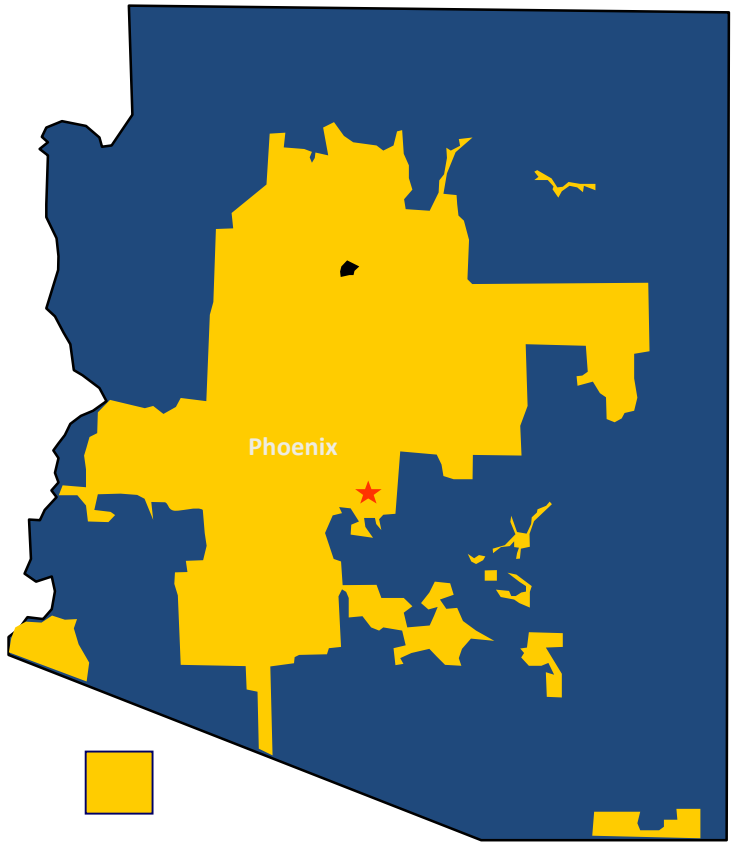
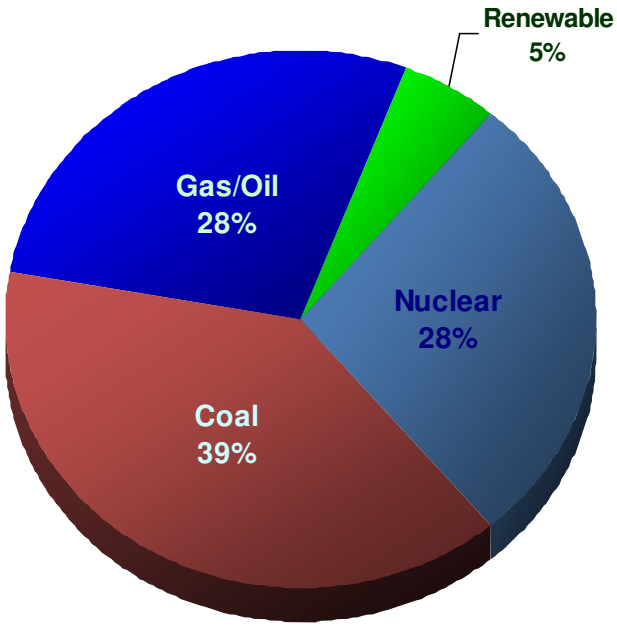
APS

- Largest utility in Arizona
- Serves about ½ of Arizona's population
- Peak demand over 7,000 megawatts
- Owns and operates about 5,000 miles of transmission lines
- Normal growth rate is 3-5% per year
- Energy demand will almost double in 20 yrs

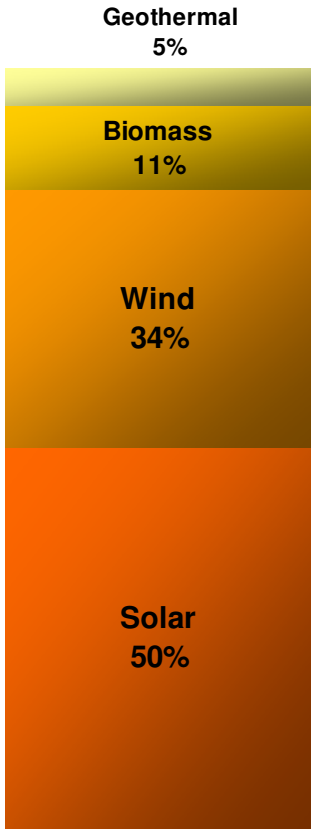


APS Retail Service Territory

APS Generation Mix - 2012



2012 Generation Mix



2012 Renewable Mix

APS Renewable Energy Portfolio

Renewable Energy Standard – Arizona Corporation Commission (ACC)

- By 2025 – 15% of APS Retail Sales (6,525,000 MWHs)
  - 70% - Renewable Generation (Utility Scale)
  - 30% - Distributed (Customer Side of the Meter – 2,000,000 MWHs)
    - 50% Residential – 50% Non-Residential
- In 2010 – 2.5% of APS Retail Sales (734,400 MWHs)
  - 80% - Renewable Generation (Utility Scale)
  - 20% - Distributed Energy (Customer Side of the Meter – 146,000 MWHs)
    - 50% Residential – 50% Non-Residential

APS Renewable Energy Portfolio

JULY 2010

DIVERSIFIED RENEWABLE PORTFOLIO

APS's renewable energy portfolio is expanding rapidly, growing from less than one megawatt in 2001 to more than **258** megawatts (MW) today. This is enough power to meet the needs of **65,000** customers.

PORTFOLIO BY ACQUISITION

Purchase power agreements. . . . . **218 MW**
APS owned and operated . . . . . **6 MW**
Customer owned and operated . . . . . **34 MW**

