PNM/EPRI Smart Grid Demonstration

High-Penetration Photovoltaics through Grid Automation, Energy Storage and Demand Response

Carla Kay Barlow, PNM
June 23, 2009

Outline

• Project Overview
  – Business problem to be solved
  – PNM’s four use cases and their scenarios
• Our current IntelliGrid step: Use Case & Requirements
  – Lessons learned during workshops
  – Example use cases
  – Anticipated public benefit
• Next Steps
• Questions
Driver: All indicators point to high penetration of solar – an intermittent generation resource

Springerville, AZ:
1 day at 10-second resolution…

…and 7 days at 1-minute resolution

Driver: Solar peaks before we really need it

Profile of typical Summer and Winter peaks for PNM Retail
Project tackles universal issues

- Tests different combinations of several elements:
  - Customer-owned PV, with and without storage
  - Utility-owned PV, with and without storage
  - Both smart and traditional meters
  - Demand response
  - Residential HAN technologies and smart appliances
  - Commercial building controls and HVAC systems
  - Data center/solar integration

- Targets a variety of issues of national interest:
  - Grid stability issues caused by intermittent generation sources
  - Effects of multiplying those sources (e.g. solar @ >15% of feeder capacity)
  - Gap between solar peak and peak demand
  - Interactions of distributed generation, dynamic pricing, demand response, storage
  - Lack of well-defined control systems, communications and security protocols
  - Conservation, efficiency, climate change and aging infrastructure challenges
Other features of interest

• Pragmatic approach divides project into:
  – Quickly achievable first step (substation-based PV and storage)
  – Second, more difficult step that requires standards development and implementation of the smart grid from the substation to the customer.

• Partners include
  – Mesa del Sol, a green-focused mixed-use development already under way
  – Sandia National Labs
  – University of New Mexico and Northern New Mexico College
  – technology vendors

• Project continues Sandia National Labs/PNM Smart Inverter research

• Sandia will employ its DETL facility and focused expertise

• Data analysis will use EPRI’s latest software tools and methods

Outline

• Project Overview
  – Business problem to be solved
  – PNM’s four use cases and their scenarios

• Our current IntelliGrid step: Use Case & Requirements
  – Lessons learned during workshops
  – Example use cases
  – Anticipated public benefit

• Next Steps

• Questions
Lessons learned

• Even at draft stage, use cases have helped PNM:
  – Identify gaps, e.g. Where do price signals originate? How do we deliver them to customer-sited DG and storage?
  – Launch DOE proposal effort. We have an excellent foundation.

• Executive engagement is crucial.
  – Consider the person-hour expense of involving multiple employees.
  – Consider the challenge of motivating all of those employees to not only show up but really dig in. It can be done!

• Stay on topic. Stay on topic. Stay on topic.

• Include your external partners to lend objectivity to the process.

• Invite partners with use-case experience to help the facilitators.

• Don’t let the size of the SCE use cases overwhelm you.
  – See the 4-page template at the Smart Grid Web site for perspective.

And by EPRI, I really mean Brian.

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PNM Completes UCW #1 Note review</td>
<td>5-days</td>
<td>Wed 5/20/0</td>
<td>Tue 5/26/0</td>
</tr>
<tr>
<td>2</td>
<td>Brian G. Completes UCW #1 Notes</td>
<td>5-days</td>
<td>Wed 5/20/0</td>
<td>Tue 5/26/0</td>
</tr>
<tr>
<td>3</td>
<td>PNM Completes UCW #2 note review</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>4</td>
<td>Brian G. Completes UC-1 draft</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>5</td>
<td>PNM completes UC-1 draft review</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>6</td>
<td>Brian G. Completes UC-2 draft</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>7</td>
<td>PNM completes UC-2 draft review</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>8</td>
<td>Brian G. Completes UC-3 draft</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>9</td>
<td>PNM completes UC-3 draft review</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>10</td>
<td>Brian G. completes UC-4 draft</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>11</td>
<td>PNM completes UC-4 draft review</td>
<td>5-days</td>
<td>Wed 6/3/0</td>
<td>Tue 6/9/0</td>
</tr>
<tr>
<td>12</td>
<td>Team begins architecture analysis</td>
<td>30-days</td>
<td>Wed 7/1/0</td>
<td>Tue 7/11/0</td>
</tr>
<tr>
<td>13</td>
<td>Team begins evaluation/technology selection</td>
<td>30-days</td>
<td>Wed 8/1/0</td>
<td>Tue 8/11/0</td>
</tr>
<tr>
<td>14</td>
<td>Technology testing</td>
<td>80-days</td>
<td>Wed 11/4/0</td>
<td>Tue 12/1/0</td>
</tr>
</tbody>
</table>
Example Use Case: Breakdown

