

## Advanced Grid-Interactive Distributed PV and Storage

February 10<sup>th</sup>, 2011

# SolarCity CSI RD&D Project

- | Develop firm, dispatchable grid-interactive combined photovoltaic and stationary storage: **FirmPV**
  - Installed in distributed, small increments
  - Enhance existing SolarGuard PV monitoring network for aggregate control
  - 12 pilot installations
- | With Tesla Motors
  - Develop stationary Li-ion storage module
- | With UC Berkeley – Professors Kammen & Callaway
  - Develop control strategies & analysis of system wide benefits
- | PG&E Advisory Committee



# About SolarCity

- Highest-Volume Solar Integrator in the U.S.
  - More than 10,000 projects completed or underway
  - Residential, commercial and government sectors
  - Energy efficiency upgrades
- 1000+ Employees
- >\$700 Million in Project Financing

**High Technology**



**Manufacturing**



**Government**



**Education**



**Retail**



**Agriculture**



**Nonprofit**



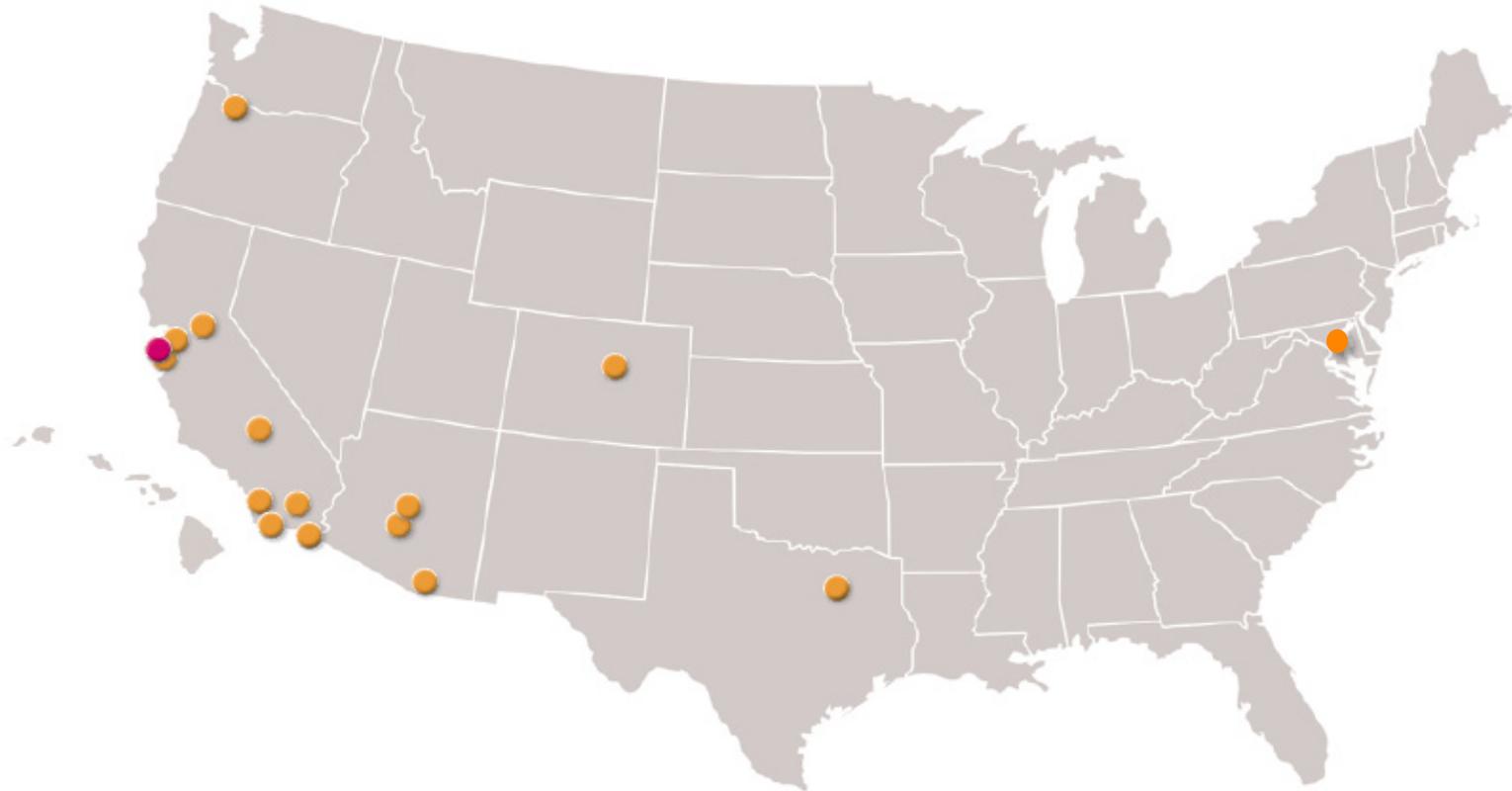
