Smart Grid Developments and Utility/Vendor R&D Interests: Observations From the SG Research Consortium

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Smart Grid Research Consortium

West Virginia University
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Topics

1. Smart grid developments
2. Smart Grid Research Consortium
3. Current industry observations
   • Utility and industry drivers
   • Utility/SG vendor R&D Interests
Traditional Utility Systems Suffer From a Variety of Shortcomings

- From 20 – 40% GT&D capital used < 100 hours/year
- Limited asset information and management
- Outages/reliability cost utility customers billions and impact customer satisfaction
- Limited ability to integrate distributed energy resources (DER)
- Environmental issues

Source: solarcellcentral.com
Traditional Utility Distribution Planning and Operations Start With Customer Loads and Work Backwards

**Color Key:**
- Black: Generation
- Blue: Transmission
- Green: Distribution

![Diagram of Utility Distribution System]

- **Transmission lines:** 765, 500, 345, 239, and 138 kV
- **Generating Station**
- **Generating Step Up Transformer**
- **Transmission Customer:** 138kV or 230kV

Source: solarcellcentral.com

### Customer #1 August 5 Hourly Loads

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>kW (AC)</th>
<th>kW (Other)</th>
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<tbody>
<tr>
<td>1</td>
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### Customer #2 August 5 Hourly Loads

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>kW (AC)</th>
<th>kW (Water Heat)</th>
<th>kW (Other)</th>
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<td>1</td>
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</table>

### Customer #3 August 5 Hourly Loads

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>kW (AC)</th>
<th>kW (Other)</th>
</tr>
</thead>
<tbody>
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<td>5</td>
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### Summer Peak Day Loads

- **Baseline**
- **With Programs**
Smart Grids Apply New Metering, Communications, Monitoring, Control, Generation Technologies and Applications to Optimize the Structure and Operation of the Electric System

- Information, communication, visibility and control across the entire grid
- Electric generation from central utility plants and dispersed throughout the grid
- Utility customer participation in generation and load reduction
- Increased reliability and power quality and reduced outages
- Reduced environmental impacts
- SIGNIFICANT REDUCTIONS in operating costs and GT&D investments
EPRI 2011 – 20 Year Costs and Benefits (partial)
  • Costs: $338-476 billion (~20% transmission/substation)
  • Benefits: $1,294-2,028 billion
  • B/C: 2.8-6.0

GTM Research
  • $5.6 billion SG expenditures in 2010
  • $9.6 billion SG expenditures in 2015
1. AMI/Smart Meters
2. Distribution automation
3. Volt/VAR – CVR applications
4. Customer engagement (includes DR, load control, education)
5. DER
AMI/Smart Meters Have Received Most Public Attention

- Digital meters
  - 15-minute reads; 2-way communications
  - Remote connect disconnect
  - Last-gasp outage notification
  - Tamper detection
  - Communications portal into facility
- Communications system
  - Radio (licensed, unlicensed), public cellular, PLC,
- Significant reduction in meter reading, field services, CIS services etc.
- Approximate cost: ~$150/meter
- Approximate benefits
  - ~$10 - $30/meter/year operating savings
  - ~$5 - $20/meter (avg)/year avoided power cost/year (from related demand response)
  - + avoided GT&D investment costs (from related demand response)
Distribution Automation Increases Reliability and Power Quality

- Identifies and isolates faults
- Automates power restoration
- Reduced momentary and long-term outage duration and frequency
- Reduces sags and swells
- Reduces utility and customer equipment damage
- ....
Conservation Voltage Regulation (CVR) Can Provide 2-3 Year Paybacks

- CVR Advantages
  - No customer participation required
  - Options: manual adjustments → full automation
  - Utility & customer savings

VVC Objective: Maintain acceptable voltage under all loading conditions

<table>
<thead>
<tr>
<th></th>
<th>kW</th>
<th>kWh</th>
</tr>
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<tbody>
<tr>
<td>Elec, No AC</td>
<td>0.40</td>
<td>0.25</td>
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<tr>
<td>Elec, AC</td>
<td>0.35</td>
<td>0.40</td>
</tr>
<tr>
<td>Non, AC</td>
<td>0.74</td>
<td>0.60</td>
</tr>
<tr>
<td>Non, No AC</td>
<td>0.81</td>
<td>0.40</td>
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</tbody>
</table>

Source: Distribution Efficiency Initiative Study

Customer bills and utility line losses are reduced
Customer Engagement Reduces Peak Period System Loads

- Direct load control (AC, WH, pool pumps)
- Programmable communicating thermostats (15-30% participant peak reduction)
- Other demand response/customer engagement
- Reduces power costs and future GT&D investments
DER Reduces Central Plant Generation and Creates Utility Operating and Control Challenges

- Combined heat and power (distributed generation, cogeneration)
- PV
- PHEV
- Cool storage
- Battery storage
- Etc.

