Integrating CSP w/ TES into a Utility System

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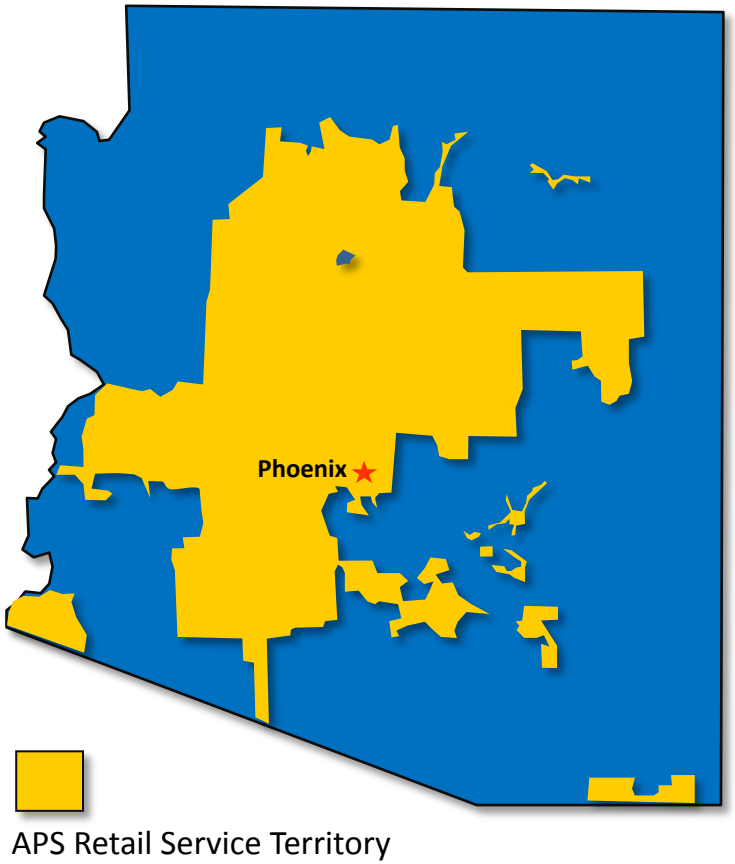
Outline

- Background on APS
- History of Solana
- Value of CSP
- Challenges and Resource Outlook

Arizona Public Service Co.

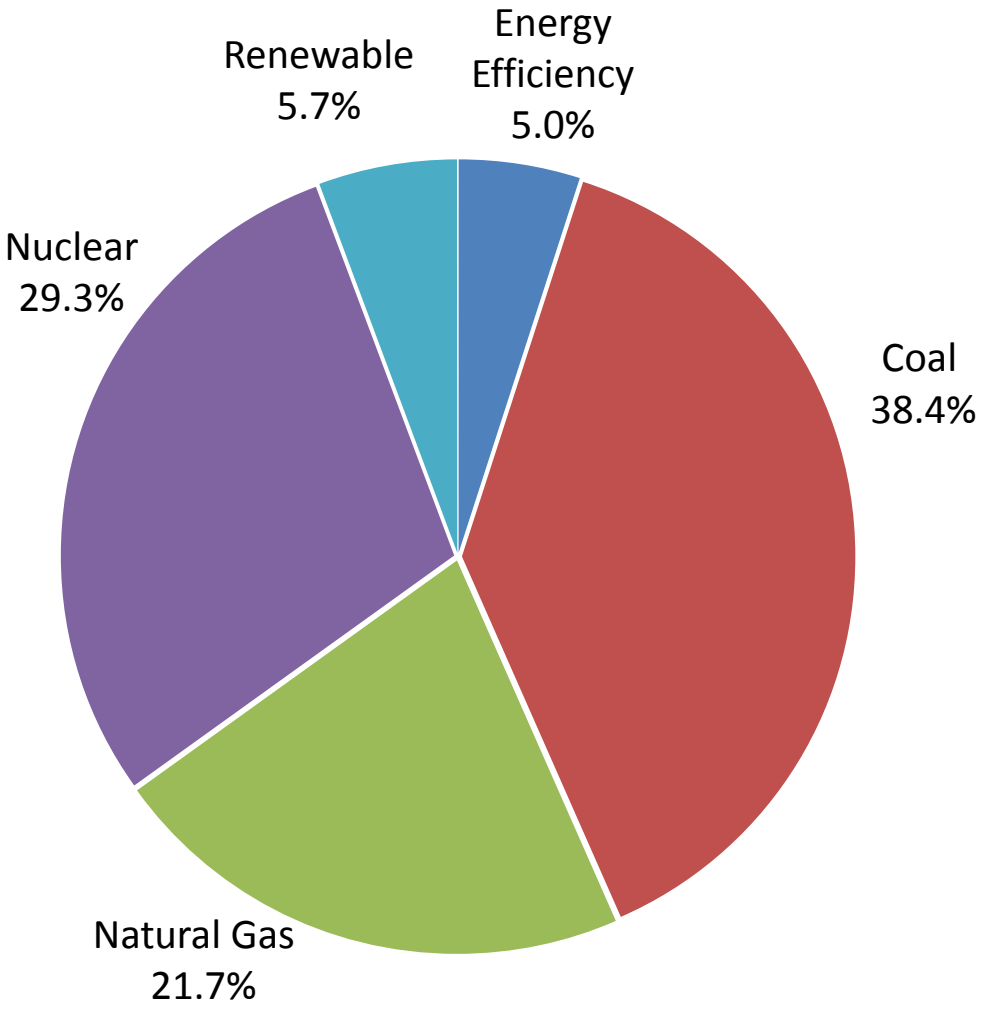
- **Largest utility in Arizona**
  - 1.1 million customer accounts
  - 34,646 square miles
- **Scope of Energy Delivery**
  - 28,000 distribution miles
  - 5,300 transmission miles
  - 410 substations
- **Resources**
  - 8,600 MW total capacity
  - Peak demand – 7,300 MW
  - Over 1,000 MWs of renewables owned or in development



