PNM/EPRI Smart Grid Demonstration

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

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PNM

October 12, 2009

Outline

- PNM Background
- Demo Background
  - RPS drivers
- Describe Use Cases
- Describe Use Case Sequence Diagrams
- Describe PNM ESB/AMI
- Gap Analysis
  - Technology
  - Functional
  - Policy
- Lessons Learned
- Describe Architectural Vision – IKB Tool output
- Questions

PNM Resources

- Serving 859,000 customers in NM and TX
- Regulated by NMPRC and TX Utility Commission
- 2,717 MW of generation

Project tackles numerous goals

- Data and results will help quantify and define requirements to create firm renewable resources - enabling high penetration of distributed resources and reduced greenhouse gas emissions
- Results will directly support a nationwide effort to develop the next-generation utility system to further the understanding of critical integration technologies and standards for renewables and energy efficiency
- Targets a minimum of 15 percent peak-load reduction at a specific feeder through a combination of substation-sited and residential PV and storage

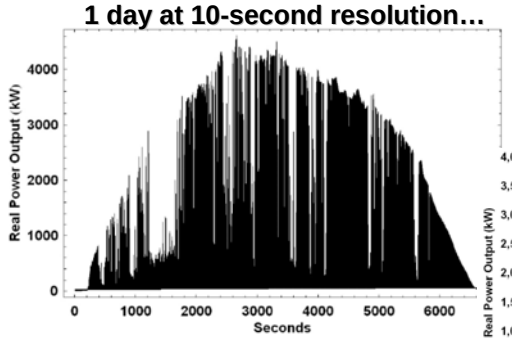
Project tackles universal issues

- **Tests different combinations of several elements:**
  - Customer-owned PV, with and without storage
  - Utility-owned PV with 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

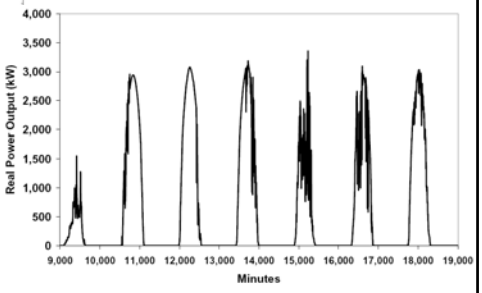
Driver: All indicators point to high penetration of solar – an intermittent generation resource

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



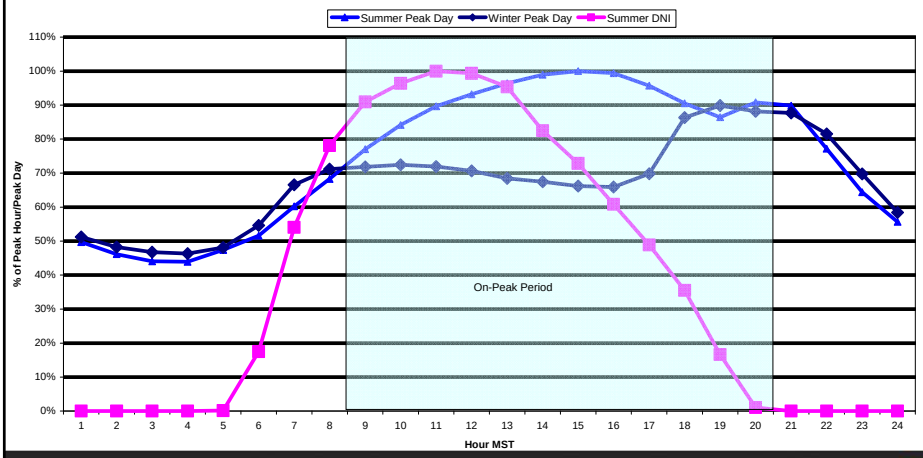
Data source: EPRI/ Jay Apt and Aimee Curtright"The Spectrum of Power from Utility-Scale Wind Farms and Solar Photovoltaic Arrays", Carnegie Mellon Electricity Industry Center Working Paper, CEIC-08-04

…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



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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