Source: Ice Energy
Smart Grid Components are Integrated in an Optimized Smart Grid Strategy

- AMI/Smart Meters
- Distribution automation
- Volt/VAR applications
- Customer engagement
- DER
- Communications
- Analytics
Smart Grid Transformation is Just Beginning

- AMI/Smart Meters (excludes AMR systems)
  - ~8% currently, ~17% approved electric
  - ~8% water meters
- Distribution automation, Volt/VAR applications just beginning
- Demand response
  - Industrial applications have grown over the past 5 years
  - Limited experience in commercial and residential
    - Promising pilots and initial program results
    - Question regarding on impact persistence
- DER
  - CHP -mature industrial applications, limited commercial, minimal residential
  - PV, PHEV, ... – minimal/limited
Smart Grid Research Consortium Developed to Assist Utilities With SG Investment Decisions

• Formed at Texas A&M University in early 2010
• Electric cooperative, municipal and public utility membership
• Established as an independent research organization in January 2011
• Provides members ongoing smart grid investment modeling and analysis support
• 15 utility applications through 2011
• Work with utilities and vendors to develop technology and applications information
Conducted Survey to Assess Need for Utility SG Investment Model

Utility Analysis Capabilities

Likely Peak Hour Impacts

Formal Business Model
Utilities Expect Relatively Rapid SG Implementations

Utility SG Development Expectations

- Trials/pilots
- Begin system-wide deployment
- Majority of customers with in-premise technologies for DR, CPP, etc.

Years

- Coops
- Municipals
Survey Results Revealed Conflict Between Current Conditions and Expectations

- Most utilities have not started or have barely started SG planning & implementation
- Utilities expect to apply conservative investment criteria
- Few utilities have developed a SG financial analysis framework
- Few utilities have customer hourly load information required to assess peak hour impacts
- Utilities see comprehensive SG systems in place by 2016-2017 (5-6 years from now)
Smart Grid Investment Model™ (SGIM)

• Comprehensive cost/benefit framework
• Incorporates utility-specific information
  o Infrastructure and customer information
  o Hourly load impact models
    • Customer engagement programs (DR, pricing, etc.)
    • Conservation voltage regulation
    • Avoided power and capital investment costs
• Intuitive, user-friendly Excel platform
Smart Grid Investment Model Scope

Back office → Substations → Feeders → Meters → In-Premise Programs

Smart Grid Investment Model Focus

Smart Grid Investment Model Impacts on Generation Functions
Model Applies Intuitive Utility-Perspective Smart Grid Investment Framework
Technology, Program and Other Impacts Are Represented in Hourly Load Model Results

Technology impacts on customer hourly loads

Program impacts on customer hourly loads

Economic and utility impacts on customer hourly loads

Monthly Customer Class End-Use Hourly Load Models

Cost/Benefit Calculations (As Appropriate for Each Utility)

- Avoided power purchase costs
- Avoided generation costs
- Avoided transmission costs
- Avoided G&T investment costs
- Avoided distribution investment costs
- Avoided equipment maintenance & capital costs
“GATEWAY” Worksheet Provides Access to all SG Programs, Model Parameters and Results

General program areas are turned “on” and “off” on this sheet.

Summary results are provided on this sheet for the current analysis scenario.

Buttons provide “drill-down” to additional technology and program detail.