UCD-1

Customer Provides PV-Based Generation Source

Scenario 1: Customer provides PV based generation source utilizing existing metering technology to 15% of the feeder capacity

Scenario 2: Customer provides PV based generation source utilizing AMI infrastructure, HAN and two-way communicating inverters that are controllable by PNM to accommodate more than 15% of the feeder capacity

Scenario 3: Customer provides PV based generation source utilizing AMI infrastructure, HAN and two-way communicating inverters that are controllable by PNM to accommodate more than 15% of the feeder capacity

PNM Benefits: Greater operating efficiencies for...

Assumptions: 15% or less PV feeder penetration...

Steps: 1) Customer completes the PNM application...

Functional Requirements: Interconnection process is accessible...

Steps: 1) Customer completes the PNM application...

UCD-2

PNM Benefits: Greater operating efficiencies for...

Assumptions: 15% or less PV feeder penetration...

Steps: 1) Customer completes the PNM application...

Functional Requirements: Interconnection process is accessible...

Southern California Edison provides a wealth of examples

Available via http://www.smartgrid.epri.com/about_repository.html

- Billing & Customer Service
  - B3 - Utility detects tampering or theft at customer site

- Customer Interface
  - C5 – Customer uses smart appliances
  - C6 – Customer uses premise Energy Management System (EMS) or In-Home Display (IHD)
  - C7 – Utility uses SmartConnect data for targeted marketing campaigns
  - C8 – Load Research performs analytics using historical SmartConnect data

- Energy Procurement
  - E1 – Real-time operations curtails/limits load for economic dispatch
  - E2 – Utility procures energy and settles wholesale transactions using SmartConnect data
...and more examples

Delivery
- D3 – Customer provides distributed generation
- D4 – Distribution operator locates outage using SmartConnect data
- D5 – Power system automatically reconfigures for reliability using SmartConnect system
- D6 – Distribution operator controls the distribution system using AMI data
- D8 – Planners perform analytics using historical SmartConnect data
- D13 – Power system automatically triggers FACTS devices using phasor data
- D14 – EMS uses online dissolved gas monitoring to detect emerging failures of transformer banks and take corrective action
- D18 – Utility collects data to determine dynamic rating levels for transmission lines and takes action to optimize throughput

Goal extends beyond PNM (or any host site) to industry-wide learning

- Advanced control algorithms and future standards
- Various optimization criteria:
  - voltage and frequency control
  - peak reduction
  - adaptability to disturbances (e.g. cloud cover, outages, etc.)
  - time-of-use rate structures
- Reduced greenhouse gas emissions through
  - use of renewable resources
  - use of storage to transform intermittent resources into firm peaking resources
- Effectiveness of managed DER, given status quo system expansion as a baseline
- Resulting data and analyses will be available to the industry
Outline

• **Project Overview**
  - Business problem to be solved
  - PNM’s four use cases and their scenarios

• **Our current IntelliGrid step: Use Case & Requirements**
  - Lessons learned during workshops
  - Example use cases
  - Anticipated public benefit

• **Next Steps**

• **Questions**

Next Steps

• Design the architecture
• Identify gaps in requirements and existing systems
• Select technologies
• Begin field testing/deployment
Outline