PORTFOLIO BY TECHNOLOGY TYPE

WIND
190 MW with an additional **99 MW** being developed

SOLAR
40 MW with an additional **280 MW** being developed

BIOMASS
15 MW

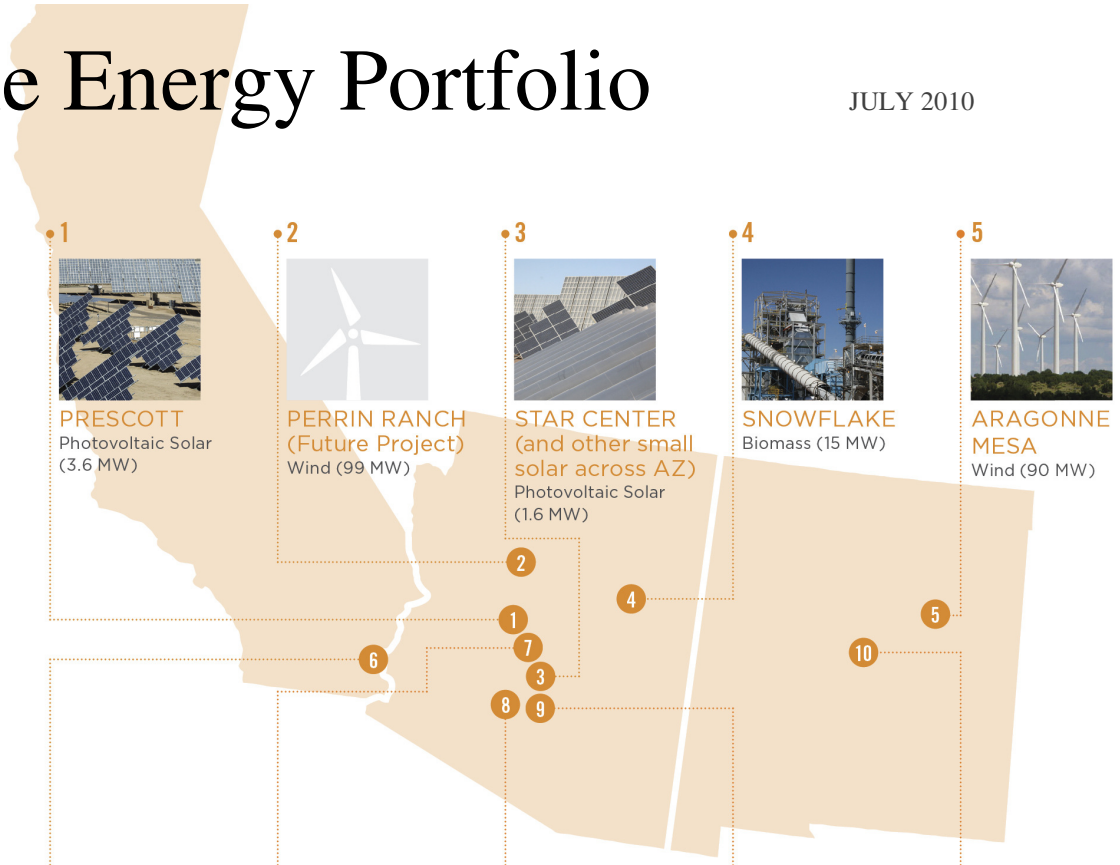
GEOTHERMAL
10 MW

BIOGAS
2.8 MW

APS Renewable Energy Portfolio

JULY 2010

APS selects renewable energy projects based on what is the best fit for its load and the best price for customers.



1 PRESCOTT
Photovoltaic Solar (3.6 MW)

2 PERRIN RANCH (Future Project)
Wind (99 MW)

3 STAR CENTER (and other small solar across AZ)
Photovoltaic Solar (1.6 MW)

4 SNOWFLAKE
Biomass (15 MW)

5 ARAGONNE MESA
Wind (90 MW)

6 SALTON SEA
Geothermal (10 MW)

7 GLENDALE LANDFILL
Biogas (2.8 MW)

8 SOLANA (Future Project)
Concentrating Solar (280 MW)

9 SAGUARO
Concentrating Solar (1 MW)

10 HIGH LONESOME
Wind (100 MW)

APS Renewable Energy Portfolio

JULY 2010

To help customers with the cost of adding renewable energy systems to their homes or businesses, APS offers the Solar and Renewable Energy Incentive Program.

KEY FACTS

- Started in 2002 with photovoltaic solar electric systems and then added solar water heaters in 2003.
- Additional incentives were added in May 2008 for wind, biogas/biomass and geothermal.
- **8,549** APS customers have participated in the program since inception.
- All told, program participants have the capacity to generate **34** megawatts of "green" electricity.
- Since the program's inception in 2002, APS has provided **$92 million** to customers to install their own renewable energy systems.
- APS customers who took advantage of the solar water heater and other thermal technology incentives are expected to displace **27,000** megawatt hours of energy.

APS Renewable Energy Portfolio

APS will exceeded compliance with the RES and Distributed Energy (DE) targets in 2010

2010 Customer participation in DE programs has increased 320% over 2009

By year-end 2010, APS funded nearly 11,000 customer DE installations

More than 210 MW of Renewable Energy including 70 MW of DE under contract, reserved or installed during 2010 alone

APS Renewable Energy Key Challenges

Challenge No. 1
How do we maximize the value of distributed generation?

Challenge No. 2
What energy are we really seeing on our system?

Challenge No. 3
Meeting Peak Needs and Energy Storage.

Challenge No. 4
"Smart Grid" and what this means w/ distributed generation.

<u>External and Internal Stakeholder Support and Education</u>

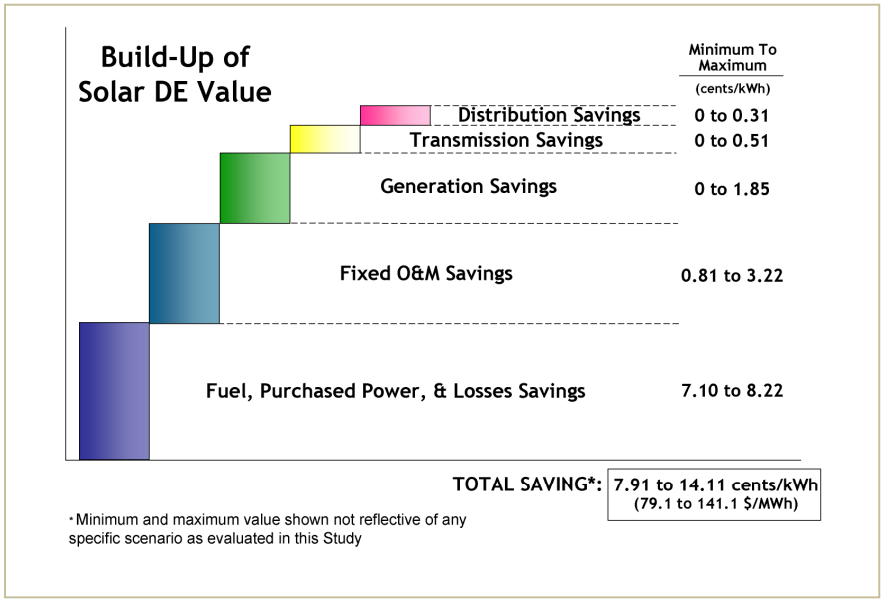
Distributed Renewable Energy Operating Impacts and Valuation Study (RW Beck)

Potential savings associated with:

