Operational Planning Areas

Generation  Transmission  Distribution
Generation Planning: Balancing Energy Needs, Resources and External Factors

<table>
<thead>
<tr>
<th></th>
<th>20 Years Ago</th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Scrutiny</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>New Resource Options</td>
<td>Nuclear, Coal, Oil, Natural Gas, Hydro, Renewables, DSM</td>
<td>Nuclear, Coal, Oil, Natural Gas, Hydro, Renewables, DSM 2.0, Battery Storage</td>
</tr>
<tr>
<td>Generation Load</td>
<td>Growing</td>
<td>Flat</td>
</tr>
</tbody>
</table>
U.S. Electricity Consumption Remains Flat

Electricity Consumption vs. Customer Count

Customers (Millions)

Electricity Consumption (TWh)
Today’s U.S. Coal Fleet Is Aging

Aging U.S. Coal Fleet

- **2020:**
  - < 30 years old: 12%
  - 30-39 years old: 24%
  - 40-49 years old: 41%
  - 50-59 years old: 17%
  - >= 60 years old: 6%

- **2030:**
  - < 30 years old: 9%
  - 30-39 years old: 4%
  - 40-49 years old: 24%
  - 50-59 years old: 41%
  - >= 60 years old: 22%

- **2040:**
  - < 30 years old: 4%
  - 30-39 years old: 6%
  - 40-49 years old: 4%
  - 50-59 years old: 24%
  - >= 60 years old: 63%

- **2050:**
  - < 30 years old: 4%
  - 30-39 years old: 6%
  - 40-49 years old: 4%
  - 50-59 years old: 87%
  - >= 60 years old: 0%
### U.S. Nuclear Fleet Is Aging, Too

#### Aging U.S. Nuclear Fleet

<table>
<thead>
<tr>
<th>Year</th>
<th>% &lt; 30 years old</th>
<th>% 30-39 y.o.</th>
<th>% 40-49 y.o.</th>
<th>% 50-59 y.o.</th>
<th>% &gt;= 60 y.o.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>4%</td>
<td>53%</td>
<td>41%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>3%</td>
<td>52%</td>
<td>39%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>3%</td>
<td>52%</td>
<td>42%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>2%</td>
<td>94%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- % < 30 years old
- % 30-39 y.o.
- % 40-49 y.o.
- % 50-59 y.o.
- % >= 60 y.o.
Fossil Fuels Are Under Attack

74 percent of coal can be replaced today at lower cost

New Report: Renewable Energy Will be Cheaper Than Fossil Fuels by 2020

Fossil Fuels, Utilities & Gas Cars To Be Obsolete By 2030

Funding for fossil fuel power plants is drying up

Moody’s developing new system to score companies on carbon transition risk
CO₂ Emissions Decline As Coal Plants Retire and Natural Gas Plants Come Online
The Excitement About Renewables

Google Officially Hits Its 100% Renewable Energy Target

**Budweiser’s New Symbol Stands For Every Beer Made With 100% Renewable Energy**

**Apple Now Runs On 100% Green Energy, And Here’s How It Got There**

**100 U.S. Cities are Committed to 100 Percent Clean, Renewable Energy**
100% Renewable vs. 100% Renewable (Annual net zero vs. no fossil fuels)
Large Investment To Serve A Small Area

Search: LG&E and KU Solar Study
Solar Costs Have Declined

Cost of Renewables vs. LG&E -KU Marginal Energy Costs

- LG&E-KU Marginal Costs
- Solar PPA (NREL PPA "Low")
Key Generation Planning Questions

• What amount of renewables can be integrated into the grid without battery storage?
• Will regulations be promulgated to reduce CO$_2$ emissions or limit the lives of existing generating units?
• What is the future of nuclear generation in the U.S.?
• How much generation will be supplied by the consumer?
• What is the future adoption rate for electric vehicles?
Transmission Planning:
Rules, Regulations and More
Transmission Risks and Challenges

- Cyber and physical security
- Extreme weather
- Geomatic events, or solar storms
- Electromagnetic pulse events
Reliability and Resiliency = Industry Priority

- Enhanced physical security at critical substations
- Increased spare inventory
- Mobile control houses
- Electric Power Research Institute
- Electromagnetic Pulse research
- Emergency-response drills: the national GridEx
- RESTORE equipment-sharing initiative
Distribution Planning: Changing With The Times

Past Planning
Substation

Customers
Distribution Planning: Changing With The Times

• Technological advancements
  — Advanced metering
  — Electric vehicles
  — Battery storage
• Load data collection
• Energy efficiency
• Distributed energy resources
  — Rooftop solar
• Increased urbanization
• Customer experience
• Reliability solutions
• Business analytics
Distribution Planning: Today and The Future

- Substation
- Battery Storage
- Customers
- Solar

Future Planning: Solar and Battery Storage Integration
Effective Planning For The Future Utility

• The industry continues to be ever-changing and complex

• New and old challenges are a part of doing business
  — Regulations
  — Renewable resource development/technological advancements
  — Environmental sensitivities/public scrutiny
  — Energy efficiency
  — Economic changes
  — Long-term requirements of effective planning

• New analytical tools help to better address challenges

• Savvy planners; innovative, analytical thinking; and flexibility will continue to drive success.