Regulatory Commitments

- **Arizona's Renewable Energy Standard (RES)**
  - 15% of retail sales by 2025
    - 4.0% in 2013, increasing one half-percent annually to 5% in 2015
    - DE Requirement is 30% (of total)
- **2009 APS Rate Case Settlement Agreement**
  - Requires an additional 1.7 GWHs above 2008 contracts
  - Represents approximately 3.4 GWHs by 2015
  - Projected to be >10% of retail sales by 2015
- **APS is on-track to meet these targets**

Projected 2013 Energy Mix



Five Major Categories of Resources

Nuclear

- Palo Verde

- Reliable source of carbon-free around-the-clock power
- Lowest operating cost

1,146 MWs

Coal

- Four Corners
- Cholla
- Navajo

- Affordable source of around-the-clock power
- Relatively expensive and time consuming to start/stop

1,753 MWs

Natural Gas Intermediate Units

- Redhawk, Gila, Arlington
- West Phoenix Units 1-5
- Saguaro and Ocotillo Steamers

- Large, high efficiency units
- Long start-up, required minimum up and down times
- Reliable and flexible to system demands

3,371 MWs

Natural Gas Peaking Units

- Sundance
- Yucca
- West Phoenix, Saguaro, and Ocotillo GTs

- Small, less efficient units
- Short start –up, can be online in 10-30 minutes
- Very flexible

1,017 MWs

Renewables

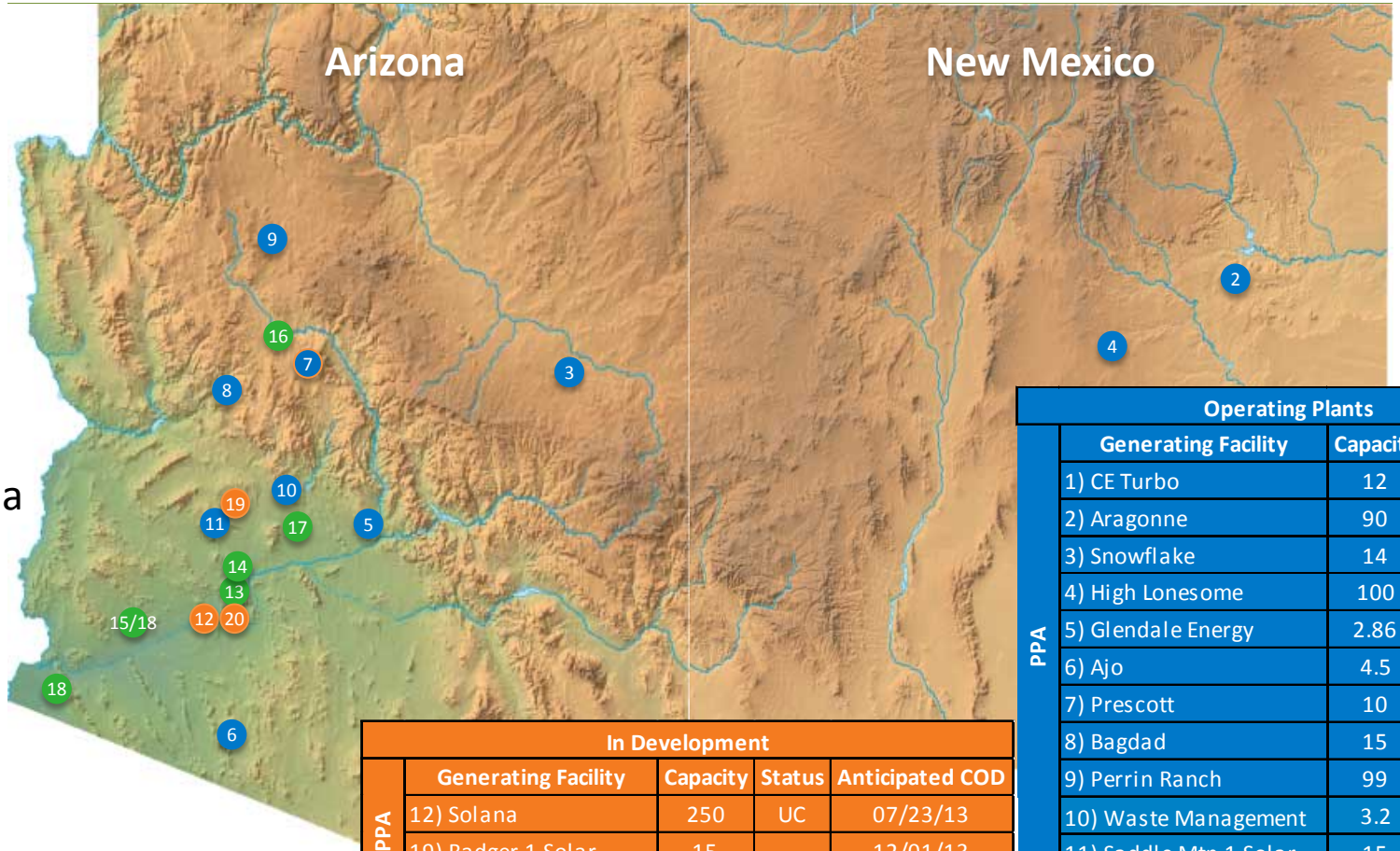
- Wind
- Solar
- Geothermal/Biomass

- Clean source of energy
- Most sources are non-dispatchable (must take energy as it is produced)