**Multifamily Housing**



**Houses of Worship**



# SolarCity Locations & Regional Operations Centers



**● Headquarters**

Foster City, CA

**● Regional Operations Centers**

Berkeley, CA

Foster City, CA

Fresno, CA

Los Angeles, CA

Pomona, CA

Sacramento, CA

San Diego, CA

Santa Ana, CA

Deer Valley, AZ

Phoenix, AZ

Tucson, AZ

Portland, OR

Denver, CO

Dallas, TX

# We Build Solar Cities



## **Soaring Heights Communities, Davis Monthan Air Force Base**

The Largest Solar-Powered Community in the Continental U.S.

6MW Project, Including 2.7 MW of Roof Mounts

# SolarGuard® – Every SolarCity System is Monitored

## Online Account

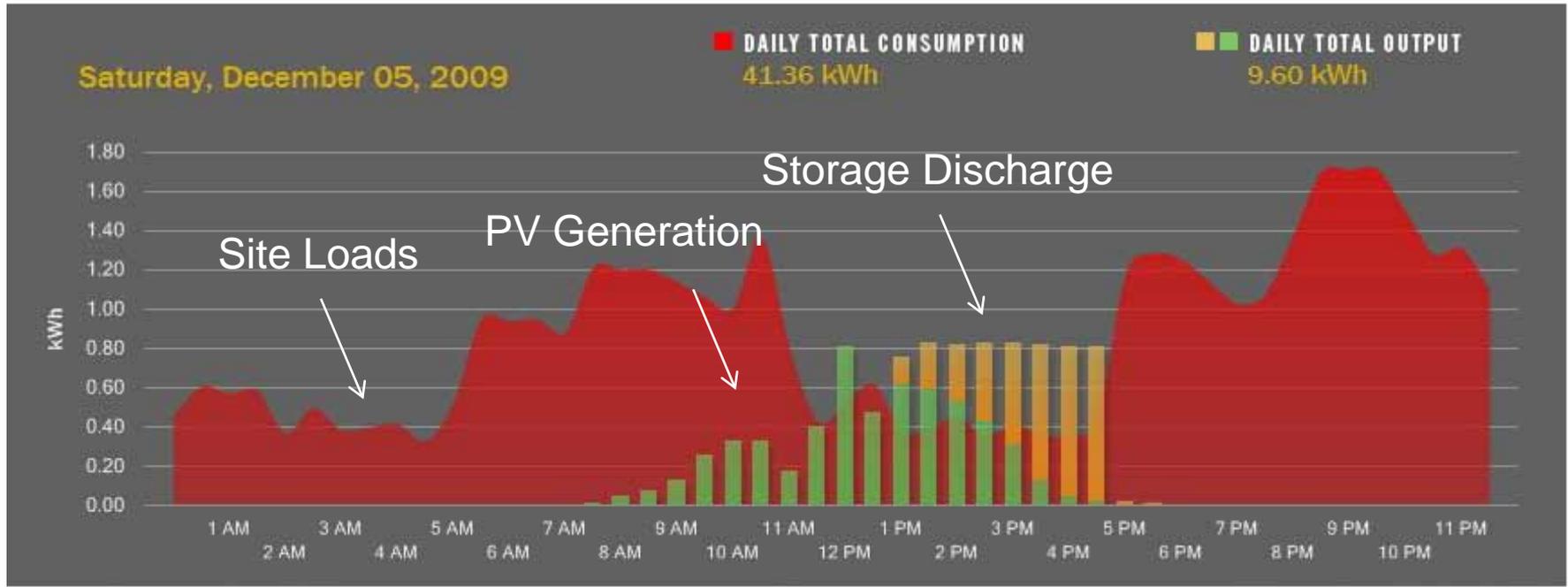
- i Tracks solar system production 24/7
- i Viewable from computer, corporate website, lobby kiosk or iPhone

## Monitoring & Repair Service

- i SolarCity takes responsibility by continually monitoring
- i We will dispatch repair crew if necessary