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

Northern NM College
- PNM/NNMC RA
- Data acquisition, analysis

Vendors
- NDA w/EPRI

Mesa del Sol
- PNM customer
- Equipment funding target

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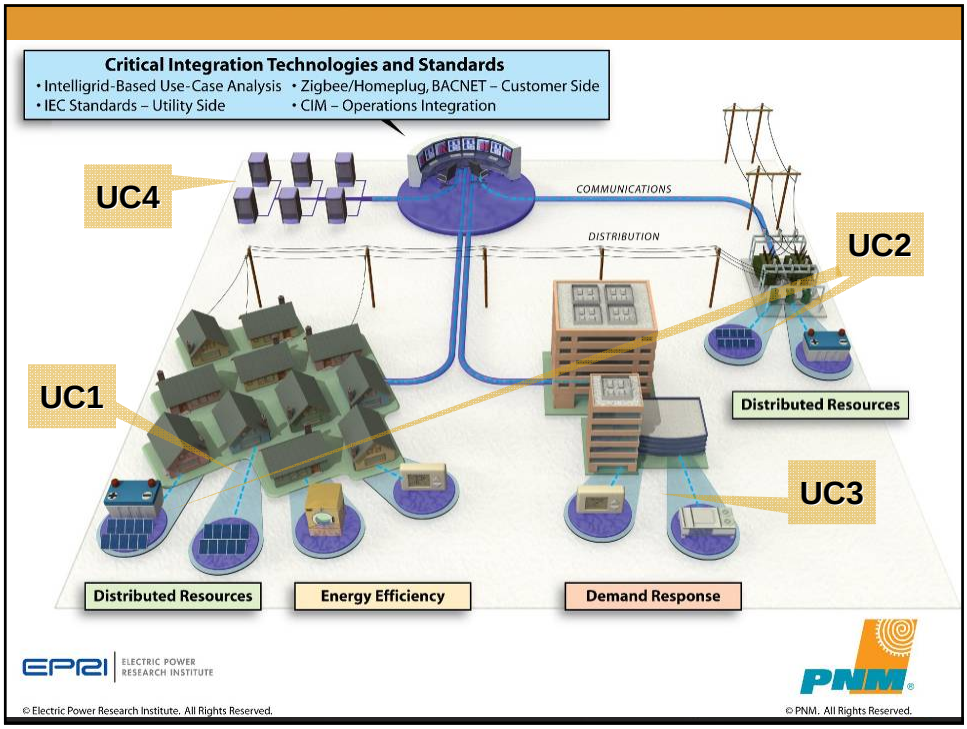

PNM Use Cases and Scenarios

- **UC 1 – Customer provides PV based resource**
  - Utilize existing metering to 15% feeder capacity
  - Utilize AMI to 15% feeder capacity
  - Utilize AMI, HAN, PNM controlled inverters
- **UC 2 – Utility and/or customer provides electrical energy storage in conjunction with PV**
  - Customer uses AMI, dynamic pricing and storage to optimize costs
  - Utility uses storage to mitigate adverse voltage issues associated with PV
- **UC3 – Customer implements demand response (DR) and responds to DR signal from Utility**
  - Utility responds to a variety of drivers and sends dynamic pricing signal to induce peak shaving
  - Utility responds to a variety of drivers and sends dynamic pricing signal to induce reliability based response
- **UC 4 – Utility implements integrated management of Distributed Energy Resources (DER – includes DG, DR and storage)**
  - Utility monitors and manages feeder voltage
  - Utility uses DER to address peaking requirements
  - Utility uses DER to address transmission constraint

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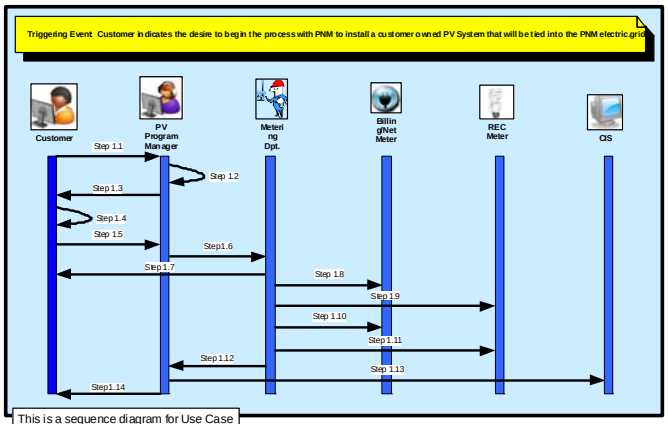
PNM UC 1 - Customer provides PV-based resource

S1 - Utilize existing metering to 15% feeder capacity



This is a sequence diagram for Use Case 1 Scenario 1. Timing for the events described in this scenario begins at the top left of the picture with the Customer (Step 1.1) and flows down, ending with Step 1.14.

