Distributed Generation, Cogeneration, and Storage - Key Factors in Energy Plans for Data Centers, Campuses and Municipalities

IDEA Campus Energy 2018

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www.siemens.com
March 2018
Agenda

• Overview of power generation market changes and associated challenges

• Distributed generation case studies
  • Primary and backup power
  • Cogeneration
  • Energy storage
  • Microgrids & hybrid solutions

• Q&A
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- Overview of power generation market changes and associated challenges
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  - Cogeneration
  - Energy storage
  - Microgrids & hybrid solutions
- Q&A
Evolving Grid Creates New Opportunities & Challenges

1. Penetration of Renewables
2. Change of Energy Mix
3. Saturation of Infrastructure
4. Increase of Grid complexity
5. Fuel Price Fluctuations
6. Deployment of Microgrids
US National Energy Profile

U.S. National Profile

Capacity Mix
- 2002: 0% Coal, 36% Natural Gas (all), 11% Nuclear, 12% Hydro, 12% Wind, 12% Oil, 12% Solar, 35% Other
- 2009: 2% Coal, 40% Natural Gas (all), 12% Natural Gas (CC), 12% Natural Gas (CT), 8% Nuclear, 12% Hydro, 12% Wind, 3% Oil, 3% Solar, 40% Other
- 2016: 3% Coal, 42% Natural Gas (all), 8% Natural Gas (CC), 8% Natural Gas (CT), 9% Nuclear, 12% Hydro, 12% Wind, 7% Oil, 7% Solar, 42% Other

Generation Mix
- 2002: 0% Coal, 50% Natural Gas (all), 7% Nuclear, 7% Hydro, 7% Wind, 7% Oil, 7% Solar, 30% Other
- 2009: 2% Coal, 44% Natural Gas (all), 8% Natural Gas (CC), 8% Natural Gas (CT), 1% Nuclear, 8% Hydro, 8% Wind, 2% Oil, 2% Solar, 28% Other
- 2016: 1% Coal, 34% Natural Gas (all), 8% Natural Gas (CC), 8% Natural Gas (CT), 3% Nuclear, 8% Hydro, 8% Wind, 5% Oil, 5% Solar, 28% Other

Data Sources:

Source: U.S. Department of Energy, Staff Report on Electricity Markets and Reliability, August 2017
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Bayonne Energy Center – Electric Power Plant
Peak power for New York City

Siemens Scope of Supply
(8) SGT-A65 (Industrial Trent) WLE ISI gas turbine units installed – more units currently getting added
512 MW dual fuel fired electric power plant

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Solution</th>
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<tbody>
<tr>
<td>Complex 10,800 square foot facility with SGT-A65 (Industrial Trent) gas turbine units in simultaneous operation, running up to 12 hours daily, to export over 500MW via under-water cable to the grid for the City of New York.</td>
<td>Full power can be delivered in less than ten minutes from start, enabling on/off cycle flexibility, reducing fuel costs and emissions. Delivers sufficient power to supply electricity to over 500,000 homes at peak times.</td>
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10min
Start from 0 to 512MW output and similar cycling capability

500K
Homes supplied with reliable electricity at peak times

Maximum flexibility to adjust to dynamic market needs
Aeroderivative Gas Turbines in Simple Cycle Applications
Operation flexibility to match evolving energy market

Operation over 2 day period
Importance of Flexible Generation
Critical facilities – reliability & resilience

- Fast cold start (less than 60 seconds)
- Fast ramp up and down capability
- High cycling capability – no start/stop penalty
- No hot lockouts
- Fuel flexibility
- High power density
- Modularity – 5 MW blocks
- Compact & light weight packaging
- Integrated controls

Data Centers

Hospitals & Medical Centers

Airports
Tate and Lyle – Tennessee Cogeneration Plant
CHP solutions in industrial applications – CO2 emissions reduction

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<td>Implement energy efficient on-site power solution to ensure safe and</td>
<td>Replaced aging coal-fired boilers with CHP system</td>
</tr>
<tr>
<td>reliable operations</td>
<td></td>
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<tr>
<td>Ensure continuity of plant operations regardless of the challenges with</td>
<td>On-site power system (CHP) boosts energy reliability and security while making use of the heat</td>
</tr>
<tr>
<td>external energy supply</td>
<td></td>
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Source: https://www.tateandlyle.com

50MW
Reliable power supply offering same electrical and thermal outputs with lower costs and emissions
City of Holland – Cogeneration Plant
Municipalities implementing CHP solutions