# SolarCity CSI RD&D Project



## FirmPV Prototype

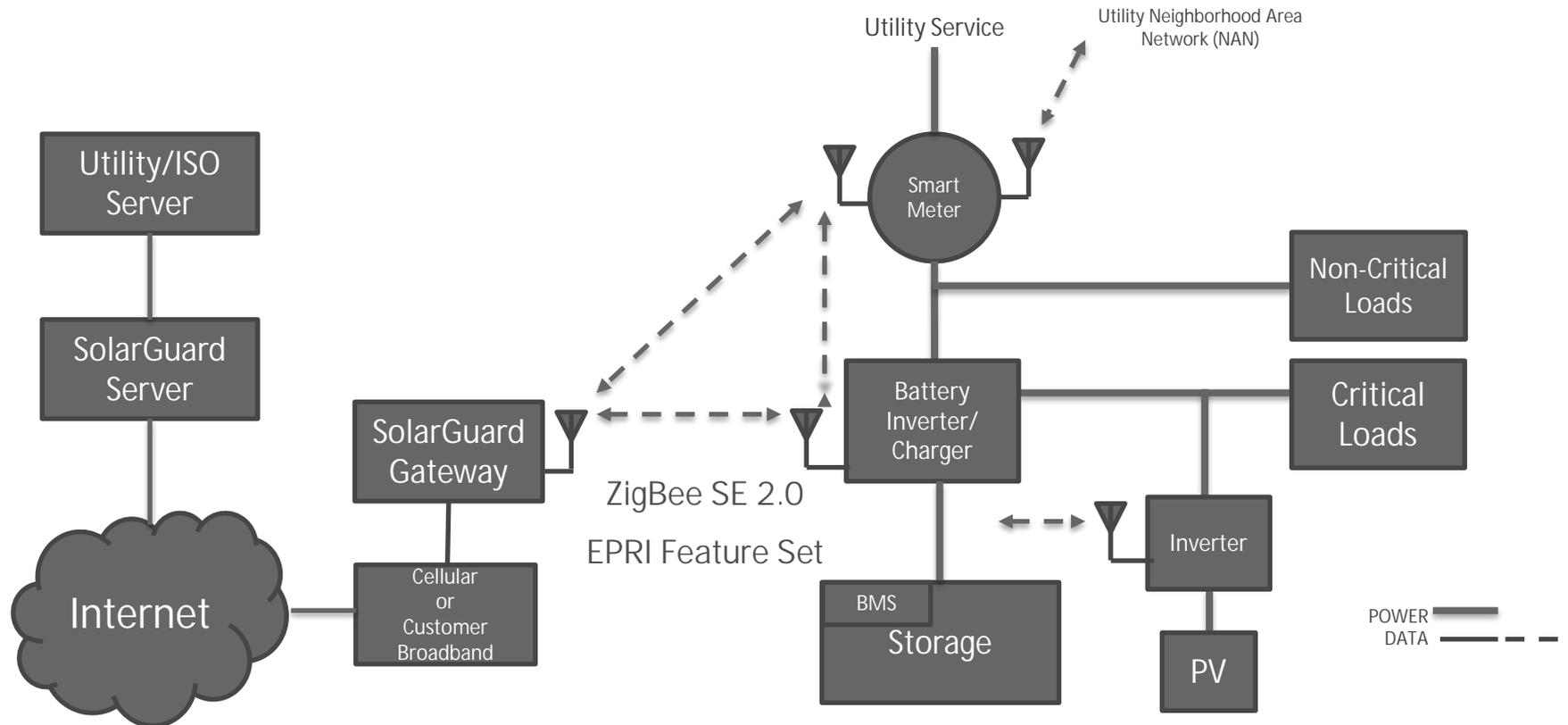
- | Installed November 2009
- | PV Generation: 4 kW
- | Storage: 5 kW / 10 kWh
- | Server Scheduled Charge and Discharge

# FirmPV Opportunities

- FirmPV can provide:
  - Voltage regulation, PV ramp rate limiting, load time shifting, T&D Asset deferral
  - A solution for intermittency and load issues at the source
  - Reduced installation costs compared to standalone storage. Shared interconnect, communications, power conversion and labor
  - Faster deployment - simplified site qualification, and design
  - An incremental solution – only what is needed where it is needed most



# FirmPV Communications and Integration



## Storage

- Residential: 5 kW / 10 kWh
- Commercial: 20 – 100 kW / 20 – 200 kWh
- 3000 – 5000 cycles

# Tesla Motors – Li-ion Stationary Storage

Adapt Li-ion vehicle battery for stationary applications

Why Li-ion?

