AEP/EPRI Smart Grid Demo

Virtual Power Plant Simulation

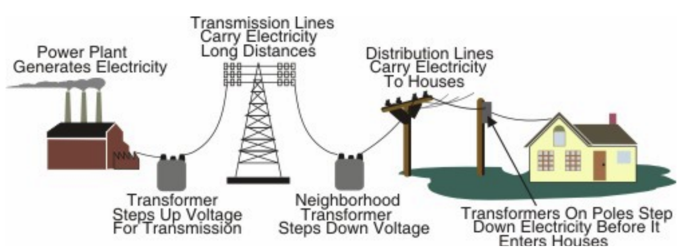
Project Overview

Smart Grid Advisory Meeting
June 23, 2009

Tom Jones / Tom Walker

Virtual Power Plant Simulation Project

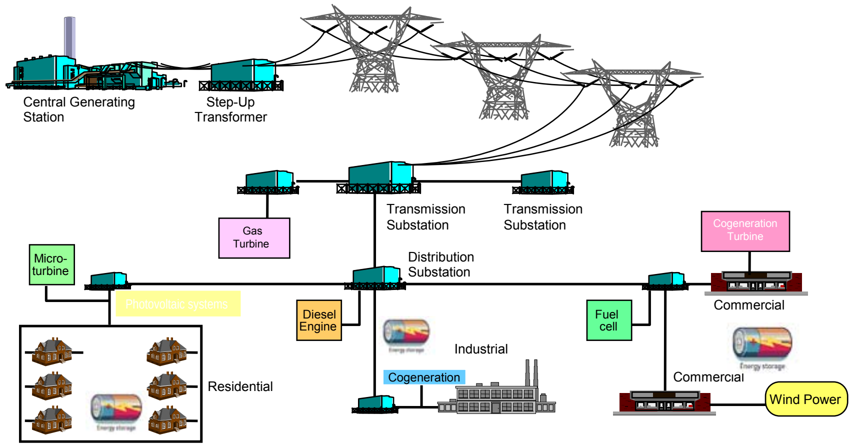
- Virtual Power Plant (VPP)
- VPP Simulation (VPPS)
- Real world components
- Practical application of VPPS
- Conclusion



Before **Smart Grid:**

One-way power flow, simple interactions

Growing complexity = challenge and opportunity



Enter The Smart Grid

- ***Two-way communication network***
- ***Smart meters at customer locations***
- ***Remote control of end-use devices***
- ***Information exchange between customers and utility***
- ***Remote monitoring and control of distribution line devices***
- ***Integration and control of distributed energy resources***

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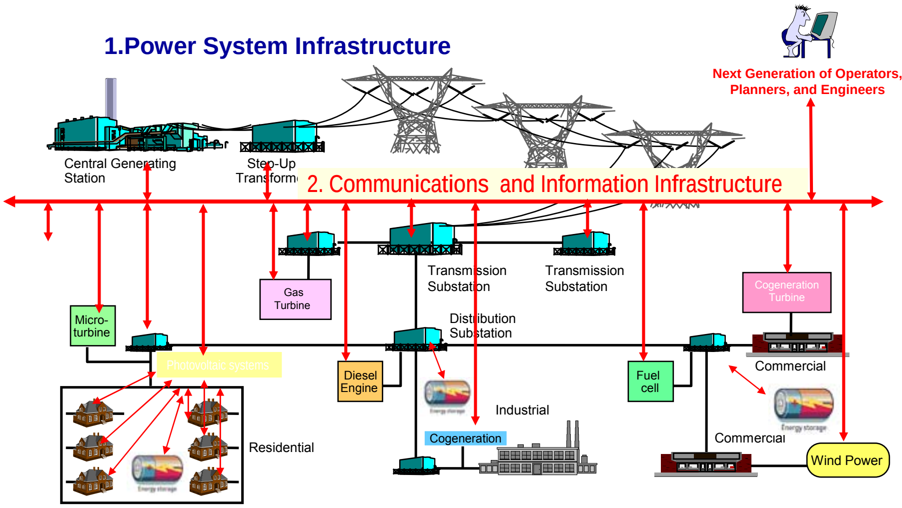