Use Case 1 Scenario 1

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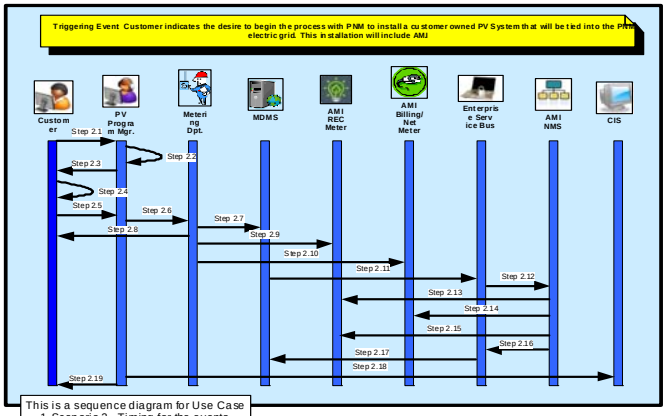
PNM UC 1 - Customer provides PV-based resource

S2 - Utilize AMI to 15% feeder capacity



This is a sequence diagram for Use Case 1 Scenario 2. Timing for the events described in this scenario begins at the top left of the picture with the Customer (Step 2.1) and flows down, ending with Step 2.19.

Use Case 1 Scenario 2

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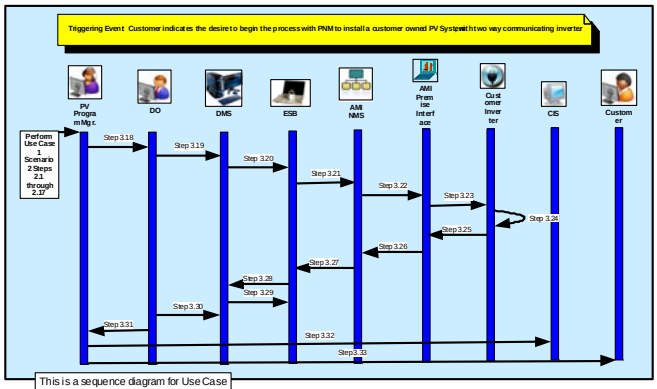
PNM UC 1 - Customer provides PV-based resource

S3 - Utilize AMI, HAN, PNM controlled inverters



This is a sequence diagram for Use Case 1 Scenario 3. Timing for the events described in this scenario begins at the top left of the picture with the successful completion of Use Case 1 Scenario 2 Steps 2.1 through 2.17 and flows down, ending with Step 3.33.

Use Case 1 Scenario 3

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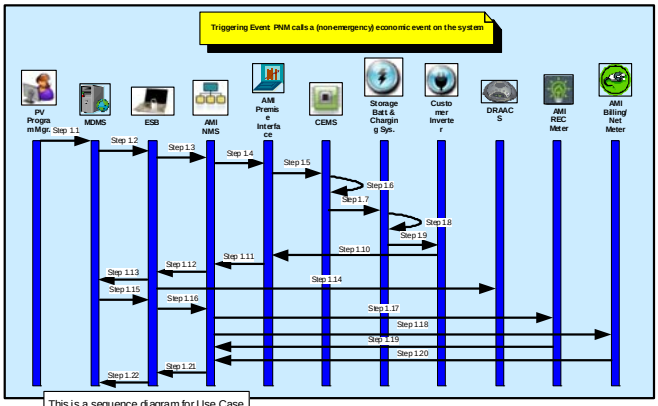
PNM UC2 - Utility and/or customer provides electrical energy storage in conjunction with PV

S1 - Customer uses AMI, dynamic pricing and storage to optimize costs



This is a sequence diagram for Use Case 2 Scenario 1. Timing for the events described in this scenario begins at the top left of the picture with the PV Program Manager (Step 1.1) and flows down, ending with Step 1.22.