- Long life, low maintenance
- High energy and power densities
- Scalable in small increments
- Rapidly dropping \$/kWh



Tesla Advantage

- 50 MWh/yr volume growing to GWhs/yr in 2012
- Deep understanding of all Li-ion chemistries
- Automotive safety standards
- Standardized cell form factor made in billions/year



# UC Berkeley Research

- | **PV variability characterization** – of 8,000 existing systems
  - Spatial scales, ranging from distribution feeder to load aggregation point, to the entire CAISO footprint
  - Time scales, ranging from sub-minute to hourly
- | **Valuing Energy Services of PV + Storage**
  - Transmission and Distribution level
- | **Planning a Decentralized Grid** - device models and control strategies
  - Decentralized / distributed control for voltage regulation
  - Methods need to be fail-safe and remotely adjustable
  - Centralized control for transmission level functions
  - Seek to minimize communication requirements

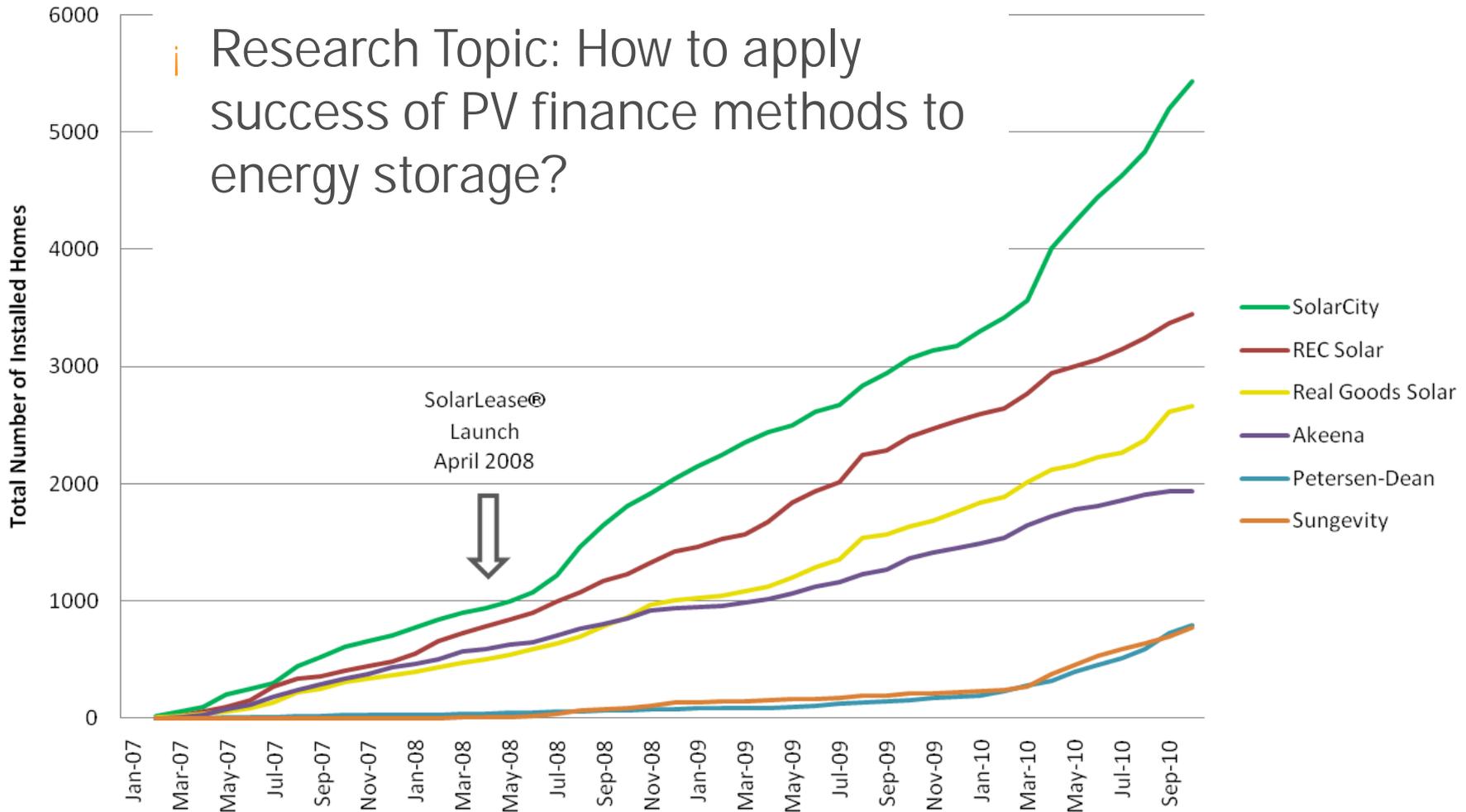
# Pilot Installations

- | 12 FirmPV Installations in California
  - 2011 Lead-acid: 3 x residential, 3 x commercial
  - 2012 Li-ion: 3 x residential, 3 x commercial
- | Test bed for storage control communication platform
- | Battery cycle testing under various scenarios
- | Quantify marginal design, permitting and construction effort
- | Highlight product integration issues, needs for standards, and new products



# Finance Methods for Energy Storage

## Residential Solar Market Share





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