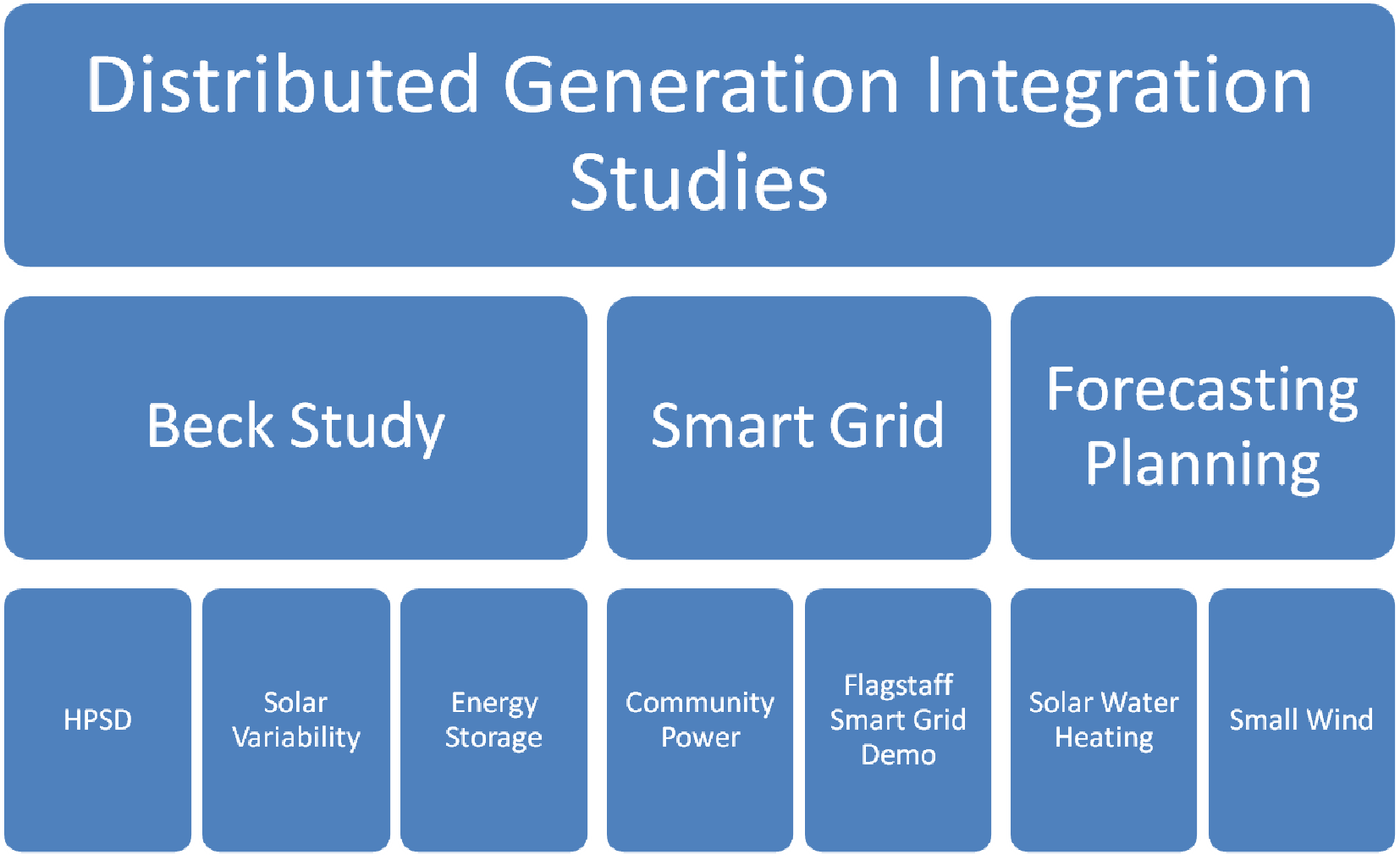
- Reduced energy production (fuel and purchased power)
- Line loss reduction
- Generation project deferral
- Deferred transmission investments

Other conclusions:

- Solar output is not coincident with APS peak demand
- Distribution system can not be downsized
- Localized peak reduction not dependable due to clouds
- Increased dispatch cost – operating reserves required



APS Renewable Integrated Studies



APS – Flagstaff Smart Grid Pilot

Smart Grid research opportunities

36,000 smart meters installed by August 31, 2009

Automating feeder mid-points and tie-points

Sensoring technologies

Adopting "self-healing" technologies on 4 feeders

"Large Pipe" fiber communications

Community Power Project

Model for use elsewhere

THE COMMUNITY POWER PROJECT FLAGSTAFF PILOT

APS – Flagstaff Smart Grid Pilot

Why Flagstaff?

Metropolitan Flagstaff

- Static electrical system/growing on outskirts
- Strong interest in sustainability
- Community and political support