Recalculate button calls the hourly load forecasting model to determine monthly impacts of SG technologies and programs.
Model Provides Intuitive Summary Cost/Benefit Results for Technologies and Programs

### SUMMARY RESULTS

#### Analysis Title:
Smart Grid Investment Model Baseline Forecast

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>Annual</th>
<th>Quarterly</th>
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<tbody>
<tr>
<td></td>
<td>5.00%</td>
<td>1.23%</td>
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</table>

#### Project Financial Indicators

- **Net Present Value (NPV, $1,000)**: $34,081
- **Internal Rate of Return (%)**: 17.8%

#### Smart Grid Initiation

- Year: 2010
- Quarter: Q4
- Payback (years): 4

#### Undiscounted Break-even Period

- Year: 2017
- Quarter: Q4
- Payback (years): 7.00

#### Discounted Break-even Period

- Year: 2018
- Quarter: Q4
- Payback (years): 8.00

#### Expenditures and Benefits Over 20 Years ($1,000)

<table>
<thead>
<tr>
<th>Nominal</th>
<th>Discounted</th>
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</thead>
<tbody>
<tr>
<td>Total Capital Expenditures</td>
<td>$36,291</td>
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<tr>
<td>Total O&amp;M Expenditures</td>
<td>$26,167</td>
</tr>
</tbody>
</table>

#### Cost Benefits 2010-2030

- **Meter Reading**
- **Field Services**
- **Outage Restoration**
- **Billing Services**
- **Theft/Tampering**
- **Meter Accuracy Registration**
- **Uncollectibles**
- **Improved Cash Flow**
- **Avoided Power Purchase Charges**
- **Distribution Operations**
- **Other AMI Benefits**
- **Improved Transformer Load Management**

#### Discounted Costs 2010-2030

- **AMI Meters**
- **Meter Installation**
- **Network**
- **AMM Network**
- **IT**
- **DA-Hardware**
- **DLC-hardware**
- **Inpremise-install**
- **Impremise-hardware**
- **DLC-Install**
- **DA-Install**
- **Other**

#### Cumulative Net Benefit

- Years:
  - 2010
  - 2012
  - 2014
  - 2016
  - 2018
  - 2020
  - 2022
  - 2024
  - 2026
  - 2028
  - 2030

- $0
  - $10,000
  - $20,000
  - $30,000
  - $40,000
Example Analysis Requested by a Consortium Member

- Residential programmable thermostat/water heater program
  - Independent communications
  - $1,000 per customer (includes program costs)
- Specific results will vary by utility
  - AC & water heating load profiles
  - Avoided power cost parameters ($/kWh, peak kW charges, etc.)
  - Pricing program incentives
- Example Results

<table>
<thead>
<tr>
<th>Analysis Title</th>
<th>Example SGIM Analysis</th>
</tr>
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<tbody>
<tr>
<td>Discount Rate</td>
<td>Annual: 5.00%</td>
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</table>

Project Financial Indicators
- Net Present Value (NPV, $1,000): $10,656
- Internal Rate of Return (%): 11.4%

- 11.4% internal rate of return (IRR) and 11.5 year discounted payback reflect a marginal program.
- Alternative scenarios can be evaluated to determine impacts of reductions in program costs and/or future increases in power costs.

<table>
<thead>
<tr>
<th>Smart Grid Initiation</th>
<th>Year</th>
<th>Quarter</th>
<th>Payback (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undiscounted Breakeven Period</td>
<td>2022</td>
<td>3</td>
<td>9.50</td>
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<tr>
<td>Discounted Breakeven Period</td>
<td>2024</td>
<td>3</td>
<td>11.50</td>
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Expenditures and Benefits Over 20 Years ($1,000)

<table>
<thead>
<tr>
<th>Total Capital Expenditures</th>
<th>Nominal</th>
<th>Discounted</th>
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<tbody>
<tr>
<td>Total O&amp;M Expenditures</td>
<td>$4,844</td>
<td>$2,811</td>
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<tr>
<td>Total Benefits</td>
<td>$75,756</td>
<td>$39,519</td>
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Detailed Analysis Results are Provided in a Dashboard Worksheet
2012 Consortium Focus

- Work with:
  - Utilities
    - Evaluate SG technologies & applications
    - Develop smart grid strategies
  - Vendors
    - Detail technology cost/benefits
    - Detail applications costs/benefits
    - Differentiate vendor-specific technologies/applications
  - Expand utility membership
Utility SG Investments Observations

- Distribution smart grid investment drivers
  - Cost savings
  - Reliability, power quality
  - Customer satisfaction
  - Preparation for new technologies (DER, PEHV, ?)
  - Environmental

