Commercial and Industrial Perspectives on Smart Grids

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Acknowledgements

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• Nonetheless, all errors and other shortcomings are my fault solely! Comments welcome!
Objectives for this presentation

• Increase awareness of C&I sectors, as related to smart grid requirements and issues

• Highlight the progress that has already been made, and the benefits that are already being realized, in C&I smart-grid-like developments

• Advocate for a greater role for the C&I sectors in SGIP
Outline

• Commercial sector—diversity and complexity
• Industrial sector—diversity and complexity
• Examples of successful C&I smart grid applications
• C&I versus R
• Recommendations for the SGIP GB
• Conclusions
Wide range of building energy costs

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Per Building Per Square Foot (thousand)</th>
<th>Per Building Per Square Foot (thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Service</td>
<td>4.54</td>
<td>25.3</td>
</tr>
<tr>
<td>Food Sales</td>
<td>4.36</td>
<td>24.2</td>
</tr>
<tr>
<td>Health Care</td>
<td>2.57</td>
<td>63.3</td>
</tr>
<tr>
<td>Public Order and Safety</td>
<td>1.93</td>
<td>29.8</td>
</tr>
<tr>
<td>Office</td>
<td>1.87</td>
<td>27.7</td>
</tr>
<tr>
<td>Public Assembly</td>
<td>1.61</td>
<td>22.9</td>
</tr>
<tr>
<td>Lodging</td>
<td>1.60</td>
<td>57.3</td>
</tr>
<tr>
<td>Mercantile</td>
<td>2.08</td>
<td>35.5</td>
</tr>
<tr>
<td>Education</td>
<td>1.34</td>
<td>34.1</td>
</tr>
<tr>
<td>Service</td>
<td>1.29</td>
<td>8.4</td>
</tr>
<tr>
<td>Warehouse and Storage</td>
<td>0.74</td>
<td>12.6</td>
</tr>
<tr>
<td>Religious Worship</td>
<td>0.71</td>
<td>7.2</td>
</tr>
<tr>
<td>Vacant</td>
<td>0.32</td>
<td>4.5</td>
</tr>
<tr>
<td>Other</td>
<td>2.78</td>
<td>61.0</td>
</tr>
</tbody>
</table>

http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=3.3.9

- Over an order-of-magnitude spread in energy costs, both on per-square-foot and per-building bases

High diversity in construction and use of buildings
Considerable variety in energy management functions in buildings. Function use depends significantly on type of business.

Increasing integration between facility-side and business-side systems/functions.

Figure 2.1. Surveyed Prevalence and Usage Rates for Selected EMCS Functions (from Lowry 2002)

Commercial building energy management—complexities

- Building codes must be followed (indoor air quality, energy efficiency, etc.)
  - specific operating conditions must be maintained
- Control schedules for commercial buildings must be designed with knowledge of weather, indoor conditions, expected occupancy, etc.
  - building should be “comfortable” just in time for first occupants but not any earlier
- The energy used for “overhead” (HVAC / lighting / etc.) must be balanced with the energy used for “production,” or meaningful work in a facility
  - requires detailed knowledge of overhead and production loads
- Startup of loads (in occupied mode or after power failure) must be managed
  - e.g., electrical spikes cannot be tolerated
- Complete replacement of existing control systems typically not feasible
  - gateways used to interface with newer technologies
- Thermal / ice storage increasingly common for load shifting
  - requires knowledge of current and future cost of energy, weather information, current and future demand, existing storage capacity, etc.
- Energy costs must often be apportioned to other tenants / departments

Domain knowledge essential for load management
Building automation system example

Numerous existing standards/protocols
- BACnet
- LonWorks
- Dali
- Modbus
- ASHRAE 189.1-2009
- OPC
- OpenADR
- ZigBee
- ... and many others