Area characteristics

- 35,000 meters
- 4 substations
- 14 feeders

High Penetration Solar Deployment Study

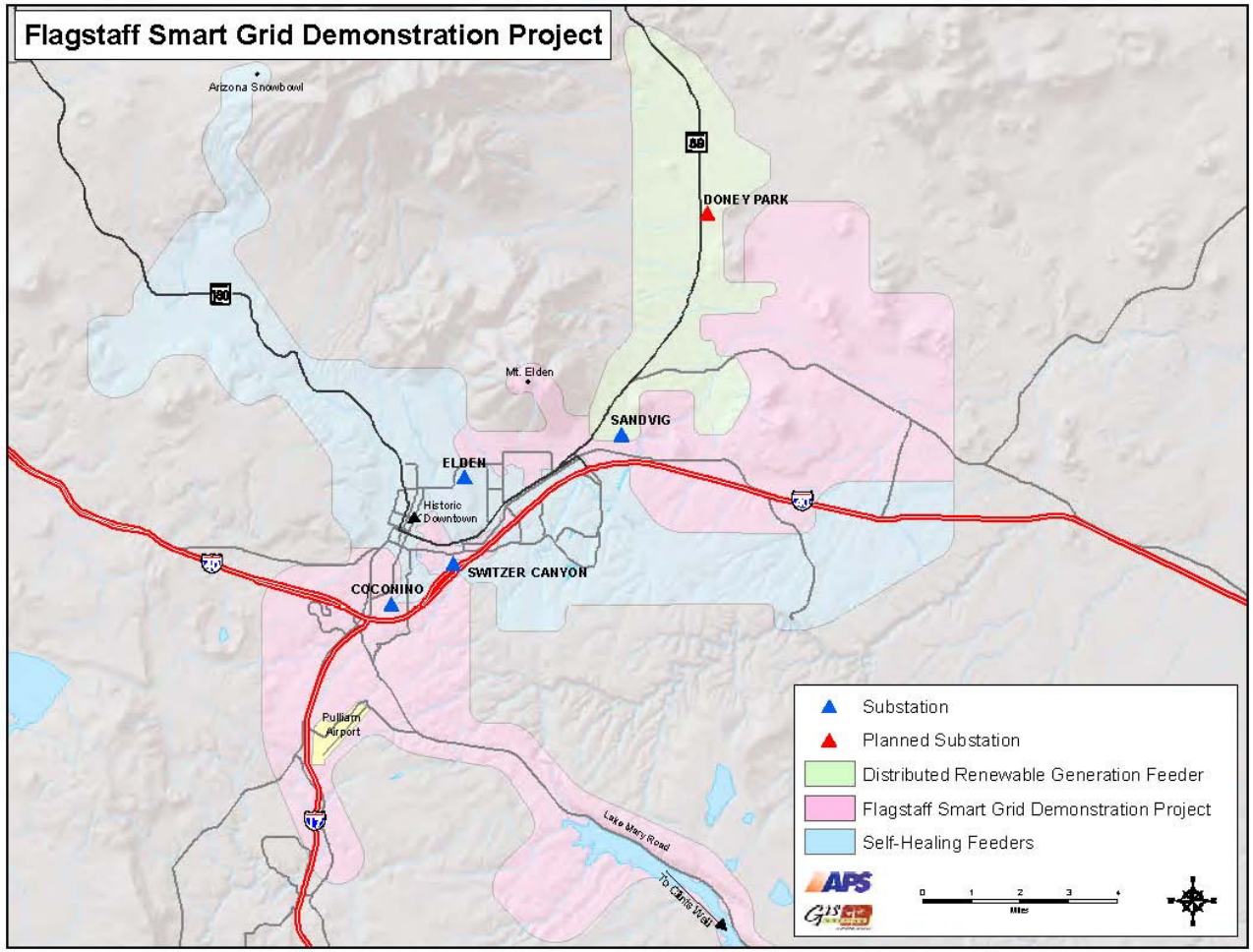
Technical Study

- High concentration of solar on a single feeder
- Leverage advanced distribution system management technologies
- Evaluate distributed generation and system impacts

DOE FOA-0000085 High Penetration Solar Deployment

- Demonstrate through simulation and application how high penetrations of PV on a working distribution feeder will affect grid operations.
- Partners - GE Global Research & GE Energy, ASU, Via Sol, NREL
- Evaluate distributed generation and system impacts

Community Power Project - Flagstaff



Sandvig 4: 10-11 MW

Peak

Market Potential

2,306 Residential Accounts

300 C & I Accounts

Target

1.5 MW PV Capacity

Residential: 600 kW

C & I : 400 kW

APS: 500 kW

Solar Water Heating

Small Wind

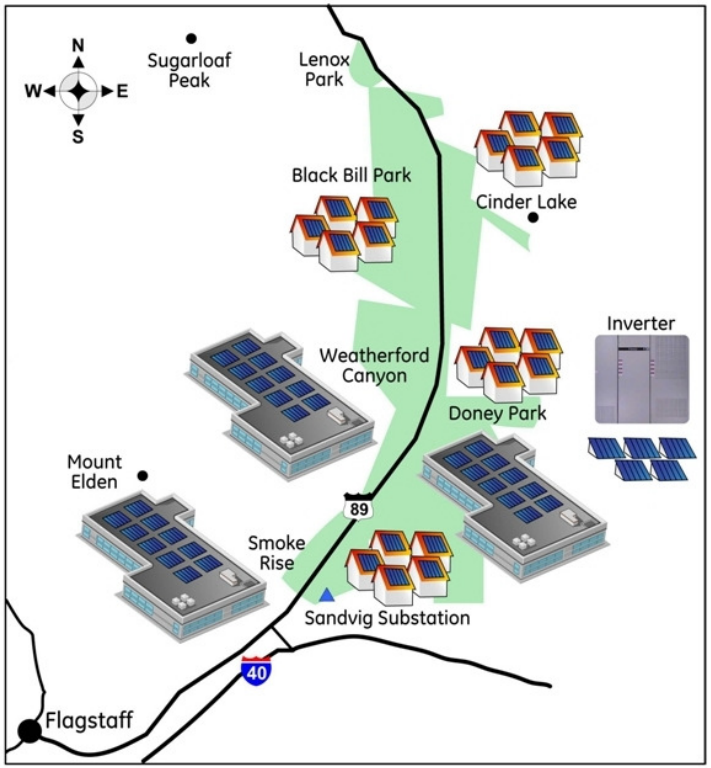
High Penetration Solar Deployment Study

Use the Community Power Project Deployment to:

Study the effects of large amounts of distributed PV our feeder and associated customers

Create and validate models to describe the interactions between weather/PV/feeder equipment and operations

Identify technical and operational modifications that could be deployed in the future to enhance value