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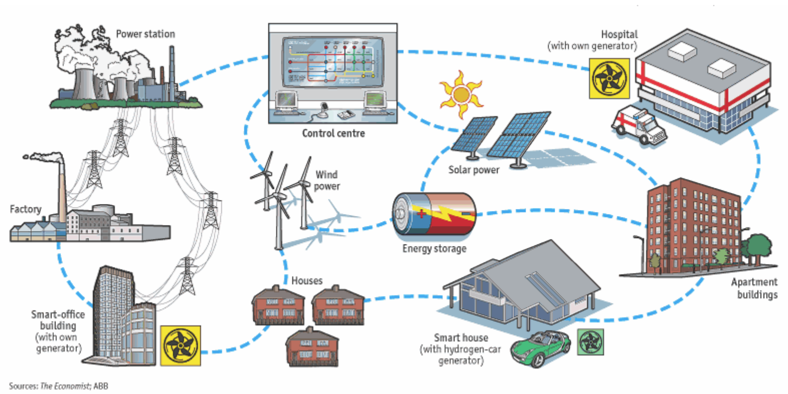
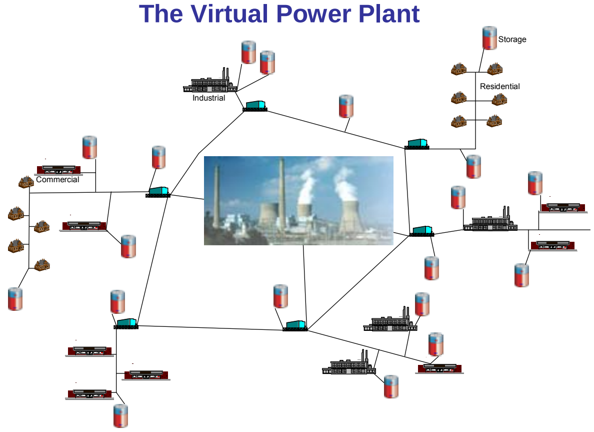


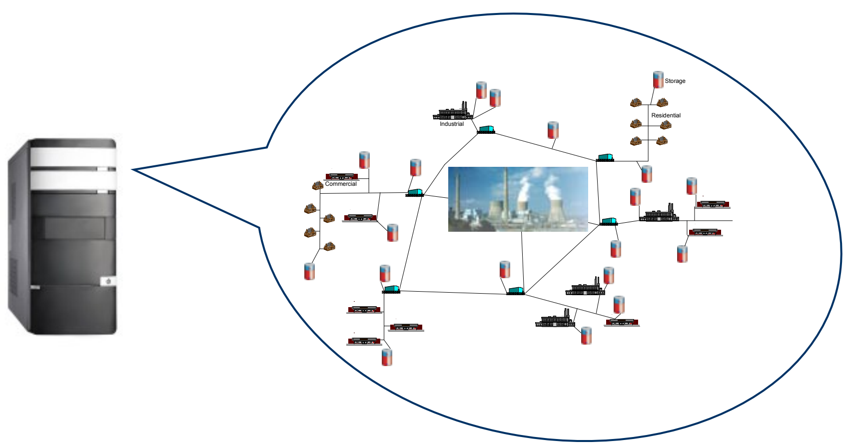
After Smart Grid:

Two-way power flow, multi-stakeholder interactions

Putting It All Together:
The Virtual Power Plant

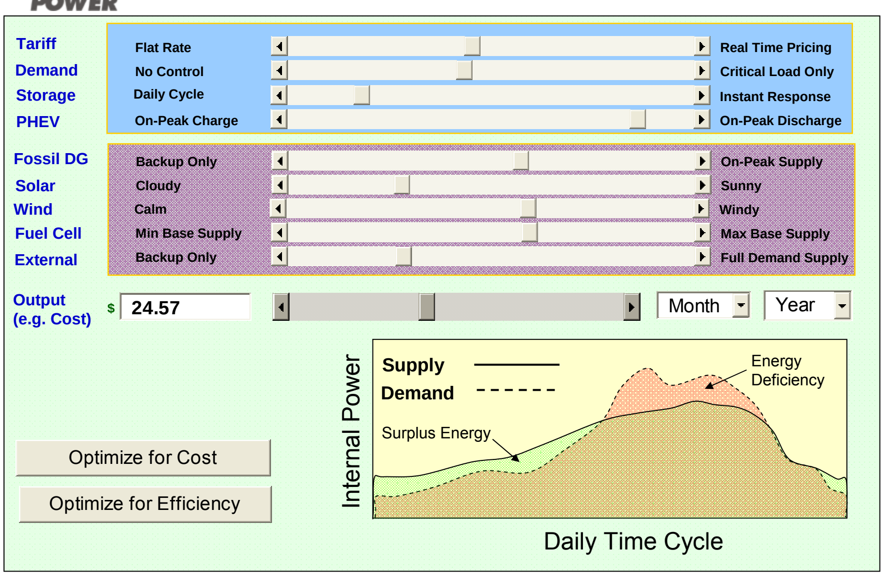


Putting It All Together:
The Virtual Power Plant Simulator



Virtual Power Plant Simulation Project Objective

Assess the functionality, performance and benefits of a fully integrated and robust smart grid as a ***Virtual Power Plant***, from end-use to RTO, by leveraging Real system and device information and data with a comprehensive modeling and ***Simulation*** tool



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Resource Types for Integration

Distributed energy resources that are in operation or under test across AEP will be assessed on location and will be virtually installed on the South Bend VPPS foundational system, including:

- ***MW-scale battery installations (e.g. sodium sulfur or NaS),***
- ***kW-scale flat panel photovoltaic systems (e.g. roof-top),***
- ***kW-scale concentrating solar systems (electrical and thermal),***
- ***kW-scale natural gas fired reciprocating engines (with CHP)***
- ***Plug-in hybrid electric vehicles,***
- ***Ice Bear air conditioning system,***
- ***kW-scale wind turbines,***
- ***kW-scale community energy storage systems,***
- ***and others.***

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Regional Market Structure

- ***Wholesale***
  - ***PJM "Time-Stamped" Pricing***
  - ***Aggregated "Time-Stamped" VPP Resources***
  - ***Calculate Wholesale Market Value of VPP***
- ***Retail (South Bend Pilot)***
  - ***Summer on-peak period during the weekday for the months of May through September with an associated off-peak rate during the remaining hours***
  - ***Incentive for participation in thermostat control program***

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Real Time Wholesale Price From RTO

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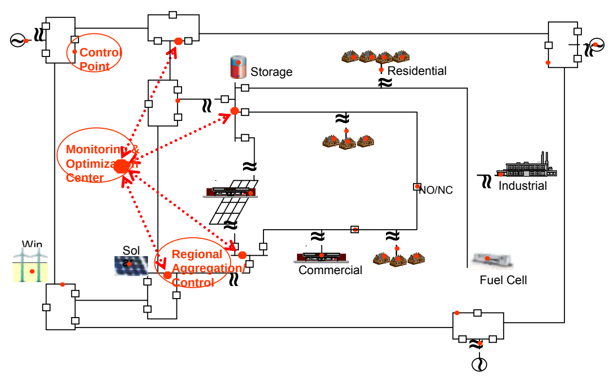
Communication & Control Infrastructure

- *Assess impacts and performance of protocols and standards*
- *Determine requirements for hierarchical control system (communication within and across "zones")*
- *Evaluate requirements for and impacts of control prioritization (e.g. transmission constraint within regional system vs. energy efficiency targets)*



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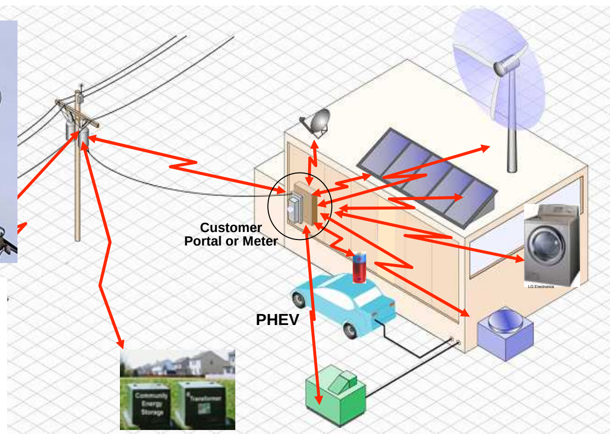