475 MWs

aps

APS Renewable Generation



Operating Plants			
	Generating Facility	Capacity	COD
PPA	1) CE Turbo	12	01/27/06
PPA	2) Aragonne	90	12/29/06
PPA	3) Snowflake	14	06/10/08
PPA	4) High Lonesome	100	07/16/09
PPA	5) Glendale Energy	2.86	01/13/10
PPA	6) Ajo	4.5	09/26/11
PPA	7) Prescott	10	11/29/11
PPA	8) Bagdad	15	12/30/11
PPA	9) Perrin Ranch	99	06/24/12
PPA	10) Waste Management	3.2	08/31/12
PPA	11) Saddle Mtn 1 Solar	15	12/20/12
AZ Sun	13) Paloma	17	09/12/11
AZ Sun	14) Cotton Center	17	10/24/11
AZ Sun	15) Hyder	16	10/31/11
AZ Sun	16) Chino Valley	19	11/25/12

In Development				
	Generating Facility	Capacity	Status	Anticipated COD
PPA	12) Solana	250	UC	07/23/13
PPA	19) Badger 1 Solar	15		12/01/13
PPA	20) Gillespie 1 Solar	15		12/31/13
AZ Sun	17) Foothills	35	UC	12/01/13
AZ Sun	18) Hyder II	14	UC	12/01/13
AZ Sun	21) Gila Bend	32	RFP	2014

Renewable Resource Summary

- **Renewable Resources by Type (by end of 2014):**

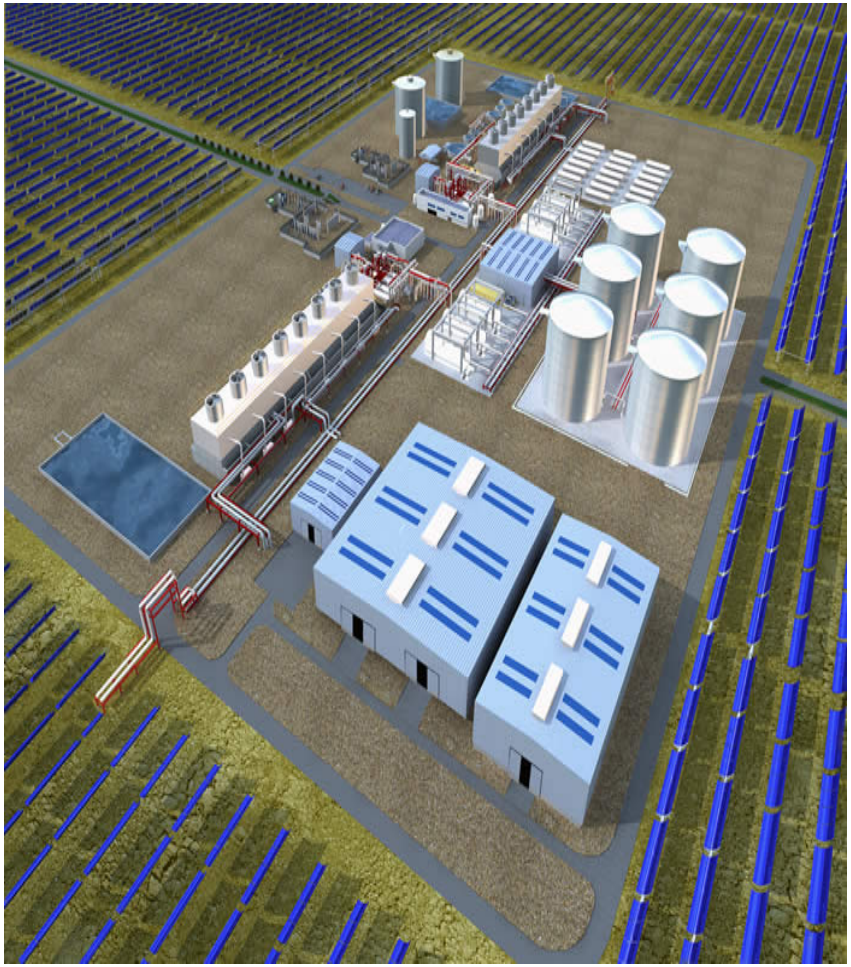
Wind	**289 MWs**
Geo./Biomass/LFG	**32**
Solar PV	**225**
Solar CSP/TES	**250**
Total =	**796 MWs**

Note – does not include Distributed Energy (DE) which is currently over 200 MWs

History of Solana

- **APS Selected Solana via a competitive solicitation process**
  - **2007 Renewable Resource RFP**
  - **Solana was not the lowest LCOE resource**
  - **Selected because it provided a favorable overall value proposition for our customers**
  - **APS entered into a 30 year PPA to purchase all of Solana's energy production**

Solana (Solar Trough with Storage)



Developer - Abengoa

Location – 10 miles west of Gila Bend, AZ

Total Generation – 250 MW ~ about 900,000 MWHs energy production per year (approximately 3% of APS overall energy requirements)

Size – 3 square miles

Construction – Scheduled completion date of Summer, 2013

Thermal Energy Storage – Includes 6 hours of thermal energy storage

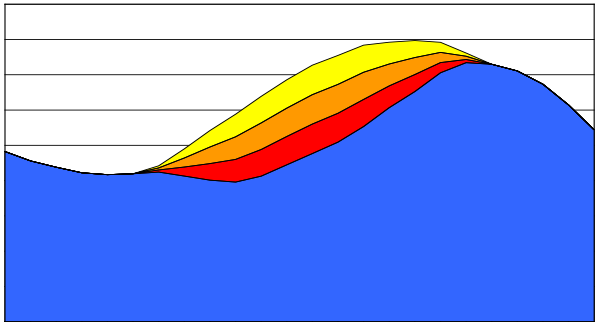
Environmental Benefits

- Zero Emissions
  - 475,000 tons annually of carbon dioxide
  - 520 tons annually of sulfur dioxide
  - 1,065 tons annually of nitrogen oxides
- Equivalent to taking half the cars off US 60 every day
- 75% Less water then current agricultural use