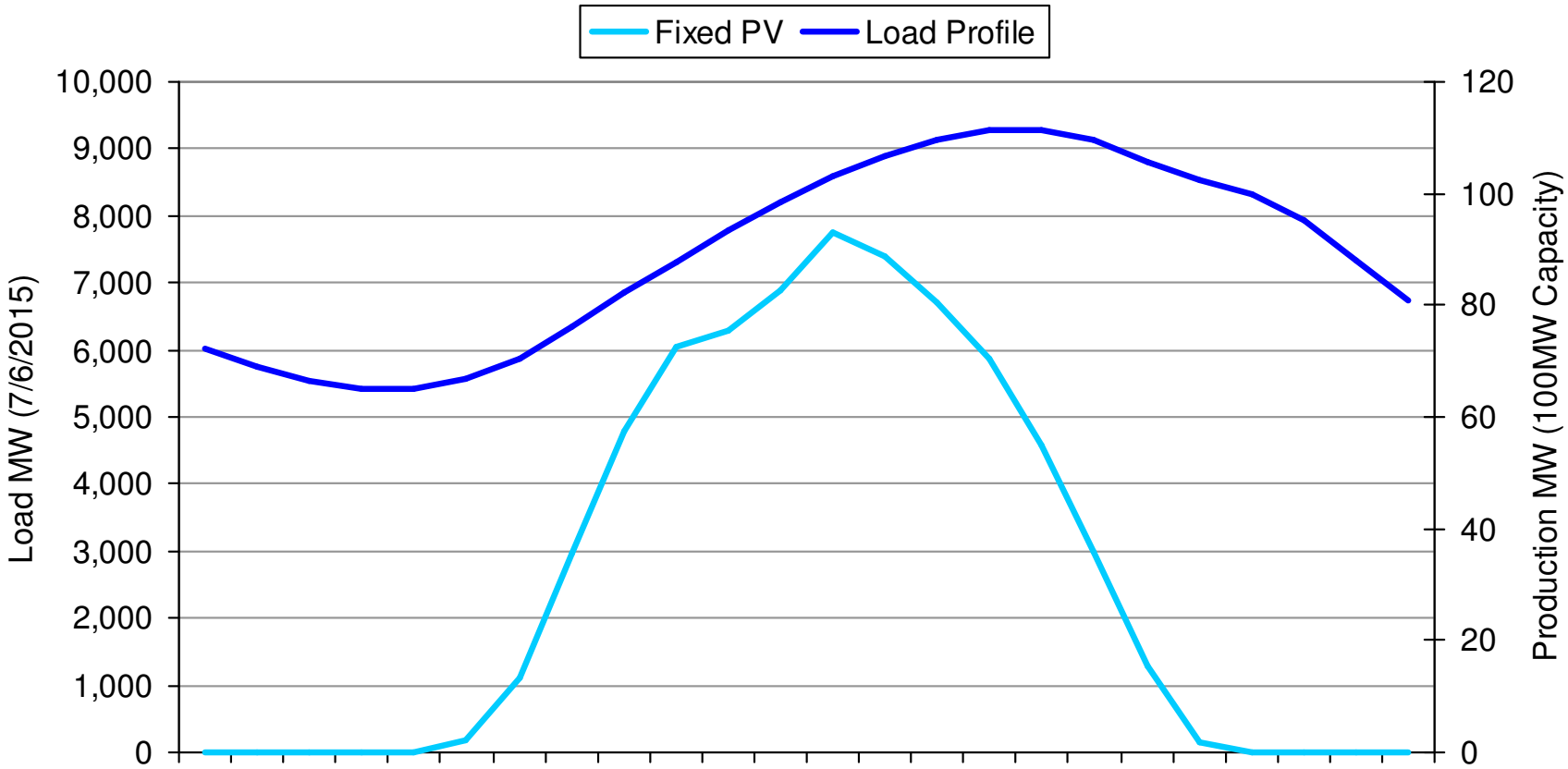


How APS can utilize DG products to possibly reduce costs through lower peak energy demand?

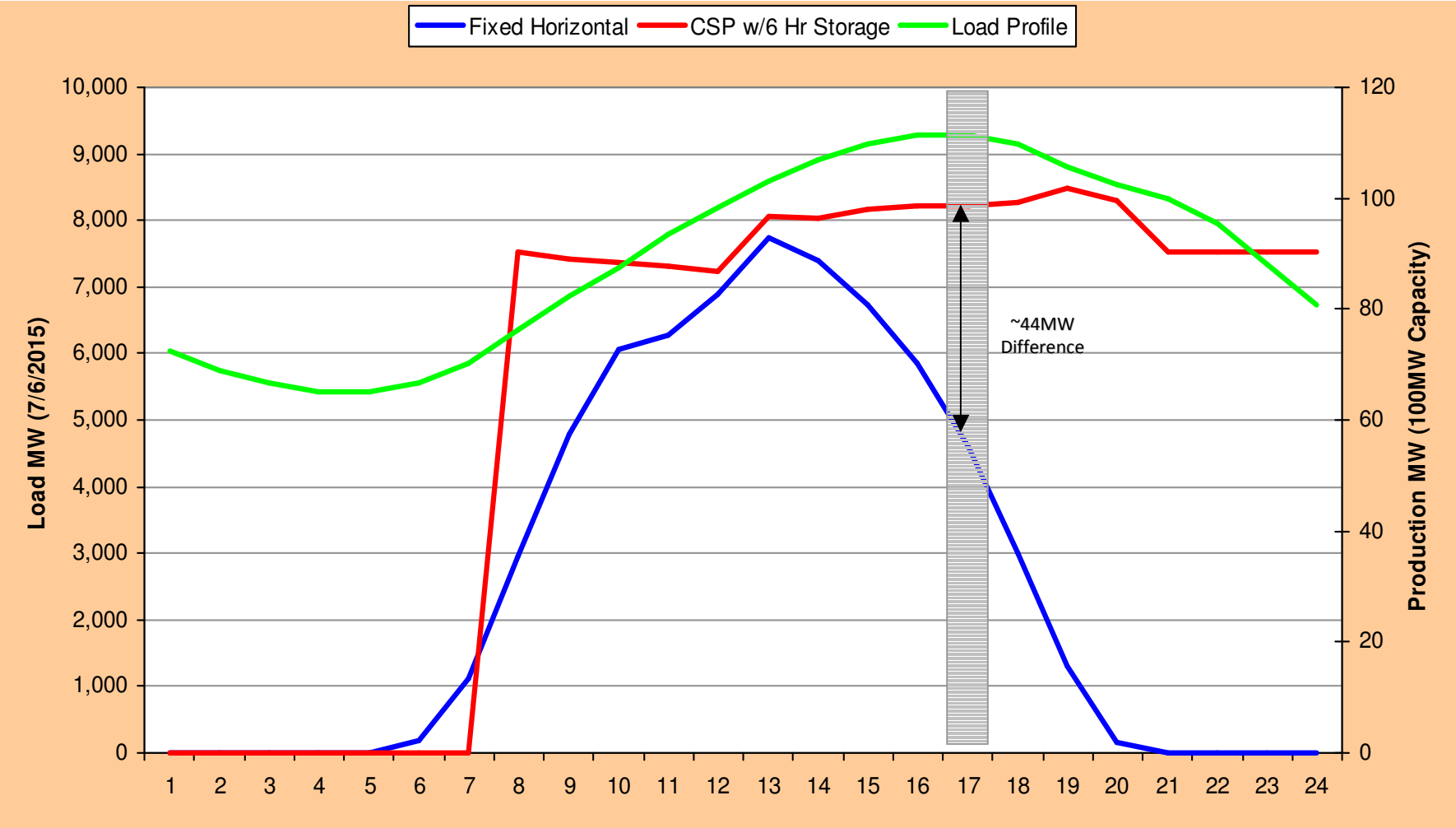
Potential energy storage opportunities may allow APS to optimize the use of the energy delivery infrastructure?

Increased understanding of the intermittency of solar and its effects on the system.?