Use Case 2 Scenario 1

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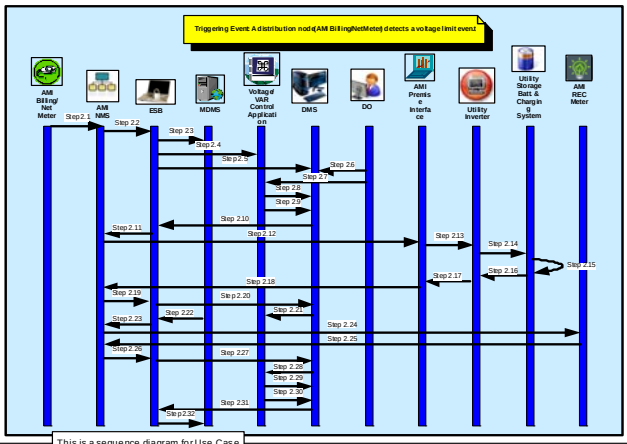
PNM UC2 - Utility and/or customer provides electrical energy storage in conjunction with PV

S2 - Utility uses storage to mitigate adverse voltage issues associated with PV



This is a sequence diagram for Use Case 2 Scenario 2. Timing for the events described in this scenario begins at the top left of the picture with the AMI Billing / Net Meter (Step 2.1) and flows down, ending with Step 2.32.

Use Case 2 Scenario 2

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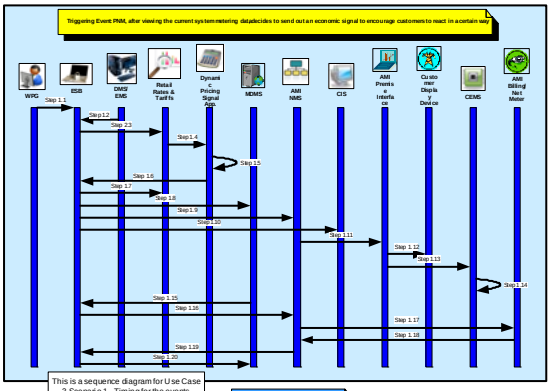
PNM UC3 - Customer implements demand response (DR) and responds to DR signal from Utility

S1 - Utility responds to a variety of drivers and sends dynamic pricing signal to induce peak shaving



This is a sequence diagram for Use Case 3 Scenario 1. Timing for the events described in this scenario begins at the top left of the picture with the Wholesale Power Group (WPG) (Step 1.1) and flows down, ending with Step 1.20.

Use Case 3 Scenario 1

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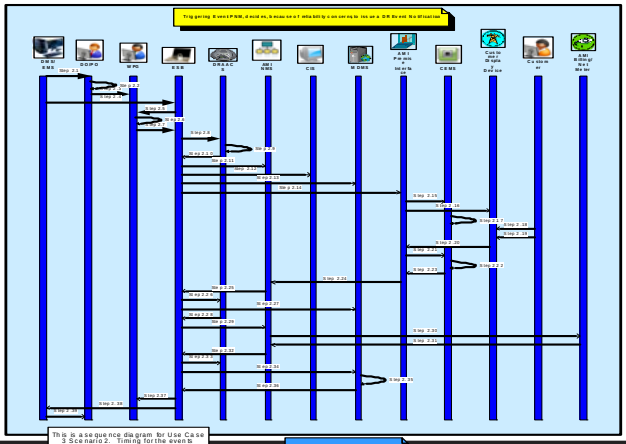
PNM UC3 - Customer implements demand response (DR) and responds to DR signal from Utility

S2 - Utility responds to a variety of drivers and sends dynamic pricing signal to induce reliability based response



This is a sequence diagram for Use Case 3 Scenario 2. Timing for the events described in this scenario begins at the top left of the picture with the DMS/EMS (Step 2.1) and flows down, ending with Step 2.39.