Complex systems; many existing standards
# Industrial sector—power use diversity

<table>
<thead>
<tr>
<th>Industry sector</th>
<th>Total electricity used (10^6 kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>207,107</td>
</tr>
<tr>
<td>Primary Metals</td>
<td>139,985</td>
</tr>
<tr>
<td>Paper</td>
<td>122,168</td>
</tr>
<tr>
<td>Food</td>
<td>78,003</td>
</tr>
<tr>
<td>Petroleum and Coal Products</td>
<td>60,149</td>
</tr>
<tr>
<td>Transportation Equipment</td>
<td>57,704</td>
</tr>
<tr>
<td>Plastics and Rubber Products</td>
<td>53,423</td>
</tr>
<tr>
<td>Nonmetallic Mineral Products</td>
<td>44,783</td>
</tr>
<tr>
<td>Fabricated Metal Products</td>
<td>42,238</td>
</tr>
<tr>
<td>Machinery</td>
<td>32,733</td>
</tr>
<tr>
<td>Wood Products</td>
<td>28,911</td>
</tr>
<tr>
<td>Computer and Electronic Products</td>
<td>27,542</td>
</tr>
<tr>
<td>Textile Mills</td>
<td>19,753</td>
</tr>
<tr>
<td>Beverage and Tobacco Products</td>
<td>17,562</td>
</tr>
<tr>
<td>Printing and Related Support</td>
<td>13,089</td>
</tr>
<tr>
<td>Electrical Equip., Appliances, and Components</td>
<td>12,870</td>
</tr>
</tbody>
</table>

(plus smaller contributors)

[http://www.eia.doe.gov/emeu/mecs/mecs2006/pdf/Table11_1.pdf](http://www.eia.doe.gov/emeu/mecs/mecs2006/pdf/Table11_1.pdf)
Industrial energy management—complexities

• Industrial plants can be high consumers of electricity
  – up to 100s of MW at peak load and 100Ms of kWh annual consumption
• Connections to the grid can be at high voltage levels
  – direct to transmission (138 kV and 230 kV) and distribution (4 kV – 69 kV) grids
• Large manufacturing facilities can have substantial on-site generation
  – nationwide industrial generation: 142 B kWh, about 15% of net electricity demand
  – sales and transfers offsite: 19 B kWh
• Automatic generation control (AGC) and ancillary services
  – large plants can (and do) play important roles for grid reliability and frequency regulation
• Some processes require high-speed meter data
  – real-time, not “near-real-time”—milliseconds in some cases
• Industrial users have high interest in ownership and protection of usage data
  – load information is often highly confidential and competition-sensitive
• Manufacturing processes can be inflexible with respect to time
  – interdependencies in process must be respected, for performance and safety
• Many customers require dynamic pricing models for process optimization
  – forecasted pricing and special tariffs from utilities in many cases

Domain knowledge essential for load management
Industrial automation system example

Numerous existing standards/protocols
- HART
- Foundation Fieldbus
- ControlNet
- ISA 100.11a
- S-88
- OPC Unified Architecture
... and many others

Complex systems; many existing standards
Outline

• Commercial sector—diversity and complexity
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• Conclusions
C&I smart grid example:
Johnson Controls (JCI) worked with Georgia Tech to implement a real-time-pricing controller for the campus. The BACnet-based JCI building automation system receives hour-ahead prices from Southern Company and adjusts temperature set points and boiler fuel source. Annual savings are estimated at $650K – $1M.

*C & I smart grid information architecture (1)

Utility

Internet

Facility

ESI

EMS

Load-1

Load-2

Load-n

*may be shadow/interval meter

Courtesy of D. Alexander, Georgia Tech
For more information:  http://www.fire.nist.gov/bfrlpubs/build07/PDF/b07028.pdf
C&I smart grid example:
Honeywell Novar is the global leader in multisite energy management, with remote energy supervision of > 10,000 sites, including 65% of the top U.S. retailers (Walmart, Home Depot, Staples, Sam’s Club, ...). In the U.S., Novar manages over 6 GW of loads in commercial buildings.

For more information:  http://www.novar.com/
C&I smart grid example:
Ice Energy’s storage solution (Ice Bear) enables peak load reduction in commercial buildings through the generation of ice during off-peak times and the use of the ice for cooling during peak load. A controller and ESI are part of the Ice Bear product, which determines the energy source (the EMS controls the cooling demand). Condensing unit peak reduction of 94 – 98 per cent is routinely realized in commercial installations.