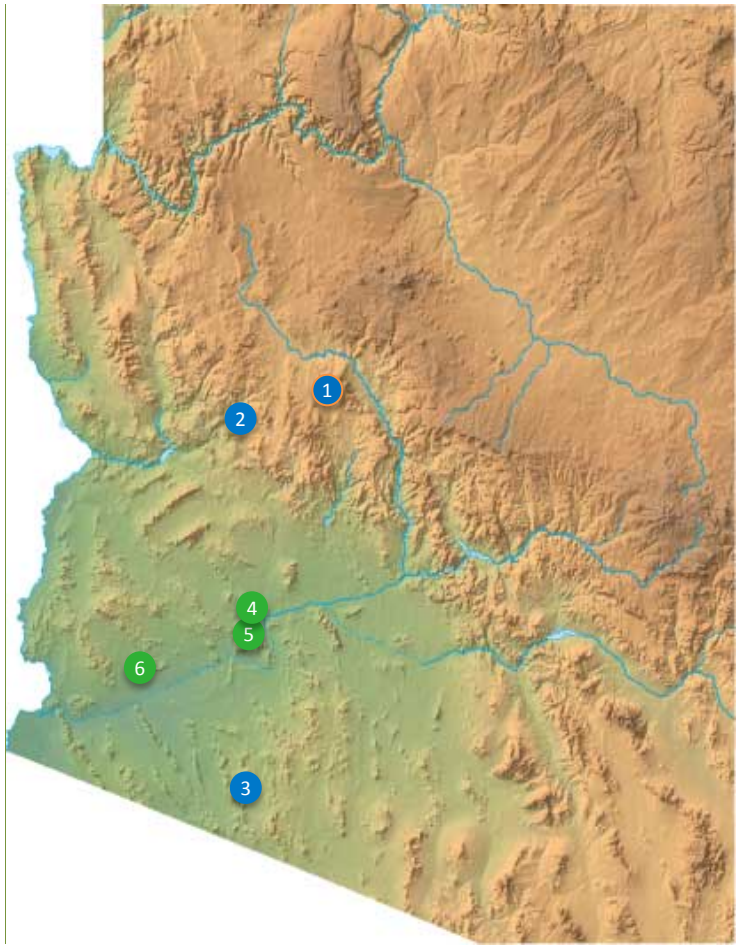
Value of CSP

- **Diversification in Several Dimensions**
  - Technology (PV, CSP w/storage, wind, biomass, geothermal)
  - Balanced resource portfolio mix
  - Ownership vs. PPA
  - Capability to integrate smaller scale projects
  - Geographic diversity
- **What Provides the Best Value for our Customers?**
  - Cost
  - Energy production pattern
  - Capacity value (contribution to meeting peak load)
  - Impact on system regulation
  - Solar PV and diminishing returns