Zone 1

<u>Customer Premise</u>

Zone 2

<u>Utility Secondary</u>

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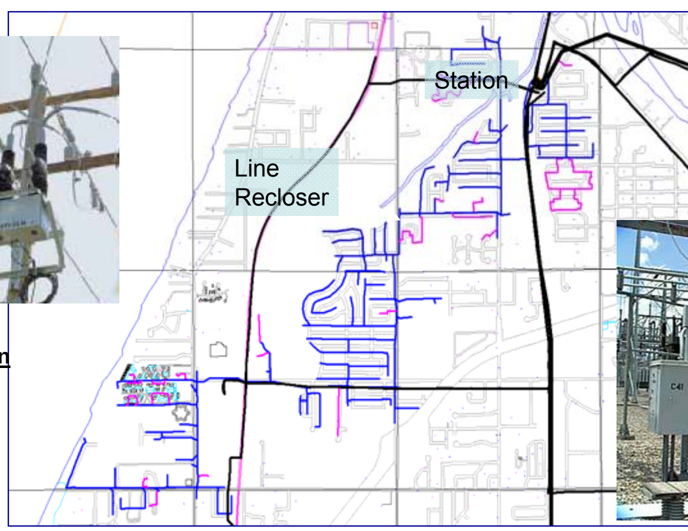

Zone 3

<u>Distribution</u>

<u>Line</u>

<u>Devices</u>

Zone 4

<u>Distribuition</u>

<u>Circuit</u>

<u>Breaker</u>

Zone 5
Distribuition
Station
Transformer

Zone 6
Regional
Power
System

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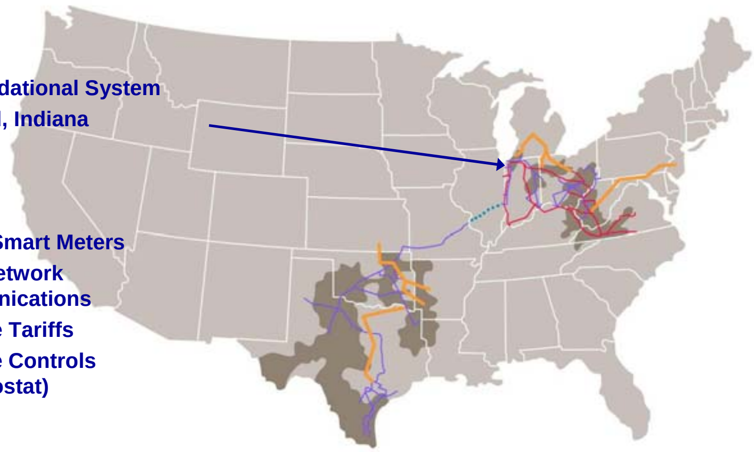
VPPS Foundational System
South Bend, Indiana



AMI / AMR

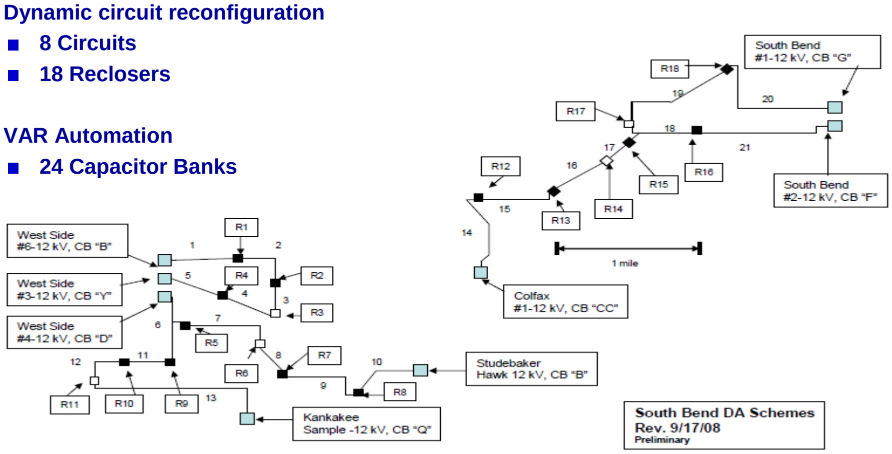
- **10,000 Smart Meters**
- **Mesh Network Communications**
- **End-use Tariffs**
- **End-use Controls (Thermostat)**

