affairs for PJM Environmental Information Services, Inc.

Mr. Burdis holds a Master of Science degree in Software Engineering from West Virginia University.

**PJM Interconnection**, founded in 1927, ensures the reliability of the high-voltage electric power system serving 65 million people in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. PJM coordinates and directs the operation of the region’s transmission grid, which includes over 82,000 miles of transmission lines; administers a competitive wholesale electricity market; and plans regional transmission expansion improvements to maintain grid reliability and relieve congestion. PJM’s regional grid and market operations produce annual savings of $2.8 billion to $3.1 billion. For the latest news about PJM, visit PJM Inside Lines at [insidelines.pjm.com](http://insidelines.pjm.com).