Value of Solar PV Declines as Deployment Levels Increase



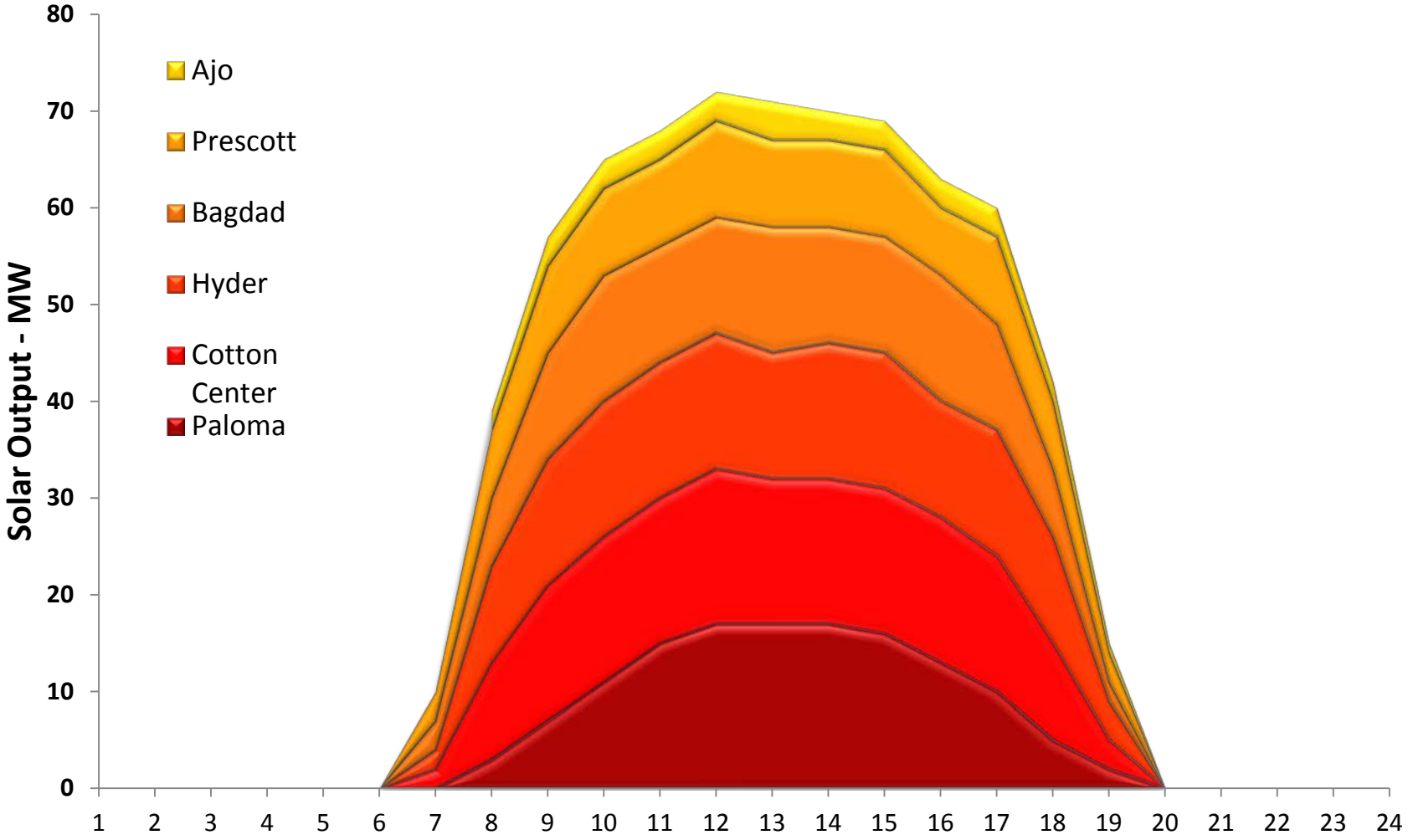
APS Solar Production on Peak Day 2012



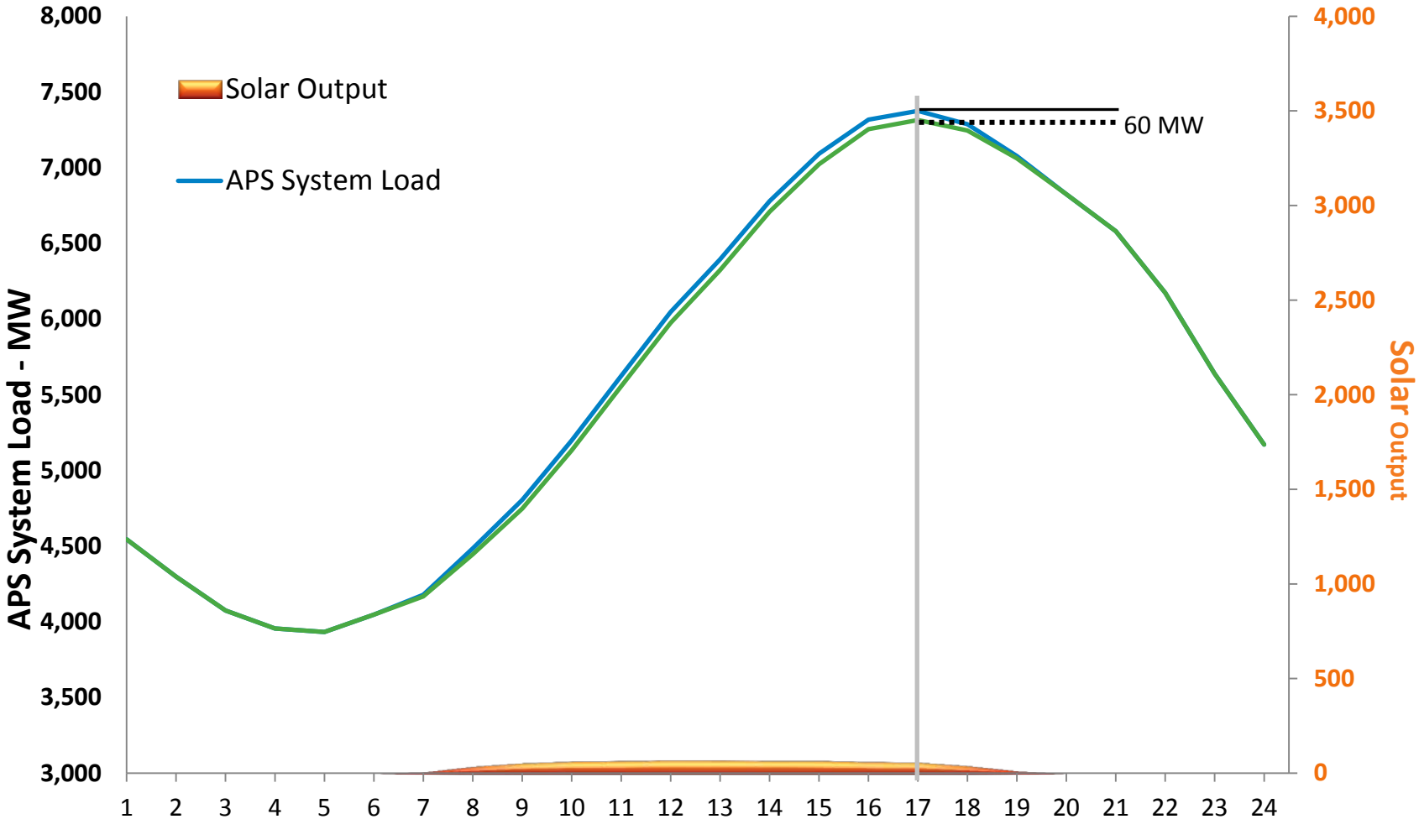
- Illustration of declining capacity value
- Actual solar production and load data
- Six operating solar plants
  - Five plants SAT
  - One plant fixed position, south facing
- Peak day, August 8, 2012

Operating Solar Plant Capacity (MW)			
	Facility	Peak	Coincident
PPA	1) Prescott	10	9
	2) Bagdad	14	11
	3) Ajo	4	3
AZ Sun	4) Cotton Center	18	14
	5) Paloma	17	10
	6) Hyder I	15	13
Total		**78**	**60**

