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Residential Smart-Grid Distributed Resources

Sharp Overview for EPRI Smart Grid Advisory Meeting

Carl Mansfield (cmansfield@sharplabs.com)

Sharp Laboratories of America, Inc.

October 12, 2009

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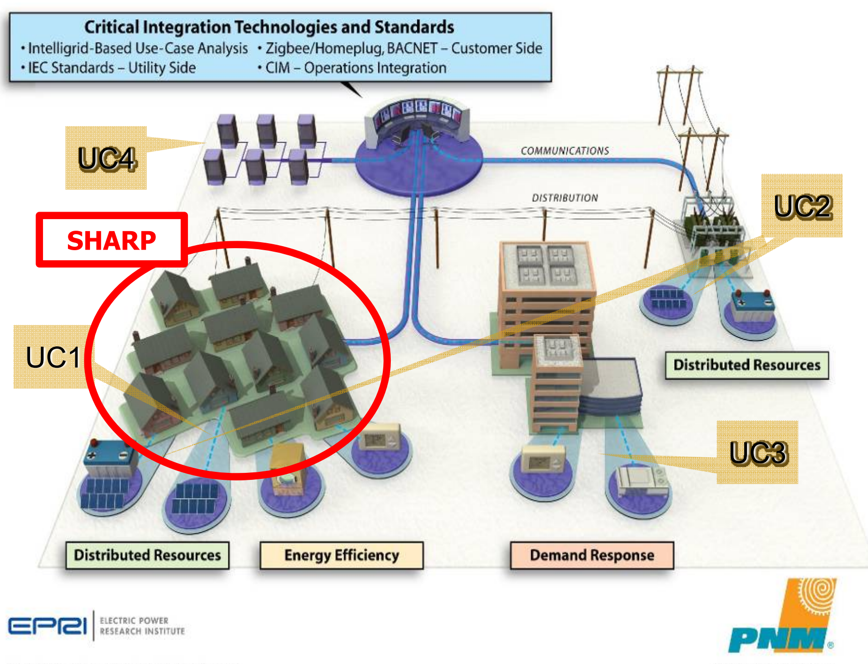
Sharp's Role in PNM's Smart Grid Project

- Sharp is leading development and deployment of the residential systems for PNM's project
- Approximately 100 smart-grid enabled residences targeted
- Significant field testing of a variety of scenarios in support of PNM use cases 1, 2, 3
  - UC1: Customer provided PV resource
  - UC2: Customer provides PV+storage
  - UC3: Customer implements demand response
- Residential systems will also be integrated into PNM use case 4



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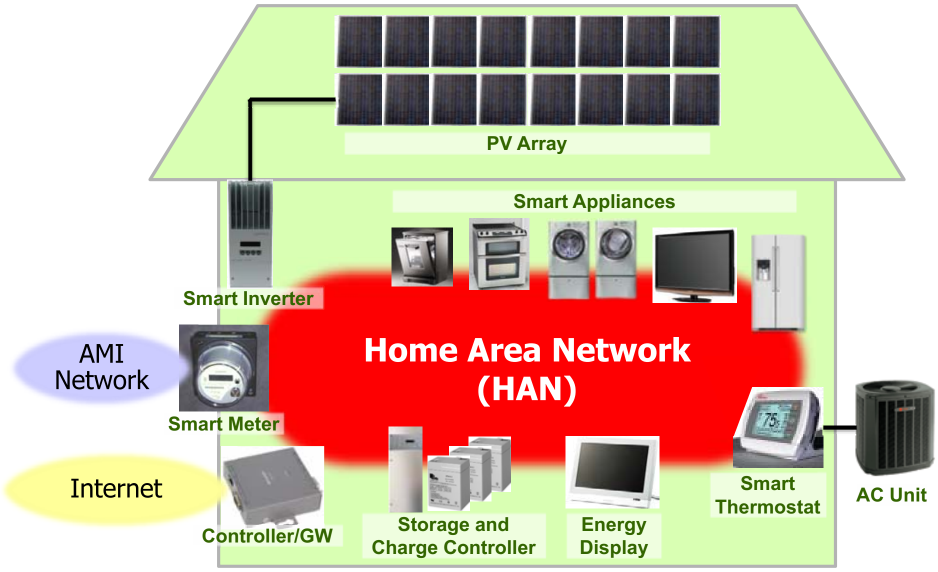
Smart-Grid Residence



- PV (2-5kW)
- Storage (5-20kWh)
- Smart Meter
- Smart thermostat
- Smart Appliances
- Energy Controller/HAN
- Energy display
- Internet Connected