South Bend Distribution Automation
Dynamic circuit reconfiguration

- **8 Circuits**
- **18 Reclosers**

VAR Automation

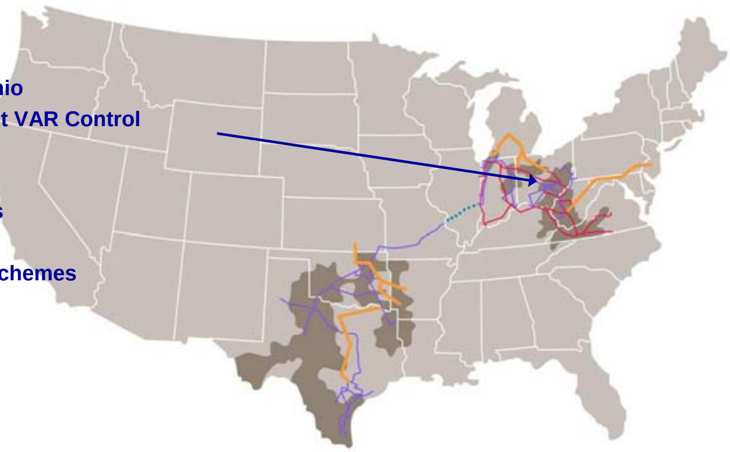
- **24 Capacitor Banks**



Columbus, Ohio
Integrated Volt VAR Control

- **6 Stations**
- **17 Circuits**

Two control schemes



Integrated Volt VAR Control Concept:

1. **Utilize communications and computerized intelligence to control voltage regulators and capacitors on the distribution system, resulting in lower demand and increased energy efficiency**

2. **Optimize power factor and voltage levels based on selectable parameters**

3. **Finer control of voltage levels can Studies indicate a 1% voltage reduction is likely to cause a 0.7% reduction in KW demand and a similar or better reduction kVAR demand**

4. **Benefits are highly predictable because customer consumption is reduced with no action required on their part**

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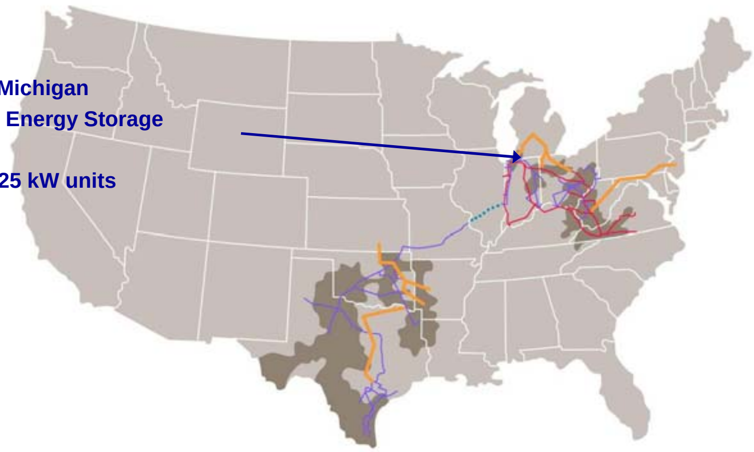
St Joseph, Michigan
Community Energy Storage

1 MW, 40 – 25 kW units



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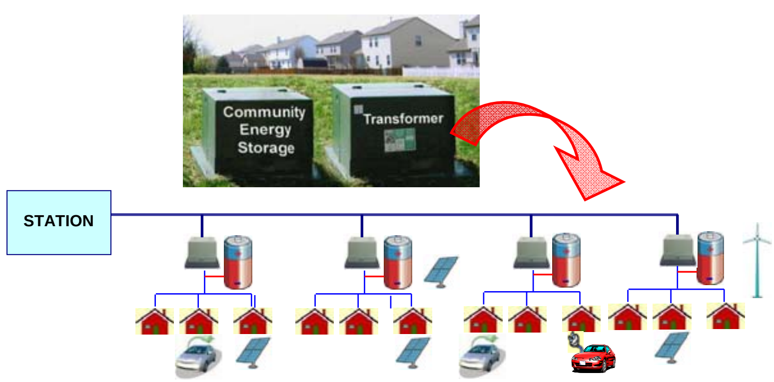
CES is a distributed fleet of small energy storage units connected to the secondary of transformers serving a few houses or small commercial loads.