Courtesy of B. Parsonnet, Ice Energy
For more information:  http://www.ice-energy.com/
C&I smart grid information architecture (4)

C&I smart grid example:
Alcoa Power Generation, Inc. participates in the MISO wholesale market by providing regulation of up to 25 MW as an ancillary service through control of smelter loads at Alcoa’s Warwick Plant (Ind.). APGI is reimbursed for load modulation as if the energy was generated. Total facility load is 550 MW. More than 15 GW of regulation capability is available in U.S. industry. Additional capability exists for other ancillary services.

For more information:
**C&I smart grid example:**
A food manufacturer participates in a CAISO demand response program. Proposed day-ahead events are received from the utility. A person examines the production schedule to decide which (if any) manufacturing loads can be shed. The load shedding is enabled in the EMS for automatic execution based on further events the following day. The site receives utility compensation for participation based on actual meter readings compared to a baseline.

**Diagram Description:**
- The diagram shows a network involving a utility, internet, EMS, and facility.
- The utility is connected to the internet, and the internet is connected to the EMS.
- The EMS is connected to multiple loads labeled Load-1 and Load-n.
- The facility is connected to the EMS through an ESI and meter.

**Note:**
- Courtesy of D. Brandt, Rockwell Automation.
C (medium-to-large) & I versus R

- **C&I** well advanced in energy efficiency, demand response, and other smart grid functions, compared to residential sector
  - energy management systems in use for decades
- **Direct load control** of less relevance—domain knowledge required for load management
  - I: not acceptable as the sole or a principal demand response mechanism
  - C: many building owners insist on managing their own loads
- **Energy information over the Internet**
  - pricing signals and other information increasingly obtained over Internet
- **Data ownership and control** are critically important
  - utility or public cloud-resident applications are less acceptable; require higher levels of data privacy and integrity
- **Much greater complexity of facility operation, control, and load management**
  - automation systems typically custom-designed and installed for each facility
  - many users and skill-sets—managers, engineers, operators, CFOs, ...
- **Well-established protocols and standards** already exist, with extensions in progress
  - large investments, installed base, operational practices impose switching costs

*C&I developments today ... tomorrow’s residential model*
Grid-side and consumer-side demarcation

- Loose coupling logically separates control signals from utility communications
- Line of demarcation needed between utility and consumer domains

*Grid-side and consumer-side separation a C&I best practice: scalability, security, competition, innovation*
SGIP (GB) recommendations

- Increase consumer stakeholder categories on Governing Board
  - one seat is inadequate for all consumer sectors ... important and diverse stakeholder communities
- Ensure better representation of C&I on other SGIP bodies
  - especially SGAC ... successful architectural concepts from C&I are models for the smart grid as a whole
- Elaborate “customer” portions of the conceptual model and related documents
  - customer-domain content is sketchy, especially for C&I ... separate, detailed diagrams for residential, commercial, and industrial domains would be useful
- Increase participation of industrial end-users in SGIP
  - important consumer set, not well represented
- Launch new PAP for facility-side information modeling
  - follow-up to effective PAP-10 resolution toward a basic energy usage information model
Conclusions

• Commercial and industrial sectors are a large consumer base
  – about 64% of U.S. electricity consumption is in C&I
• C&I are rich, diverse domains from energy- and load-management perspectives
  – reflected in complexity of automation strategies, EMS systems
• C&I energy management increasingly reliant on Internet, Web
  – non-meter-centric architectures, price signals, remote services
• Liberating smart grid values today is much easier, faster, cheaper from C&I sectors than from residential
  – C&I developments can be models for the residential sector
• Innovation occurring in C&I space already, and more will come
  – standards and architectures should enable future innovation, not be a barrier to it
• Advocacy on SGIP GB effectively limited to one stakeholder category
  – more understanding of, and participation from, C&I is needed

**Smart grid decision-making must be deeply informed by commercial and industrial sectors**
Thanks for your attention!

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