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Residential Project Objectives

- Investigate **grid impact** of high penetration PV (leverage commercial/utility PV)
- Experiment with advanced schemes to **mitigate observed adverse grid impacts**
- Assess **economic models** for proposed systems and methods
- Assess **consumer acceptance** of proposed systems and methods
- Facilitate maturing of **necessary technology and standards**

Sharp's Proposed Approach

Baseline System
- Capture PV system performance data
- Correlate against PNM distribution grid performance data from DMS/SCADA

Smart-Grid System
- Deploy "controls" leveraging storage and load management
- Correlate against (improved) distribution grid performance data

Advanced System (A)
- Assess community-wide control and optimization schemes

Advanced System (B)
- Assess adv. inverter controls
- Lab and test-bed setting only

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Target Methods

Deployable Methods

Residential System Controls

- PV transient smoothing using battery
- PV transient smoothing by load management
- PV/system disconnection (isolation)
- Load shifting (and grid support) using battery
- Load shifting using smart appliances
- Peak load reduction using utility generated events or pricing incentives

Community Based Controls

- Aggregate control of PV transient effects
- Forecasting and predictive controls
- Inhomogeneous control methods

Undeployable Methods (Lab)

Advanced Inverter techniques

- Grid voltage support
- Unintentional inverter trip due to transients
- Reactive power control
- Islanding control

Modeling and Simulation

Significant modeling efforts

- Alternate grid site models
- Very high penetration PV models
- Advanced inverter deployment models

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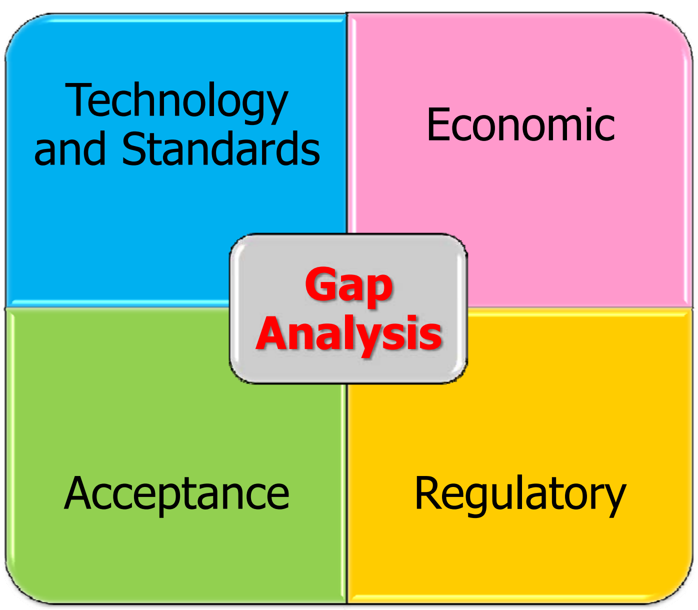
Gap Analysis



- Gaps for success of these systems are not solely technical
- Our efforts will address gaps in four distinct categories

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Technical and Standards Gaps (1/2)

Home Area Network

Requirement
- Standardized HAN protocol
- Certification and branding
- Reliable, secure coverage
- Profiles defined supporting HEMS and utility required energy applications
- Low cost
- Future proof

Key Gaps
- SE1.0 (now): lacks key features (only simple metering; no support for gateway, storage, inverter)
- SE1.5 (1/10): an interim solution; deployment unclear
- SE2.0 (3/11): ambitious re-write (IP-based) – delay likely
- Coverage performance

Project Approach
- Extend SE1.0 to support storage, inverter, gateway
- Promote developed solutions for standards adoption
- Verify coverage performance in field
- Adapt to emerging SE2.0 when possible (field SW upgrade)

Utility to Residence Interface

Requirement
- Standardized protocol
- Reliable, secure, low cost
- Flexible: support for control, monitoring, influencing of distributed energy resources
- Integrate with utility systems

Key Gaps
- No standardized solution
- Two architectures possible:
  (1) AMI-based
  (2) Web/IP based
- No common utility DMS, AMI or EMS system architecture

Project Approach
- Support and evaluate both architectural approaches:
  (1) AMI-based
  (2) Web/IP-based
- Support EPRI efforts to define DER communications standards
- No DMS/EMS integration

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Technical and Standards Gaps (2/2)

