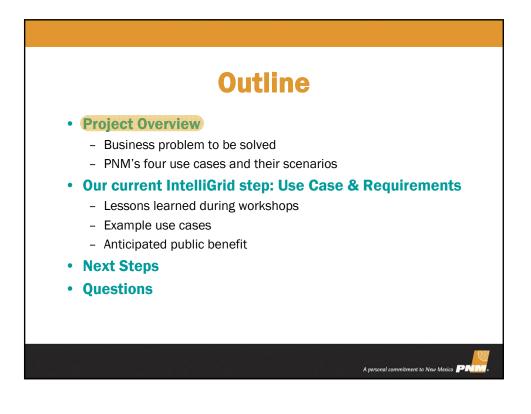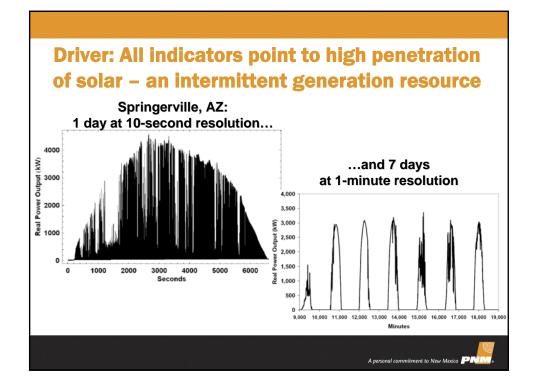# PNM/EPRI Smart Grid Demonstration

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

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Driver: Solar peaks before we really need it

Profile of typical Summer and Winter peaks for PNM Retail

Summer Peak Day — Winter Peak Day — Summer DNI

On-Peak Period

Hour MST

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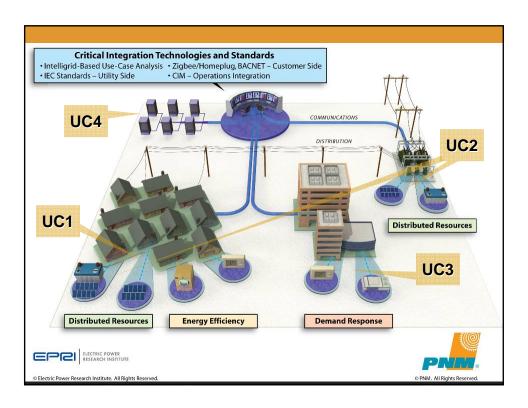
Project tackles universal issues

- **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

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Critical Integration Technologies and Standards
- Intelligrid-Based Use-Case Analysis
- IEC Standards – Utility Side
- Zigbee/Homeplug, BACNET – Customer Side
- CIM – Operations Integration

UC4

COMMUNICATIONS

DISTRIBUTION

UC2

UC1

Distributed Resources

UC3

Distributed Resources

Energy Efficiency

Demand Response

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

PNM®

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**

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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.

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EPRI does a <u>lot</u> for you.

And by EPRI, I really mean Brian.