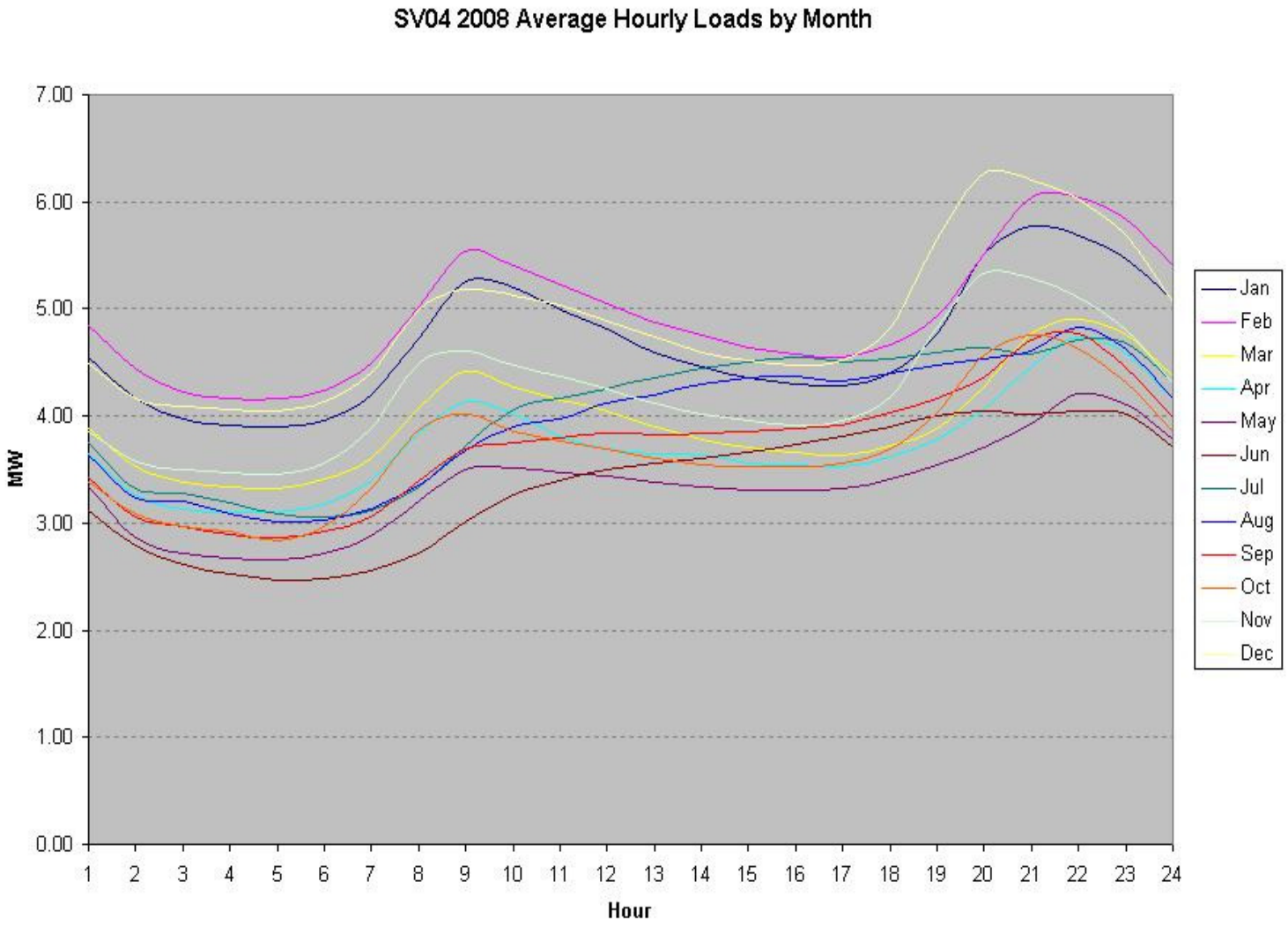
PV Integration Challenges



Solar Production Profile / Load Profile



Flagstaff Profile



Energy Storage- Benefits and Risks

- Why energy storage?
  - Shift energy to help generation meet load peaks
  - Reduce effects of variability from renewable energy sources
  - Support energy load stability during grid transients
- Potential benefits:
  - Capacity firming for renewable
  - Energy shifting, peak shaving
  - Asset upgrade deferral
  - Power quality improvement (voltage support, regulation, etc)
  - End user cost management (customer Time of Use benefits)
- Risks involved:
  - Increased cost for improved reliability
  - New technologies with less commercial history

Energy Storage – APS Demonstration

Purpose- study to determine what value energy storage provides to APS.

Targeted project area- Flagstaff Community Power Project

Utility Scale areas of study focus

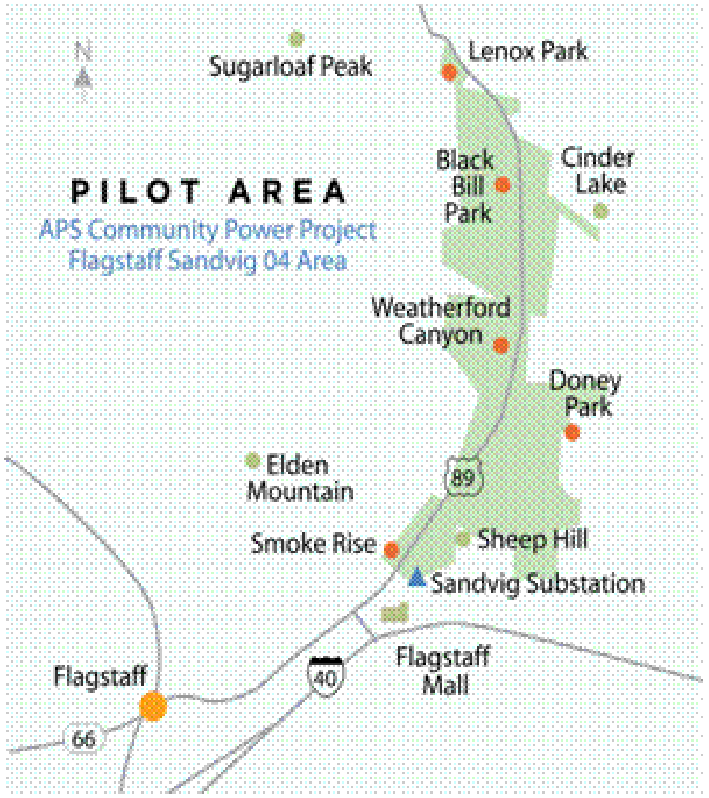
- Reducing short-term PV variability
- Load profile smoothing

Commercial Scale areas of study focus

- Improving power quality
- Shifting energy for time-of-use benefits

Schedule (preliminary)