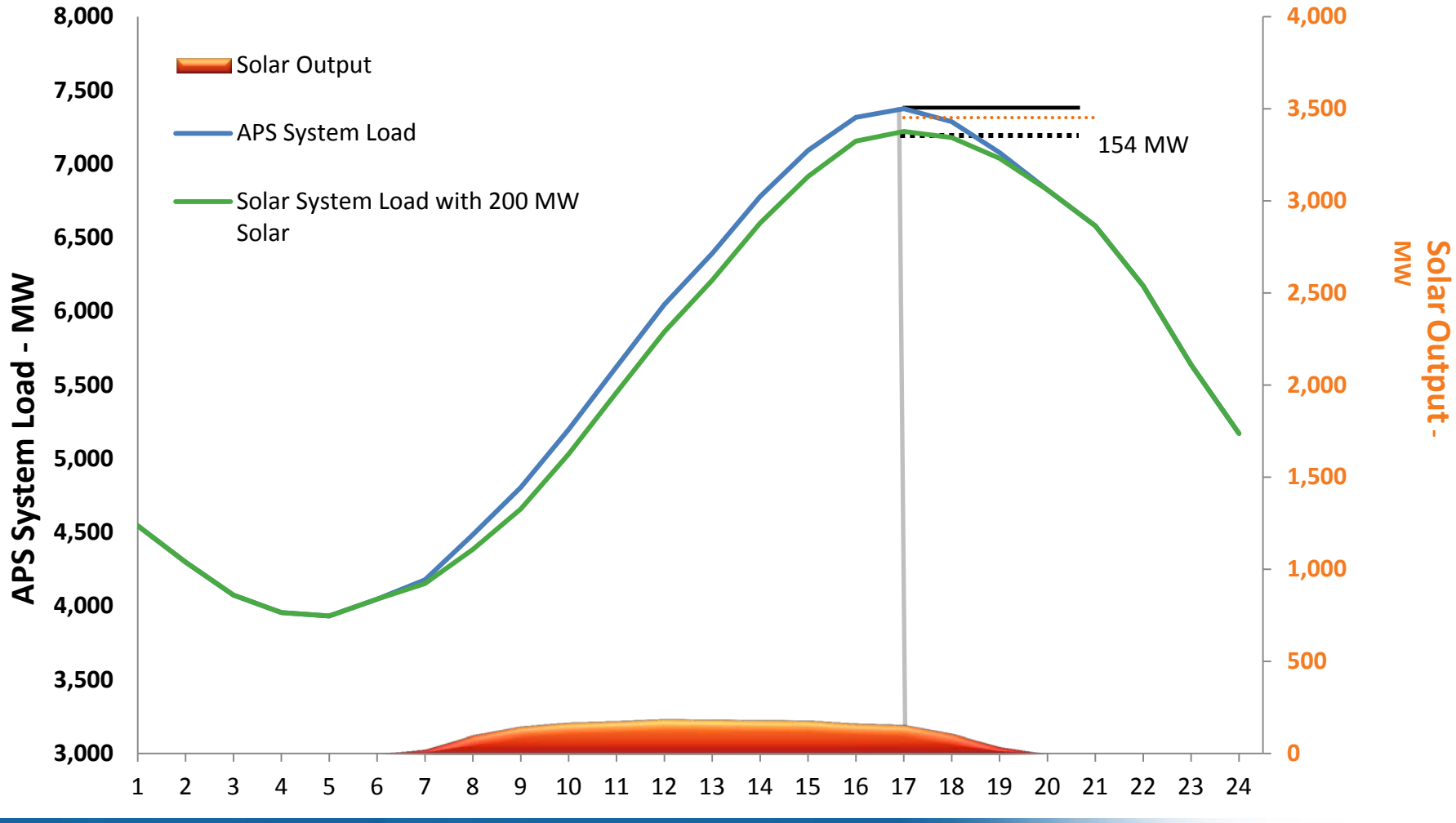
Solar Output on APS System Peak Day
(August 8, 2012)



