Driving Transformational Change

Doug Arent
2018 Annual Meeting
April 3, 2018
Logistics and Safety

RSF Building Evacuation Routes

Recycling/Compost/Trash

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>• Plastics 1-7</td>
<td>• Any food product</td>
<td>• Foil and cellophane wrappers</td>
</tr>
<tr>
<td>• Glass</td>
<td>• Paper Plates</td>
<td>• Plastic bags</td>
</tr>
<tr>
<td>• Cans</td>
<td>• Napkins, Paper towels, Kleenex</td>
<td>• Styrofoam</td>
</tr>
<tr>
<td>• Paper</td>
<td>• Compostable cups, plates, utensils</td>
<td></td>
</tr>
<tr>
<td>• Any food product</td>
<td>• Tea bags</td>
<td></td>
</tr>
<tr>
<td>• Paper Plates</td>
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• Foil and cellophane wrappers
• Plastic bags
• Styrofoam
Connecting technologies, economic sectors, and continents to catalyze the transition to the 21st century energy economy.
SYSTEMS SOLUTIONS

Integrated and coordinated energy solutions across power, thermal, buildings, industrial, and transportation sectors...in context of institutions, resources, earth and human systems.
Exploring nuclear-renewable hybrid energy systems:

- System configurations
- Operations, Product options
- Value Stream
- Economics & Investment Insights
Improving life cycle surface land-use intensity for power generation; Prior work on Water and GHGs
Value Streams of Hybridization:

- Energy arbitrage
- Frequency regulation
- Spinning reserves
- Generation capacity
- Transmission deferral
- Demand charge reductions
- Resilience and reliability
- Decreased diesel generation
SUPPLY CHAINS

Analysis and Insights of the supply chains from critical materials to final products

Bottom-up cost analyses of emerging global supply chains
Wide bandgap semiconductor devices, notably silicon carbide (SiC) devices, show potential to:

- **Reduce energy lost** during power conversion
- Have a **smaller footprint, lighter weight**
- **Lower system cost** compared to traditional silicon devices
- Have the **largest energy impact**, followed by data centers, renewable generation, and EVs.
LITHIUM-ION BATTERIES

Cost Analysis & Market Dynamics
GLOBAL TRANSFORMATION

Serves as a platform to advance integrated policy, regulatory, financial, and technical solutions in power markets around the globe.
GLOBAL THOUGHT LEADERSHIP

Helping Inform Energy Planning, Operations & Regulatory Considerations...
ACCELERATING TOWARD WHAT’S NEXT

• Co-simulate power and natural gas network operations.
• Define an “IEEE Standard” interconnected power and natural gas test system.
• Explore the potential coordination of day-ahead power and natural gas network operations.
Looking Forward

Connecting technologies, economic sectors, and continents to catalyze the transition to the 21st century energy economy.
Backup slides
TEST SYSTEM
(Power – IEEE 118)

• Day-Ahead (DA) & Real-Time (RT) Unit Commitment & Economic Dispatch
• Peak Load: 4,620 MW
• Regulation & Contingency Reserves
• Wind & Solar Penetration Scenarios: 20% - 30% - 40%

<table>
<thead>
<tr>
<th>Type</th>
<th># Generators</th>
<th>Installed Capacity (MW)</th>
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<tbody>
<tr>
<td>Hydro</td>
<td>4</td>
<td>1,035</td>
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<tr>
<td>Nuclear</td>
<td>1</td>
<td>238</td>
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<tr>
<td>Coal</td>
<td>2</td>
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<td>Geothermal</td>
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<td>Biomass</td>
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<tr>
<td>Biogas</td>
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<td>Natural Gas</td>
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<td>4,395</td>
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<tr>
<td>Oil</td>
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<td>43</td>
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</tbody>
</table>

Only showing natural gas generators
90 Nodes

46 Demand Nodes
- 25 Gas Fired Power Plants (GPP)
  - Min Delivery Pressure 30 [bar-g]
- 17 City Gate Stations (CGS)
  - Min Delivery Pressure 16 [bar-g]

3 Supply Nodes
- 2 Cross Border Entry Stations
- 1 LNG Terminal
  - Max Inventory 80 [Msm³]

2 Underground Gas Storage Facilities
  - Max Total Inventory 1000 [Msm³]
FUTURE WORK

- RT Coordination

**Diagram:**
- DA Fuel Offtake Constraints based on DA forecasted gas network conditions
- Hourly DA Natural Gas Fired Power Plants’ Fuel Offtakes
- Hourly RT Natural Gas Fired Power Plants’ Fuel Offtakes
- Potential Fuel Offtake Constraints/Challenges
- RT Fuel Offtake Constraints based on RT gas network conditions

**Text:**
- RT Coordination
- Electric (PLEXOS)
- Natural Gas (SAInt)