- Barriers to investment
  - Uncertainty over costs and benefits
  - Technology performance/maturity
  - Uncertainty over customer engagement impacts
  - Lack of smart grid “vision”
  - Security, interoperability, resistance to change
  - Ownership-based issues (IOU, coop, public)
Vendor/Industry Observations

- “New Industry” characteristics
  - Only smart meters are approaching maturity
  - Vendors include giants (IBM, Oracle, Siemens, ...) and many start-ups
  - Focus on market share
  - Consolidation beginning

- Vendor struggles
  - Differentiate products and services
  - Motivate utility investments

- Vendor limitations
  - Subjective marketing information
  - Each has limited focus relative to SG universe
  - Limited case study/results
What Value Can University Distribution Research Provide Utilities?

• Traditional role: new technologies applications
• New applications associated with SG
  • Objective analysis/evaluations of important planning, strategy issues
    • Cost/benefits, environmental, economic development, systems analysis, spatial load growth, ...
  • Analysis/software that addresses new requirements/value associated with smart grid:
    • Distribution system analysis/visibility
    • Data analytics: how to manage and use new system data
    • Customer engagement issues
      • Potentials, program design
      • Detailed distribution impacts (feeders, customer level)
        • CVR, PV, PEV, CHP, ...
• Utilities are inclined to support university research
  • Priorities and funding interest vary significantly by utility and utility type
What Value Can University Distribution Research Provide Vendors?

• Traditional role: new technologies development
• New applications associated with SG
  • Association with university projects provides marketing/sales value
  • Establish objectivity utility analysis/evaluation results
  • Extend vendor-specific value to other utility SG value items
  • Differentiate products/services from competitors
  • Provide objective utility/vendor interface
  • Reduce utility-perceived risk
Organizing Research Projects Around Utility Applications Provides Several Advantages

• Utilities can provide in-kind and/or financial project support
• Vendor support is predicated on utility applicability
  • Large vendor sales potential motivates research project participation
• Energy-efficiency and other related interdisciplinary applications areas
  • Water resources, building efficiency, ...
• Potential state agency support (PSC, economic development, ...)
• Federal priority is to encourage utility smart grid development (DOE, FERC, EPA,...)
• Research projects that include SG implementation provide demonstrable financial benefits for utility customers in a well-defined geographic area
An ETown-Type Smart Grid Project Can Be Promoted as a Tool to Avoid Excel’s Smart Grid City Outcome

“SmartGridCity is a technology pilot in Boulder, Colorado that allows us to explore smart-grid tools in a real-world setting. The goal of this pilot is to help determine:
• Which energy-management and conservation tools our customers want and prefer
• Which technologies are the most effective at improving the way we deliver power
• How best to incorporate smart-grid technology into our business operations to improve efficiency, reduce carbon emissions and modernize the energy delivery system
• How to roll out the most promising smart-grid components on a wider scale”
Source: Exel.com

Two Years Later:
“In the past two years, the projected cost of SmartGridCity, a pilot program designed to better manage electricity distribution and give consumers detailed information about their usage, nearly tripled to $44.8 million.

"There is not a clear consensus among the members of the Boulder City Council with regard to the value of SmartGridCity in its present state or the prudence of this investment," the city said in the filing

http://www.denverpost.com August 24, 2010
"Headquartered at The University of Texas at Austin, Pecan Street Inc. is a research and development organization focused on developing and testing advanced technology, business model and customer behavior surrounding advanced energy management systems. Simply put, we’re helping reinvent America’s electric system.

Our flagship effort is the Pecan Street Demonstration, a smart grid research project in Austin’s Mueller community.

The initiative began in 2008 as a community collaboration to spark the nascent “smart grid” market in Austin the way that the MCC and SEMATECH consortia sparked the region’s semiconductor and information technology sectors a generation ago.

Representatives of the founding members – the City of Austin, Austin Energy, The University of Texas, the Austin Technology Incubator, the Greater Austin Chamber of Commerce and Environmental Defense Fund – enlisted the participation of nearly a dozen private companies to explore the technical, economic and policy implications of an energy system that relies on better energy efficiency, locally generated renewable energy and a new economic model for electricity utilities.” pecanstreet.org
Discussion

WVU Utility/SG Vendor R&D Projects Development Issues Discussion