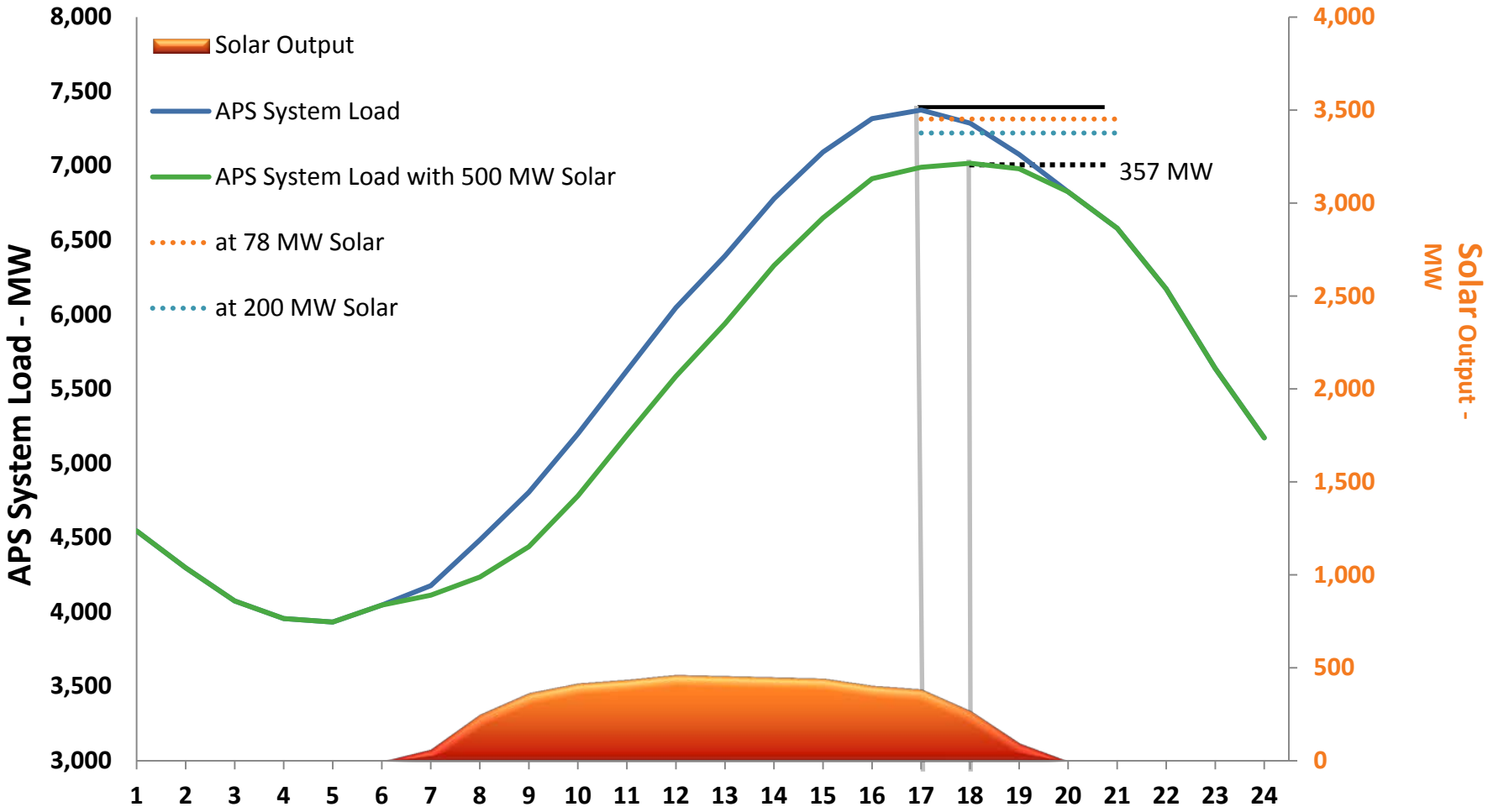
APS System Load Profile With 78 MW Solar PV



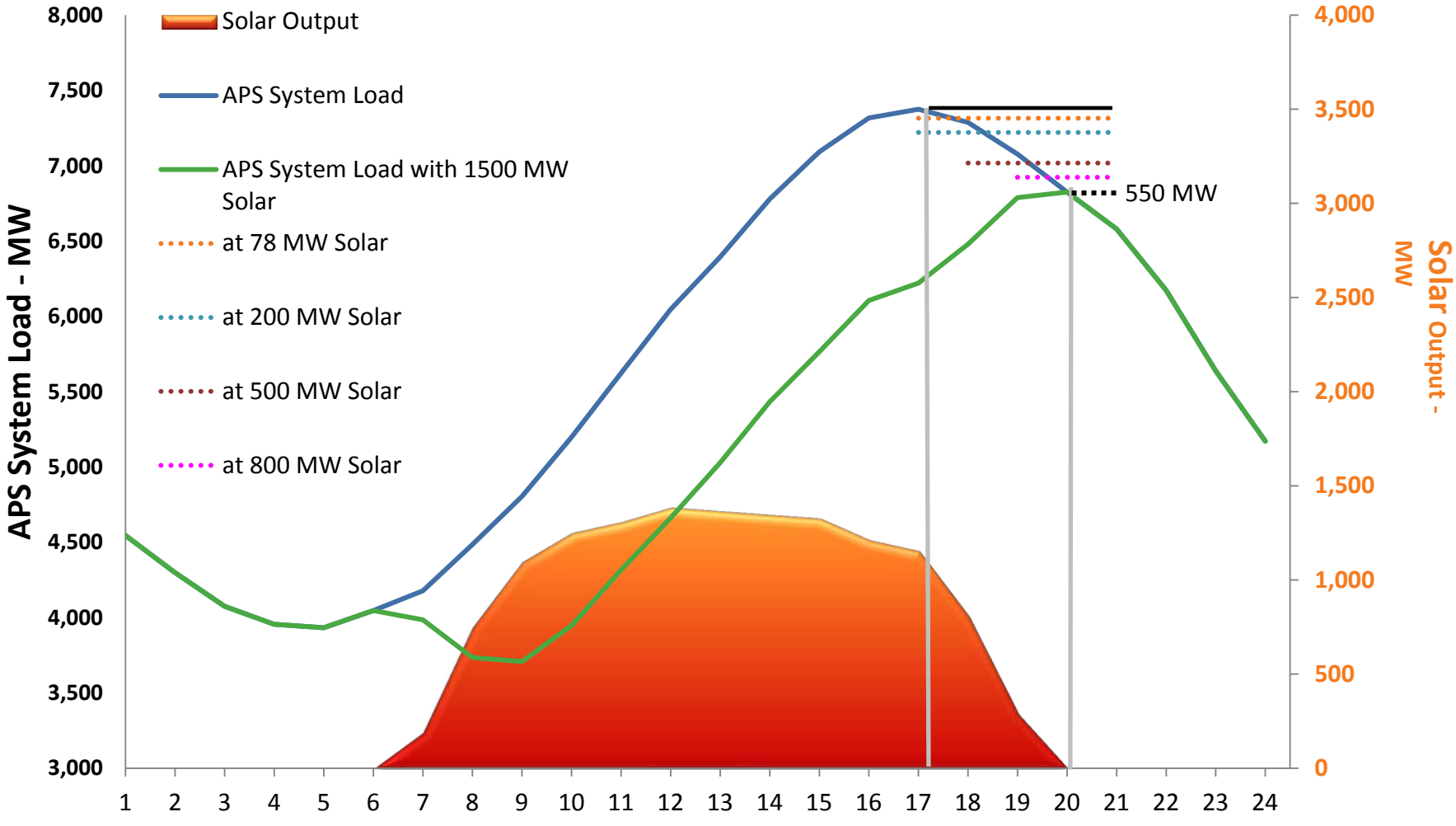
APS System Load Profile With 200 MW Solar PV