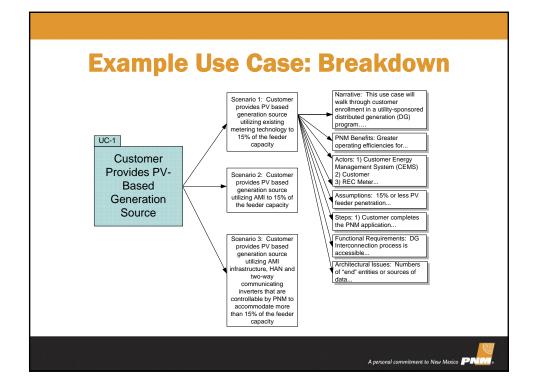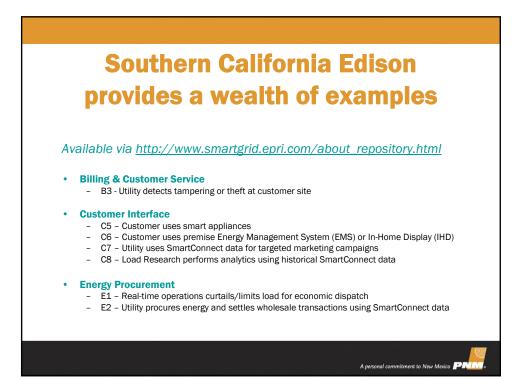| ID		Task Name	Duration	Start	Finish	May 17, '09			Jun 14, '09		Jul 12, '09		
						M	F	T	S	W	S	T	M
1		PNM Completes UCW #1 Note review	5 days	Wed 5/20/09	Tue 5/26/09								
2		Brian G. Completes UCW #2 notes	5 days	Wed 5/20/09	Tue 5/26/09								
3		PNM Completes UCW #2 note review	5 days	Wed 5/27/09	Tue 6/2/09								
4		Brian G. Completes UC-1 draft	5 days	Wed 5/27/09	Tue 6/2/09								
5		PNM completes UC-1 draft review	5 days	Wed 6/3/09	Tue 6/9/09								
6		Brian G. Completes UC-2 draft	5 days	Wed 6/3/09	Tue 6/9/09								
7		PNM completes UC-2 draft review	5 days	Wed 6/10/09	Tue 6/16/09								
8		Brian G. Completes UC-3 draft	5 days	Wed 6/10/09	Tue 6/16/09								
9		PNM completes UC-3 draft review	5 days	Wed 6/17/09	Tue 6/23/09								
10		Brian G. completes UC-4 draft	5 days	Wed 6/17/09	Tue 6/23/09								
11		PNM completes UC-4 draft review	5 days	Wed 6/24/09	Tue 6/30/09								
12		Team begins achitecture analysis	30 days	Wed 7/1/09	Tue 8/11/09								
13		Team begins evaluation/technology selection	60 days	Wed 8/12/09	Tue 11/3/09								
14		Technology testing	60 days	Wed 11/4/09	Tue 1/26/10								

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Example Use Case: Breakdown

UC-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 to 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

Narrative: This use case will walk through customer enrollment in a utility-sponsored distributed generation (DG) program….

PNM Benefits: Greater operating efficiencies for...

Actors: 1) Customer Energy Management System (CEMS) 2) Customer 3) REC Meter...

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

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

Functional Requirements: DG Interconnection process is accessible...

Architectural Issues: Numbers of "end" entities or sources of data...

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
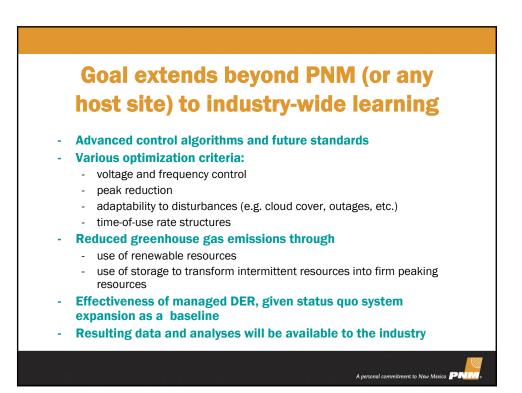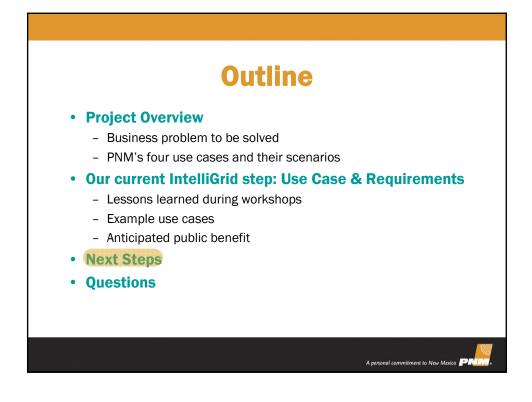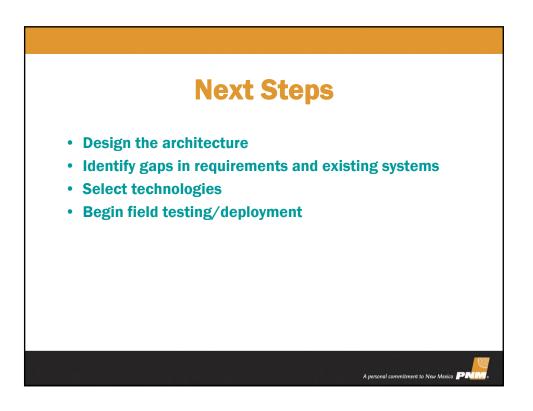
...and more examples