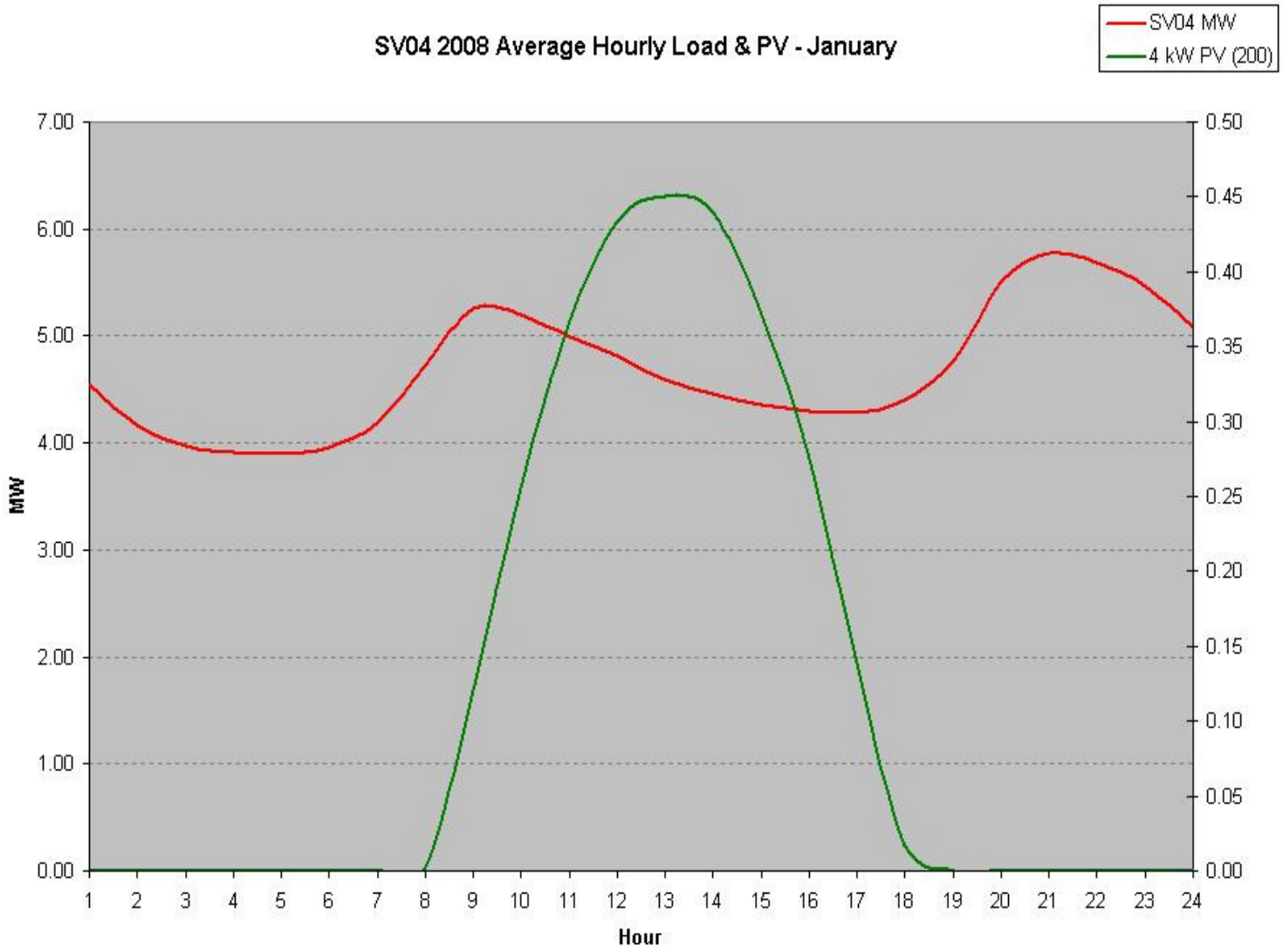
- RFI responses due- May 14
- Start procurement process- Q3 2010
- Installation- 2011