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Community Energy Storage Unit Specifications

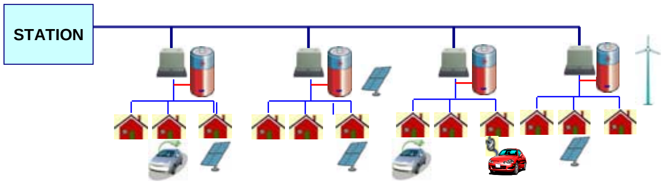
Key Parameters	*Value*
Power	*25 kW*
Energy	*50 kWh*
Voltage	*240 / 120V*
Round Trip AC Efficiency	*> 85%*
Life	*> 3000 cycles, 15 years*
Audible Noise	*< 48dBA (no fans or filters)*
Size	*Comparable to a Pad-mount transformer*

www.aeptechcenter.com/ces

AEP AMERICAN ELECTRIC POWER

Community Energy Storage Fleet Deployment

- Capital deferral of Transmission, Station, and Circuit improvements
- Scalable, flexible deployment by location and phase
- Integration into circuit voltage and VAR control
- Improved reliability, including reduction of momentary interruptions
- Improved operations including reduction of cold load pick-up
- Improved power quality, flicker (transformer size)



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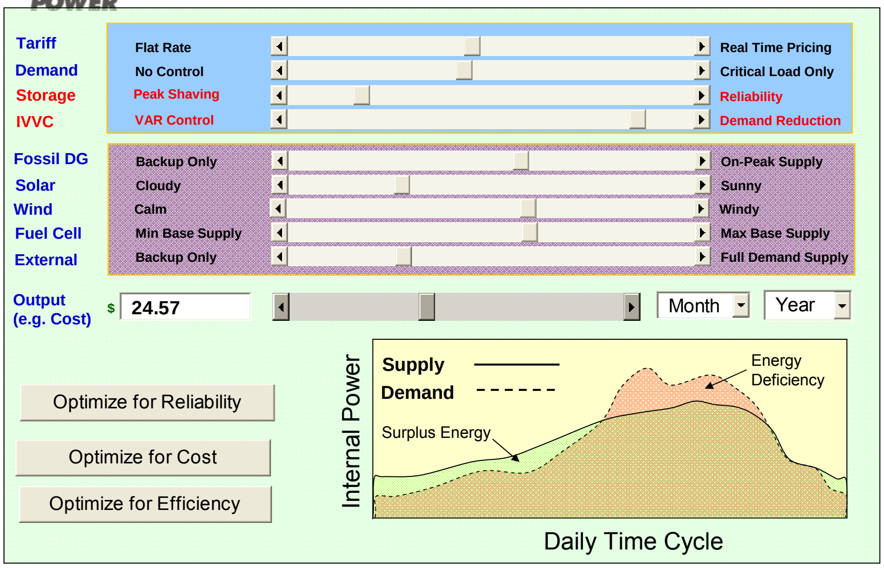

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ID	Task Name	2009 Q1	Q2	Q3	Q4	2010 Q1	Q2	Q3	Q4	2011 Q1	Q2	Q3	Q4	2012 Q1	Q2	Q3	Q4	2013 Q1	Q2
1	ID data requirements for model; Collect data and input into Virtual Power Plant (VPP) simulator																		
2	Measure and record system performance																		
3	Run simulations without new technologies (base case); Step by step include new technologies and system controls in simulation																		
4	Compare measurements against simulations, Refine system and component models																		
5	Continue additional modeling - modify model and simulations Assess impacts of new technologies and controls																		
6	Issue Report. Include Measurements and system performance																		