Use Case 3 Scenario 2

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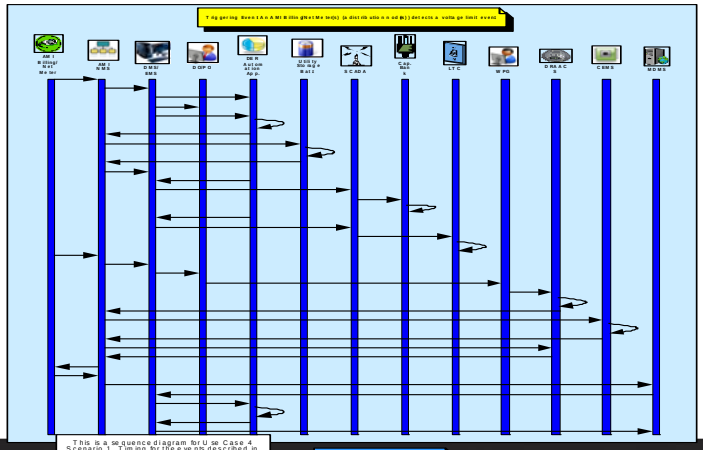
PNM UC4 - Utility implements integrated management of Distributed Energy Resources (DER includes DG, DR and storage)

S1 - Utility monitors and manages feeder voltage



This is a sequence diagram for Use Case 4 Scenario 1. Timing for the events described in this scenario begins at the top left of the picture with the AMI Billing Network Meter and flows down to the bottom of the diagram, ending with the information exchange between the DMS/EMS and the MDMS. Due to the number of steps in this scenario some of the steps have been omitted from the diagram.

Use Case 4 Scenario 1

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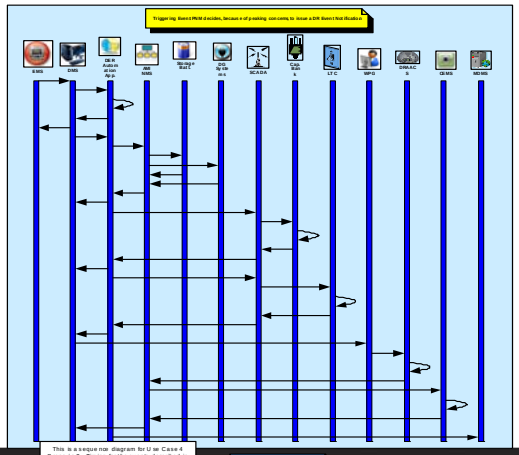
PNM UC4 - Utility implements integrated management of Distributed Energy Resources (DER includes DG, DR, storage)

S2 - Utility uses DER to address peaking requirements



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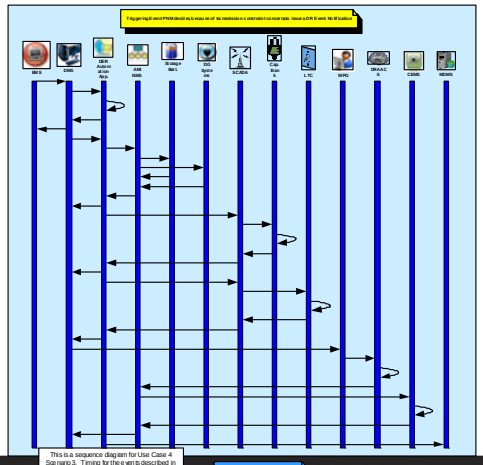
PNM UC4 - Utility implements integrated management of Distributed Energy Resources (DER includes DG, DR, storage)