- **Project Overview**
  - Business problem to be solved
  - PNM’s four use cases and their scenarios
- **Our current IntelliGrid step: Use Case & Requirements**
  - Lessons learned during workshops
  - Example use cases
  - Anticipated public benefit
- **Next Steps**
- **Questions**
Supplements

Responsibilities Matrix

<table>
<thead>
<tr>
<th>Organization</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPRI</td>
<td>• Project management • Industry Interface</td>
</tr>
<tr>
<td></td>
<td>• DOE</td>
</tr>
<tr>
<td></td>
<td>• Standards-making bodies • Other national-level smart-grid efforts • Funding for analytics phase</td>
</tr>
<tr>
<td>Sandia Labs</td>
<td>• EPRI contractor • Modeling • Lab testing • Integration to Mesa del Sol • DOE integration</td>
</tr>
<tr>
<td>UNM</td>
<td>• EPRI contractor • Modeling – comm’l bldg • Lab testing – comm’l bldg</td>
</tr>
<tr>
<td>Northern NM College</td>
<td>• EPRI contractor • Data acquisition, analysis • Substation PV + Storage</td>
</tr>
<tr>
<td>PNM</td>
<td>• EPRI customer • Modeling • Local coordination • Equipment funding coordination • Liaison to State of NM Green Grid Initiative</td>
</tr>
<tr>
<td>Vendors</td>
<td>• NDA w/EPRI</td>
</tr>
<tr>
<td>Mesa del Sol</td>
<td>• PNM customer • Equipment funding target</td>
</tr>
</tbody>
</table>
Schedule aligns with other funding initiatives

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Generic Timeline, expected to commence within 90 days of award</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use Case and Specifications</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>2</td>
<td>Modeling</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>3</td>
<td>Unit Testing</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>4</td>
<td>Field Demo</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>5</td>
<td>Cost/Benefit Analysis</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>6</td>
<td>Install</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>7</td>
<td>Field Demo</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
<tr>
<td>8</td>
<td>Cost/Benefit Analysis</td>
<td><img src="image" alt="Timeline" /></td>
</tr>
</tbody>
</table>
**DETL is centerpiece of Sandia effort**

- Configurable test bed where new hardware integrations can be tested and optimized
- Simulation of daily load profiles for several different microgrids:
  - Single residence w/multiple loads
  - Multiple residences
  - ≥ 1 commercial buildings
  - A mix of the above (non-balanced loads)
- Added generators and motor loads help simulate real-world situations

*Sandia’s Distributed Energy Technologies Lab*

**Associated Projects**

- **Zero Energy Solar Photovoltaic Housing Development (ZESPHD) – DOE Solar Showcase**
  - Awarded by DOE in 2008
  - Tiger Team is being led by Sandia National Labs
  - Funds the study of up to 750 kW of Solar on the first 300 homes at Mesa Del Sol
- **EPRI/PNM/SNL Supplemental**
  - Distribution scale new tech battery with PV and external input signal
  - Shift PV output 2 hours based on external signal to inverter
  - Drafting test plan - Sandia Labs DETL Facility
  - Other interested parties
  - Funding will determine size/duration of test
- **DOE SEGIS & SEGIS-ES**
  - Link through Sandia Labs
Customer perspective: PV works

<table>
<thead>
<tr>
<th>Date</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/07/2006</td>
<td>$15.00</td>
</tr>
<tr>
<td>3/02/2007</td>
<td>$2.54</td>
</tr>
<tr>
<td>2/05/2007</td>
<td>$2.75</td>
</tr>
<tr>
<td>9/05/2006</td>
<td>$29.35</td>
</tr>
<tr>
<td>8/04/2006</td>
<td>$31.97</td>
</tr>
<tr>
<td>7/05/2006</td>
<td>$32.24</td>
</tr>
<tr>
<td>6/05/2006</td>
<td>$30.13</td>
</tr>
<tr>
<td>5/02/2006</td>
<td>$30.32</td>
</tr>
</tbody>
</table>