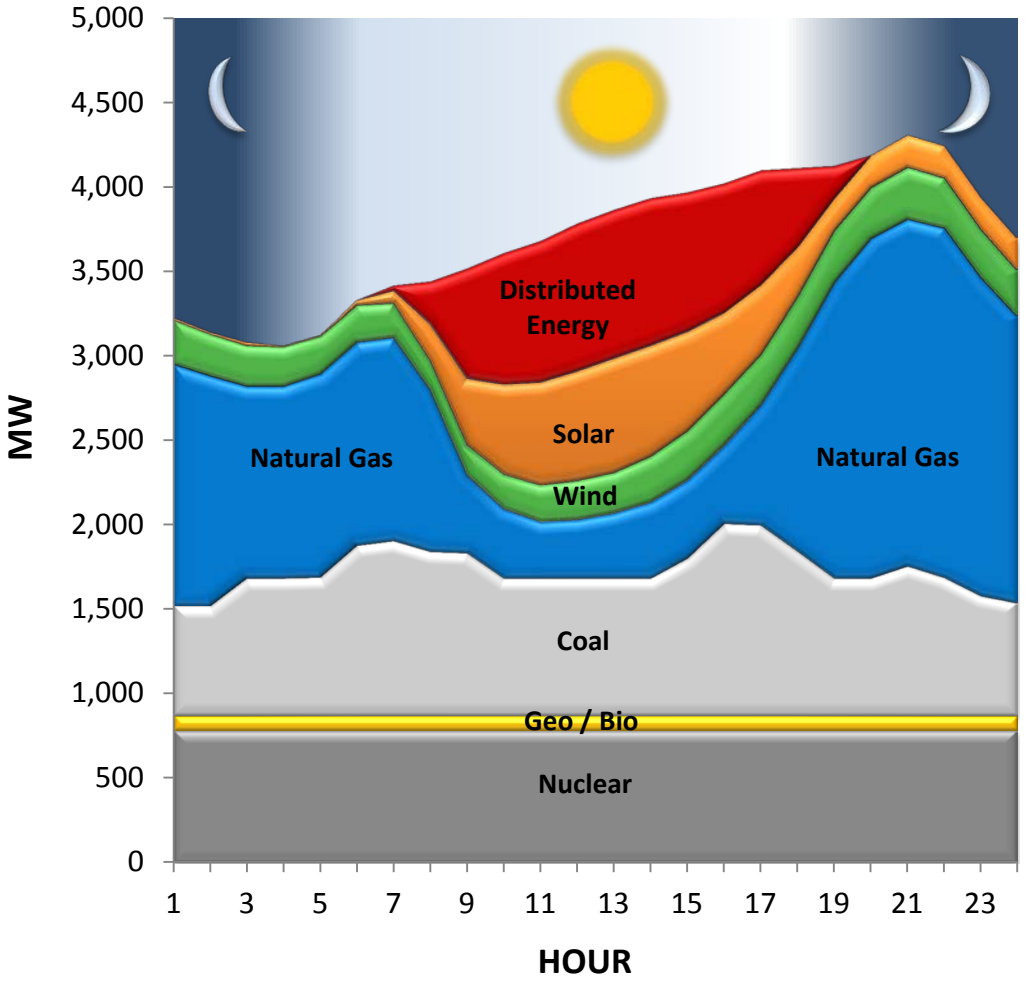
APS System Load Profile With 500 MW Solar PV



APS System Load Profile With 1,500 MW Solar PV



Solar PV Deployment Impacts System Ops



- Higher penetration of solar creates two daily peaks for gas units
  - Multiple gas unit starts per day
- Natural gas units will need to quickly ramp up and down to respond to peaks

Challenges for APS

- **Integrating Solana into our System Operations**
  - Solana is a unique resource
  - APS has not had energy storage
  - Adds complexity to our optimization decisions
  - Operators will need to become familiar with all aspects of Solana to optimize the dispatch
    - Technical aspects of Solana operations
    - Impact of weather variations
    - Contractual terms
  - Good communications are critical
- **Integration of Variable Energy Resources (VERs)**
  - Good diversity of resource type so far (mix of wind, solar PV, solar CSP, etc.)
  - Has been manageable
  - Investigating additional tools like EIM, intra-hour markets, ACE diversity
  - Need to improve solar forecasting (utility-scale and behind-the-meter)

APS Resource Outlook

- **Renewable resource needs**
  - **Have/will satisfy near-term targets**
  - **Will not require additional renewable resources (to meet state standard) for several years**
- **Major uncertainties in our resource outlook**
  - **Coal units may require significant upgrades for environmental compliance**
  - **Customer contingent resources dependent upon customer willingness to participate**
    - **EE standard of 20% by 2020**
    - **DE is 30% of our renewable requirement**

Benefits of Solar CSP with TES

- **Solana – Meeting our Customer's Energy Needs**
  - Full capacity contribution during peak load times
    - Note – no natural gas co-firing
  - Dispatchability to help meet dual-peaks in winter months
  - A stable and dependable source of utility electric generation

- **Solar CSP Deployment – Keys to Success**
  - Stakeholders must appreciate the value proposition of CSP
  - CSP (and competing renewable technologies) must be valued correctly in terms of:
    - Capacity contribution
    - Flexibility
    - Intermittency
  - Lowest LCOE does not necessarily lead to lowest overall cost to customers

Thank You