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<td>Coal-fired plant no longer met city energy needs</td>
<td>Two SGT-800 and One SST-400 provide cost-efficient power</td>
</tr>
<tr>
<td>Underground snowmelt system could not meet energy demands</td>
<td>Waste heat from circulating water system provides heat for increased snowmelt system demands</td>
</tr>
<tr>
<td>Complex development process</td>
<td>Provide “bundle buy” solutions to facilitate supply process</td>
</tr>
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145MW New power generated via CHP plant ~50% The CO2 emissions reduction rate from existing supplier

Leveraging portfolio breadth to facilitate project development goals
Hybrid Energy Solutions in Campuses
Integrating cogeneration, renewables, & storage

- Micro-grid management
- Cogeneration plant
- Solar PV
- Energy storage
- EV charging
Hybrid energy solutions in industrial facilities
SIESTART™ - integrating gas turbines & energy storage

Customer
Vulkan Energiewirtschaft Oderbrücke GmbH
Location
Eisenhüttenstadt, Germany
Date
2013

Challenges
- Black start capability for an industrial gas turbine
- Grid stability (frequency, voltage)
- Islanding and off-grid services
- Smart peak load management

Solution
- Existing GE gas turbine and generator
- SIESTORAGE Li-Ion battery storage system (2,8 MVA / 1,2 MW, 1,080 kWh)
- Integration of components to existing unit control system

Customer benefits
- Siemens turnkey solution with 57 MWel and steam generation of 180 t/h, 120 bar, 540° Celsius
- Secure power supply through black start capability for sustainable steel and rolling mill operation
Integrating Energy Storage in Existing & New Power Plants
Optimized operation - new opportunities for flexible generation

Optimized Operation and Flexible Generation
Hybrid Power Plant Integrating Several Technologies
Isabela Island microgrid

Highlights
• Full turnkey supply of complete hybrid power plant (including ESS, PV plant, Gen sets, plant automation and grid control)
• Guaranteed minimum renewable share, and capability to work with 100% renewable penetration during sunshine hours (diesel off)
  Economic optimized operation of hybrid power plant (e.g. diesel vs. ESS)

Project Size
• ESS: 305KW / 620 kWh
• Biodiesel Generators: 5 x 325kW
• PV Plant: 922 kW
• Controls: T-3000 Siemens Controller

Location
• Isabela Island, Ecuador
Hybrid Power Plant Integrating Several Technologies
Blue Lake Rancheria deploys low-carbon microgrid

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<td>Diverse renewable energy sources - .5MW solar PV, 950 kWh battery storage syst., a biomass fuel cell and diesel generators need to be optimally managed and controlled to achieve energy efficiency, cost savings and emission reduction goals</td>
<td>Siemens SP MGMS software for managing numerous energy sources and balancing with energy loads</td>
</tr>
<tr>
<td>Operations need to be automated to allow limited staff to manage the system in event of a grid outage to ensure energy security for the on-site emergency shelter</td>
<td>Microgrid defined sequence of operations programmed to coordinate with the local utility</td>
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7 days
Duration of available on-site power independent from the utility
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Questions?

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U.S. regional energy profiles

Source: U.S. Department of Energy, Staff Report on Electricity Markets and Reliability, August 2017
U.S. regional energy profiles

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Main challenges in the grid

Higher utilization of renewables and less rotational inertia from conventional power generation units

Stability of the grid and secure supply of power

Higher flexibility and shorter reaction times requirements to the producers
Grid challenges driving critical needs for power plants

Ensure grid stability

Conventional power plants (heavy duty as well as industrial scale) need:

• Accelerated load ramping for fast compensation of unbalances in the grid
• Spinning reserve as additional power reserve to stabilize the grid
• Islanding and off-grid services (especially for industrial power plants)
• Black start capability in the case of a grid failure
Modular power supply: The Battery Energy Storage System SIESTORAGE

Modular energy storage system based on technology leading power electronics and Li-ion batteries:

- Instantly available, reliable and flexible power
- Fast and accurate response time to consume and discharge energy
- Assured power quality
- Flexible and scalable design - various sizes and configurations

Designed for improved asset performance
SIESTART™ – The performance of conventional power plants combined with instant & reliable Battery Energy Storage Systems

Siemens Power Generation
- Over 600 GW of installed capacity since 1960
- More than 25,000 Siemens gas and steam turbines in commercial operation
- I&C solutions for all types of plants

Siemens BESS (SIESTORAGE)
- Cutting-edge power electronics, automation, and state-of-the-art Li-ion battery technology
- Modular battery storage concept with flexible and scalable design
- 20 battery storage projects – eight regions, seven use cases

Siemens Control Systems: More than 2,700 power plant projects with Siemens I&C