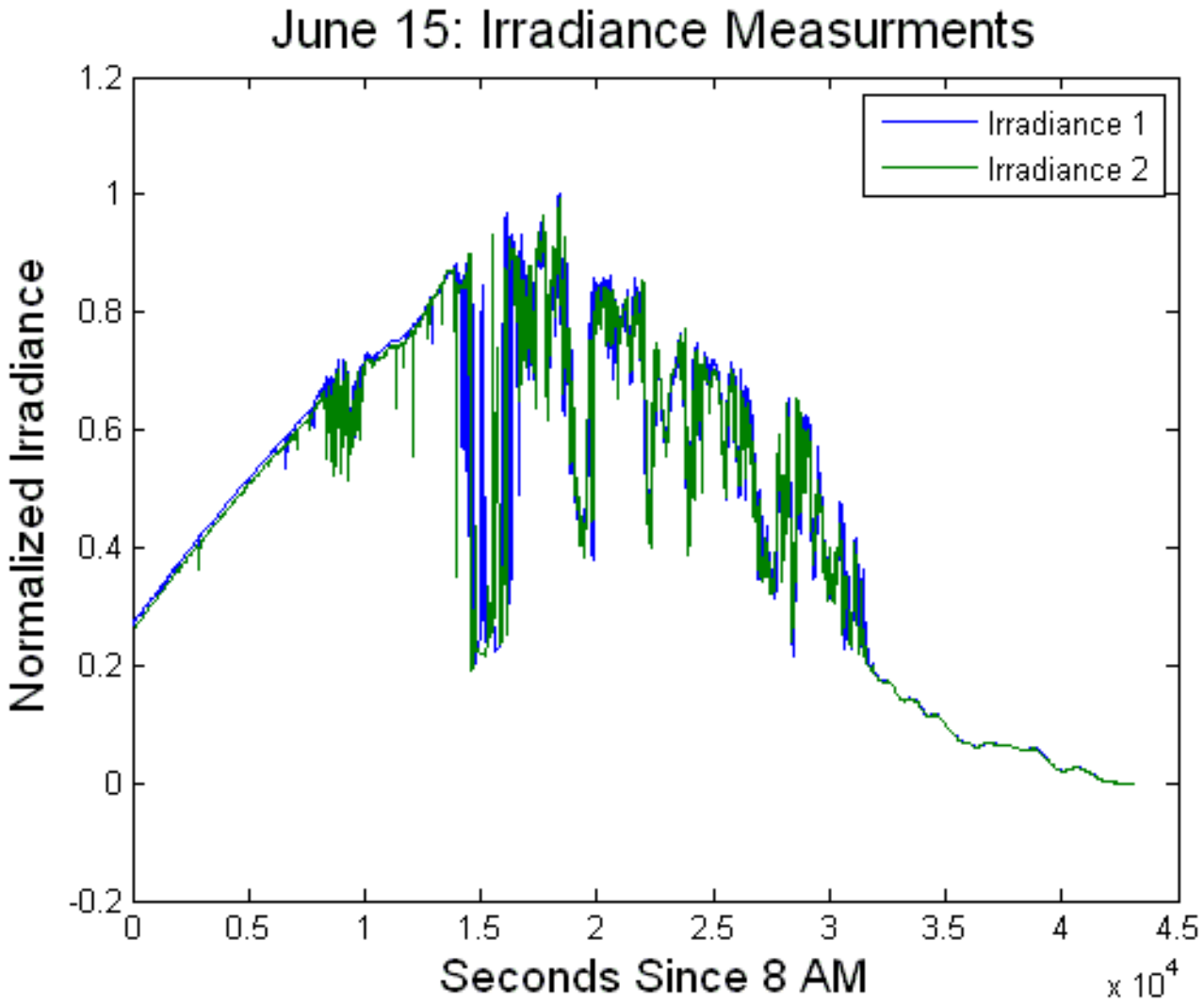
Energy Storage – APS Demonstration

- 500 Kw of Peak Power
- 1.5 Mwh of Energy
- Fast Response
- High turnaround efficiency
- Charge/ discharge cycles
- Compatibility with utility systems
  - Interconnect
  - "SCADA"
- Maintenance and operation
- "Portability"
  - Relative ease of setup
  - Fit within substations selected
- Safety
  - For personnel maintaining
  - For surrounding environment
- Good technical support/ parts availability
- Supplier participation in testing

Energy Storage – APS Demonstration



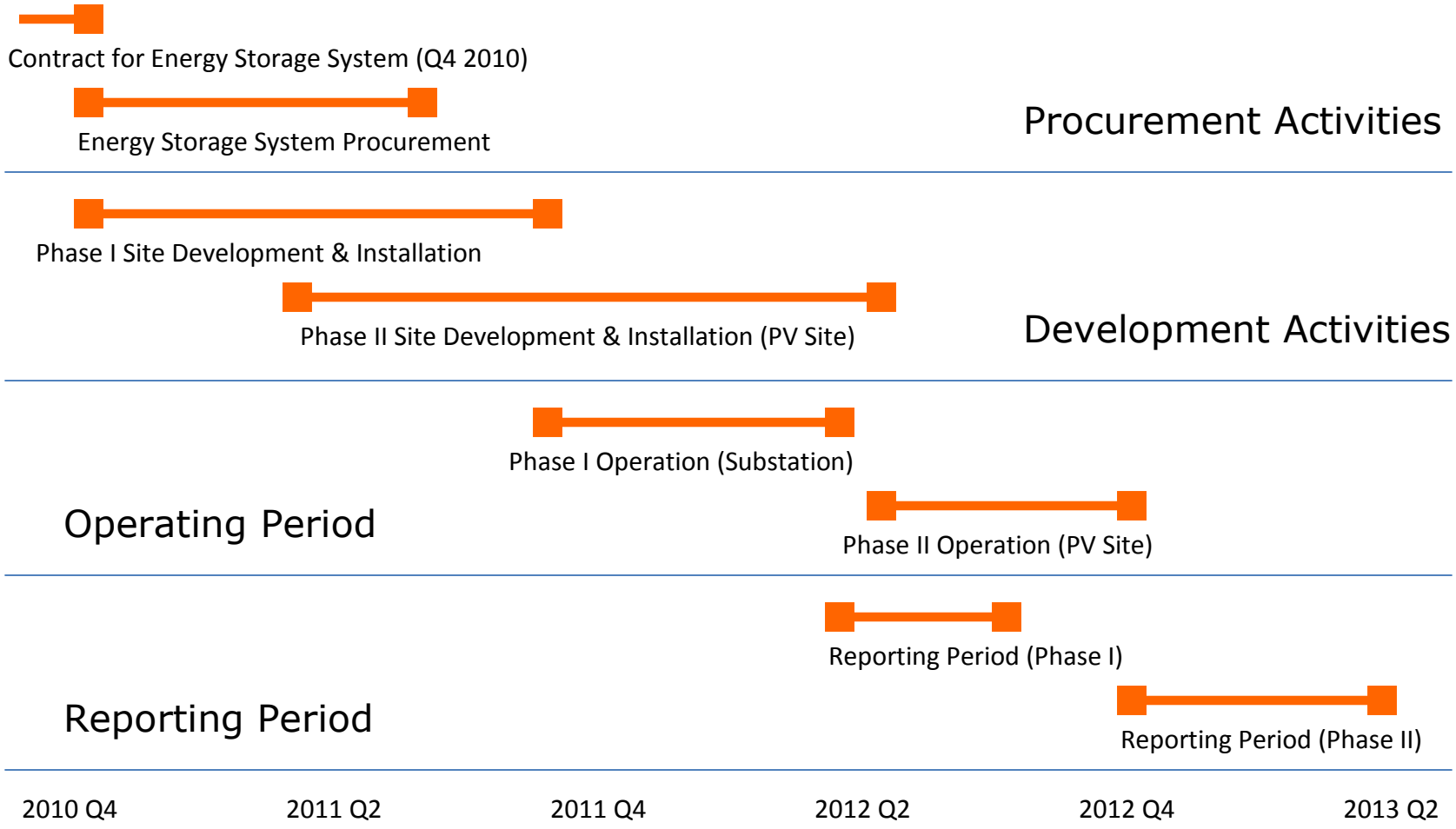
Partially Cloudy Day



Source:

Sandia National Laboratories

Energy Storage – APS Demonstration



Energy Storage – APS Demonstration – Phase I

- Locate in a Flagstaff, AZ substation
- Start testing Fall 2011
- Test control and communication interfaces
- Learn system operating characteristics
- Dispatchability
- Peak shift testing
- Test frequency/ voltage control capabilities

Energy Storage – APS Demonstration – Phase II

- Performed with Flagstaff Community Power Project though separate
- Interconnect at Doney Park complex
- Test peak shifting characteristics
- Test under different configurations of variable resource conditions and capability to reduce variability

Energy Storage – Other work…

Molten Salt Storage

Solana CSP Plant – 6 hours of Storage

Proven Technology – In operation late 2013

Currently in operation – Spain

Salt availability

Cost / Risk

Alternative Thermal Storage

US Solar and APS have been awarded a DOE grant for the exploration of Thermocline and Thermal Mass Storage

Project planned to be demonstrated at APS' Saguaro 1MW CSP Plant

Objective is to develop lower cost, efficient thermal storage that can be scaled to larger scale development

Energy Storage – Other work…

Compressed Air Energy Storage

- Below Ground Storage
  - Cavern availability
  - Transmission availability
  - Location of renewable
- Above Ground Storage
  - May provide more versatility
  - What about aux load and losses

CONTACT INFORMATION

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