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

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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**

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Next Steps

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

Sample Sequence Diagram

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Supplements

Responsibilities Matrix

EPRI
- Project management
- Industry Interface
  - DOE
  - Standards-making bodies
  - Other national-level smart-grid efforts
- Funding for analytics phase

Sandia Labs
- EPRI contractor
- Modeling
- Lab testing
- Integration to Mesa del Sol
- DOE integration

UNM
- EPRI contractor
- Modeling – comm'l bldg
- Lab testing – comm'l bldg

Northern NM College
- EPRI contractor
- Data acquisition, analysis
- Substation PV + Storage

PNM
- EPRI customer
- Modeling
- Local coordination
- Equipment funding coordination
- Liaison to State of NM Green Grid Initiative

Vendors
- NDA w/EPRI

Mesa del Sol
- PNM customer
- Equipment funding target

Schedule aligns with other funding initiatives

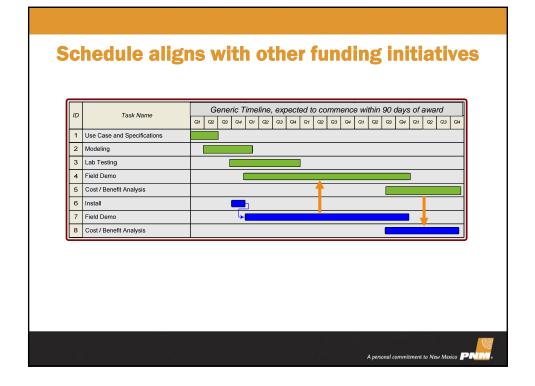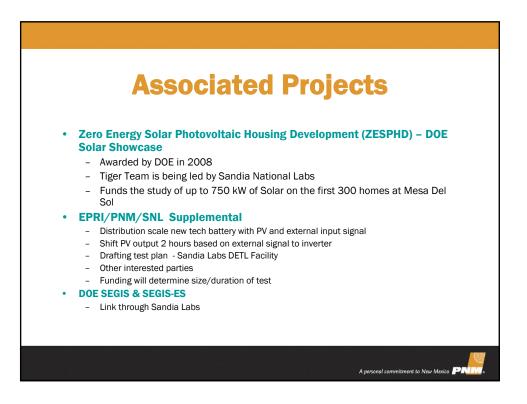| ID	Task Name	Generic Timeline, expected to commence within 90 days of award																		
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Use Case and Specifications																				
2	Modeling																				
3	Lab Testing																				
4	Field Demo																				
5	Cost / Benefit Analysis																				
6	Install																				
7	Field Demo																				
8	Cost / Benefit Analysis																				

Mesa del Sol Master Plan

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

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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

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Customer perspective: PV works

Account name: CARLA BARLOW
Account number: [redacted]
Service address: [redacted]
                  ALBUQUERQUE, NM 87102-2934

Your most recent payments	
Date	**Amount**
3/07/2008	$15.00
3/02/2007	$2.54
2/05/2007	$2.75
9/05/2006	$29.35
8/04/2006	$31.97
7/05/2006	$32.24
6/05/2006	$30.13
5/02/2006	$30.32