S3 - Utility uses DER to address transmission constraint



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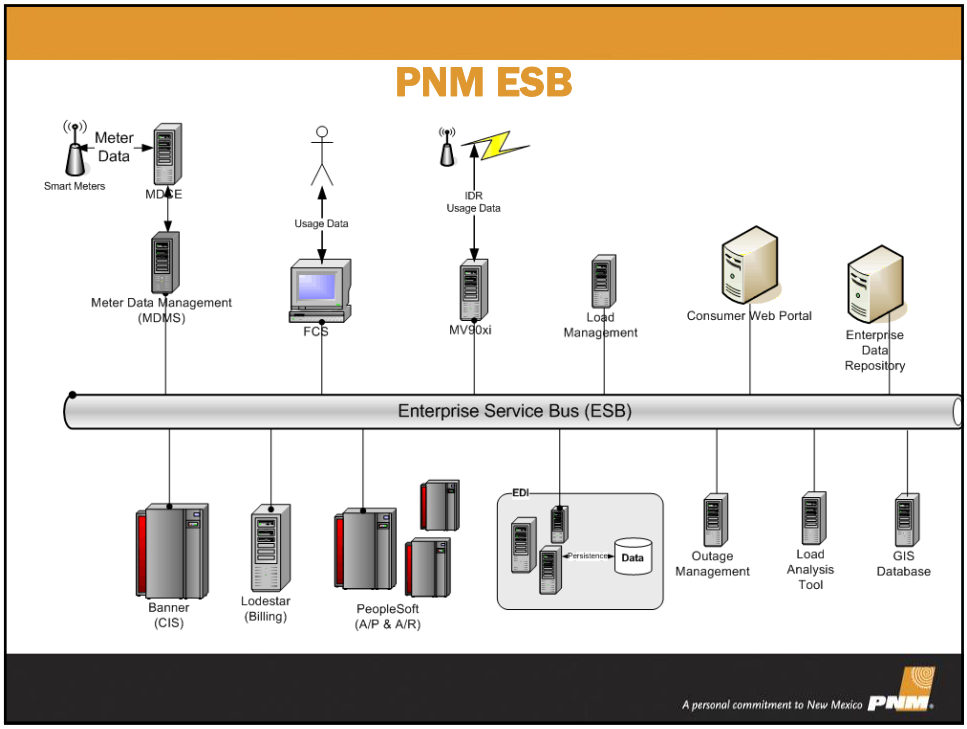
PNM ESB
Meter Data
Smart Meters
MDCE
Usage Data
IDR Usage Data
Meter Data Management (MDMS)
FCS
MV90xi
Load Management
Consumer Web Portal
Enterprise Data Repository
Enterprise Service Bus (ESB)
Banner (CIS)
Lodestar (Billing)
PeopleSoft (A/P & A/R)
EDI
Persistence
Data
Outage Management
Load Analysis Tool
GIS Database
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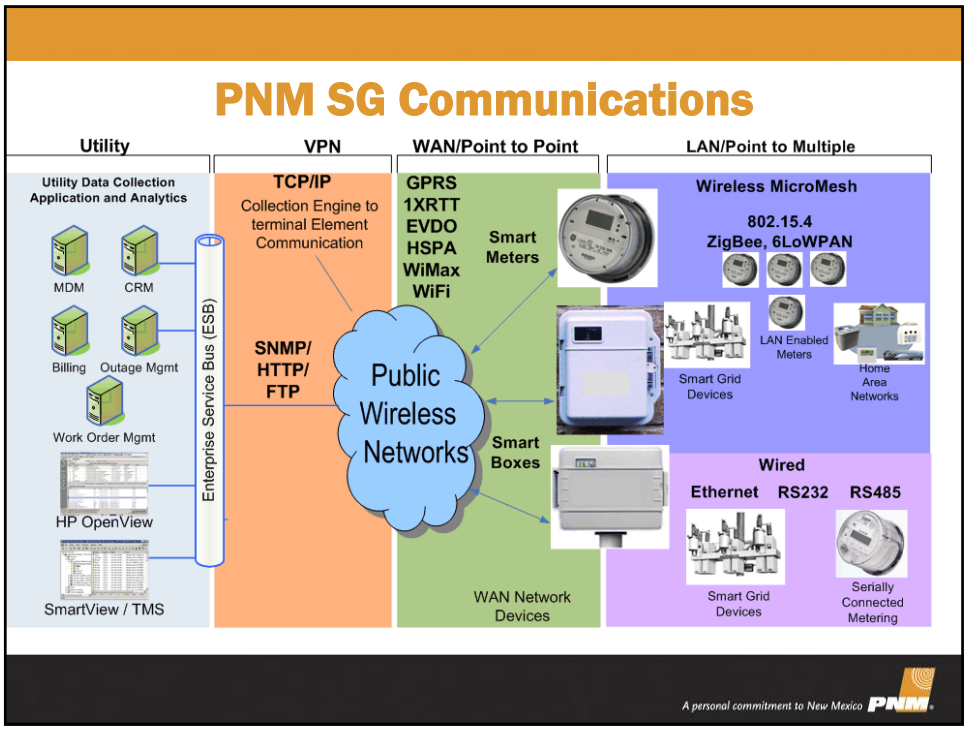
PNM