Battery System Architecture

Requirement
- Use of battery for transient reduction and peak shaving

Key Gaps
- Two architectures possible:
  (1) PV/inverter integrated storage with DC Bus architecture
  (2) Separated Battery/charge controller system & PV/inverter system
- Optimum approach for speed & efficiency

Project Approach
- Support and evaluate both architecture approaches
- Evaluate performance and cost of each approach
- Develop advanced control schemes

System Complexity

Requirement
- Aggregate controls preferred by utility (avoid individualized control of each house)

Key Gaps
- No established aggregation methods to realize virtual power plant
- Hierarchical system approaches not defined

Project Approach
- Develop aggregation schemes to present simplified neighborhood control schemes to PNM

Advanced Inverter Interconnect

Requirement
- Ability to support:
  (1) voltage regulation
  (2) Reactive power
  (3) Islanding

Key Gaps
- UL1741 and IEEE1547 do not permit deployment of these schemes

Project Approach
- Evaluate advanced schemes in lab and test-bed; build into models and simulations
- Monitor IEEE/UL development and deploy if feasible

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Economic Gaps

Battery and PV Cost

Key Gaps/Uncertainties
- Battery costs high
- Impact of battery cycling on battery performance, lifetime and economics
- PV costs high; impact of storage on PV economic models uncertain

Project Approach
- Evaluate lifetime of battery systems and impact of battery economics
- Compare alternate battery technologies
- Develop economic models and project target battery/system costs for successful deployment

Utility Value

Key Gaps/Uncertainties
- Economic value of "PV transient reduction" for utility is unclear
- Utility cost savings of peak load reduction and peak shifting are unclear

Project Approach
- Evaluate merits of PV transient reduction and load shifting by analyzing PNM DMS data
- Develop value models in collaboration with PNM

Incentive Structures

Key Gaps/Uncertainties
- Necessary incentive structures to establish effective consumer demand response are uncertain
- Incentives necessary for consumer to provide grid support are unknown

Project Approach
- Evaluate various dynamic energy tariff structures (RTP, CPP, TOU)
- Evaluate consumer response to contracted incentive schemes with utility
- Evaluate efficacy of consumer EM services

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Acceptance Gaps

Ease of Use

Key Gaps/Uncertainties
- Optimized user interface to maintain interest and participation
- Impact of format and presentation of data on system efficacy unknown
- Behavior of consumer demographic groups on system efficacy unknown

Project Approach
- Leverage Sharp's strong consumer-facing and display system expertise to design easy to use and high value systems
- Evaluate impact of various approach on participation
- Evaluate consumer centric energy management services to enhance value and ease of use

Lifestyle

Key Gaps/Uncertainties
- Optimized approach to provide consumer with "illusion of control" is unclear
- Efficacy and acceptance of mandatory versus opt-in schemes needs confirmation

Project Approach
- Design system and services offered to provide consumer control, configuration and override
- Evaluate incentive schemes to maximize voluntary consumer participation without complaint

Societal

Key Gaps/Uncertainties
- Impact of societal pressures on level of acceptance and participation are uncertain

Project Approach
- Considering development of community based performance metrics and evaluation on consumer acceptance and participation levels

Regulatory Gaps

	Key Gaps/Uncertainties	Project Approach
Rates	▪ Public Utility Commission acceptance and support for dynamic pricing schemes is variable and uncertain	▪ Evaluate experimental rate plans and leverage project performance data to promote necessary regulatory change and approvals
Mandates	▪ Regulatory mandates requiring implementation of smart energy in appliances may be required for widespread adoption	▪ None
Incentives	▪ Incentive schemes rewarding adoption of storage and grid support functionality may be required for widespread adoption	▪ Economic modeling performed by the project will identify potential cost-benefit gaps which could be addressed by appropriate incentive schemes

Project Partners and Schedule

Five year project recently proposed to DOE, response pending

2009 | 2010 | 2011 | 2012 | 2013 | 2014

Modeling and Simulation

Tech Transfer

Lab Tests (Sharp, Sandia) | Showcase Homes (MdS) | Stage 1 deployment (MdS) | Stage 2 deployment (MdS)

Main DOE Objectives

- Field deploy high penetration PV
- Gather >1 year field data
- Assess distribution grid impact
- Field verify schemes to mitigate adverse grid impact
- Create models to assist utility DER integration planning

Strong collaborative team has been assembled

Residential Pilot Project

- SHARP
- PNM
- Mesa del Sol (MdS)
- Appliance Vendors
- Inverter Vendor
- 310 Solar
- Sandia Labs
- University of NM
- EPRI