PNM SG Communications
Utility
VPN
WAN/Point to Point
LAN/Point to Multiple
Utility Data Collection Application and Analytics
MDM
CRM
Billing
Outage Mgmt
Work Order Mgmt
HP OpenView
SmartView / TMS
Enterprise Service Bus (ESB)
TCP/IP
Collection Engine to terminal Element Communication
SNMP/ HTTP/ FTP
Public Wireless Networks
GPRS
1XRTT
EVDO
HSPA
WiMax
WiFi
Smart Meters
Smart Boxes
WAN Network Devices
Wireless MicroMesh
802.15.4
ZigBee, 6LoWPAN
LAN Enabled Meters
Smart Grid Devices
Home Area Networks
Wired
Ethernet
RS232
RS485
Smart Grid Devices
Serially Connected Metering
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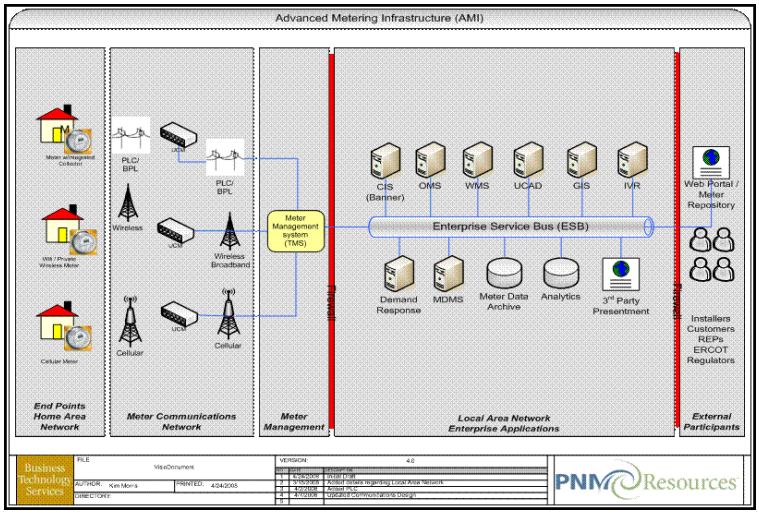
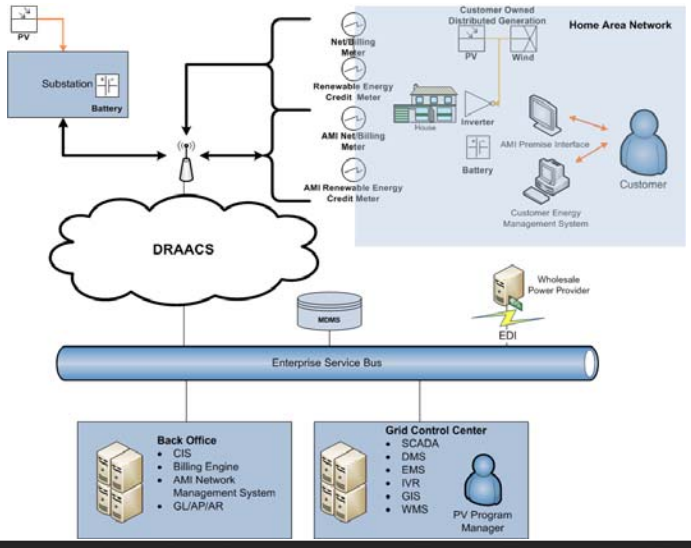
PNM AMI



PNM Use Case Architecture



Gap Analysis - Technology

Functional Requirement	Identified Gap
• Technology - AMI; how to measure RECs with storage	• Placement of the REC meter has to be thought out carefully with a battery involved; DC measurement of RECs not allowed
• Voltage/VAR application shall track LTC and capacitor bank control actions (counts).	• This is a key benefit measurement – limiting these actions in the face of high-penetration PV

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Gap Analysis - Technology

Functional Requirement	Identified Gap
• Battery storage technology shall respond fast enough and with sufficient duration to mitigate LTC operations due to PV ramp rate	• Key benefit needed from battery – ability to do smoothing <u>and</u> arbitrage/peak shifting – what portion of battery capacity is dedicated to each function? What are battery control algorithms?
• DRAACS has the capability to send out DR event notification to customers via AMI NMS and the AMI Premises Interface	• Implies a parallel control system to current SCADA?

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Gap Analysis – Functional

Functional Requirement

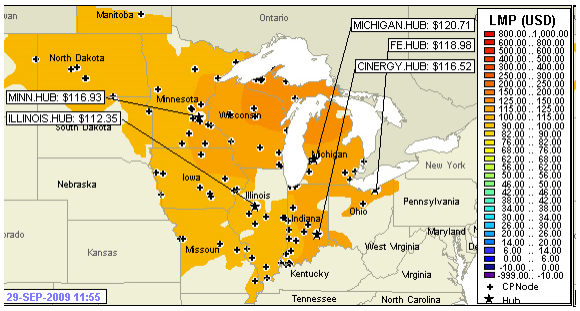
- DRAACS shall retrieve data from MDMS via AMI Infrastructure to determine effectiveness of economic signal response
- PV Program Manager may create economic signal (Day ahead, RT, TOU, etc)

Identified Gap

- Substantial development needed to fit DRAACS into current Dist Ops environment – do they make economic dispatch decisions?
- What factors into this signal: combination of wholesale, transmission reliability, distribution reliability?

Gap Analysis – Functional
Real Time Pricing Models

- Existing ISO Models
- OASIS EMIX in NIST Roadmap



Gap Analysis – Functional

Functional Requirement	Identified Gap
• Retail Rates and Tariffs is capable of retrieving information from the Wholesale Power Group	• The available information isn't really true market real time pricing – WECC has no ISO. New systems will have to be put in place to disseminate
• Retail Rates and Tariffs is capable of processing information and producing dynamic pricing	• Will need information from a lot of places to produce pricing signal - also may be different prices in different parts of the system

Gap Analysis – Functional

Functional Requirement	Identified Gap
• Distribution Operations/Power Operations has the ability to notify Wholesale Power Group of the need for a DR event	• These groups don't currently interact – may point to a different, new group that doesn't exist in the utility structure

Gap Analysis - Policy

Functional Requirement	Identified Gap
• REC meter only allows power to flow one direction (out)	• Relates to battery incorporated systems – what are implications of not permitted? grid charging?
• Wholesale Power Group has the capability to review the information from the DMS/EMS and create a DR event	• WPG may not be the right name – new group involved? Would this group be under federal and state jurisdiction?
• Customer shall have the capability to override DR event via CEMS and/or Customer Display	• What penalties should be in place? Should they be different if DR event is reliability rather than economic based?

Some of the many lessons learned

- **Modeling will be critical**
  - Little is known or tested on battery control algorithms
  - DG placed at end of feeder vs. beginning of feeder could exhibit very different behaviors
  - Models need to be calibrated on the front end for acceptance
  - Lots of data will be needed to validate front and back ends of modeling effort
- **Functional/org structure issues have to be raised as SG architecture is developed.**
  - Groups/functions will need to be in place and staffed that don't exist now
  - These are costs that have to be identified along with equipment costs
- **Technology gaps and incumbent architecture need to be displayed to industry from a non-silo'd perspective**
  - Architecture needs to incorporate NIST and align with other demo projects

Some of the many lessons learned

- **Alignment to NIST**
  - Given the parallel efforts in the industry, we may need to go back to our use cases and update them. For example, the EPRI report to NIST for the Interoperability Roadmap discusses a "DMS" actor that includes distribution automation, demand response, distributed energy, and PHEVs. These are separate actors in the PNM use cases (e.g. DRAACS).