

Existing and Future Energy Storage Opportunities

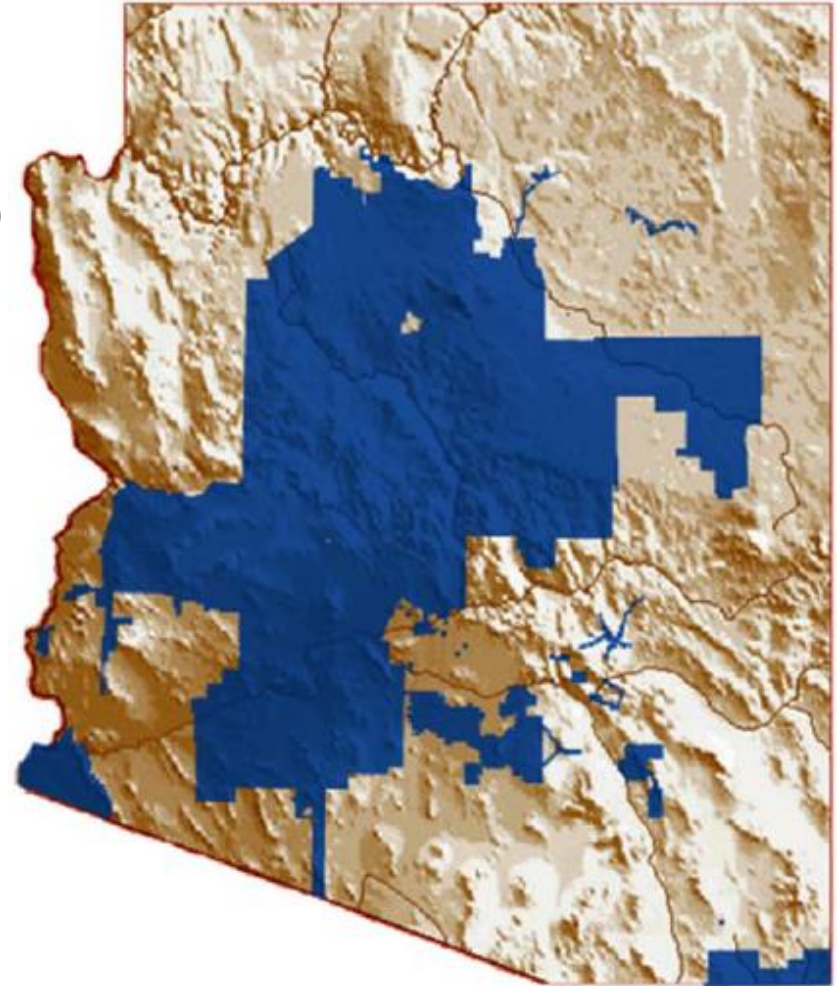
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Director, Resource Planning



APS Service Territory

- Arizona's largest and longest-serving utility – since 1886
- Service Territory
 - 11 of 15 Counties
 - 1.2 million customer accounts (89% residential)
 - Approximately 45% of Phoenix customers
 - 34,646 square miles
- Arizona's largest taxpayer
 - \$3.4 Billion annual economic impact to AZ
 - \$1 Billion spent annually with AZ businesses
 - \$400 Million with minority and women-owned businesses
- Investor-owned utility - subject to forms of public control and regulation
- ~6,400 employees
- Peak load ~7,350 MW in 2017



APS Resource Diversity

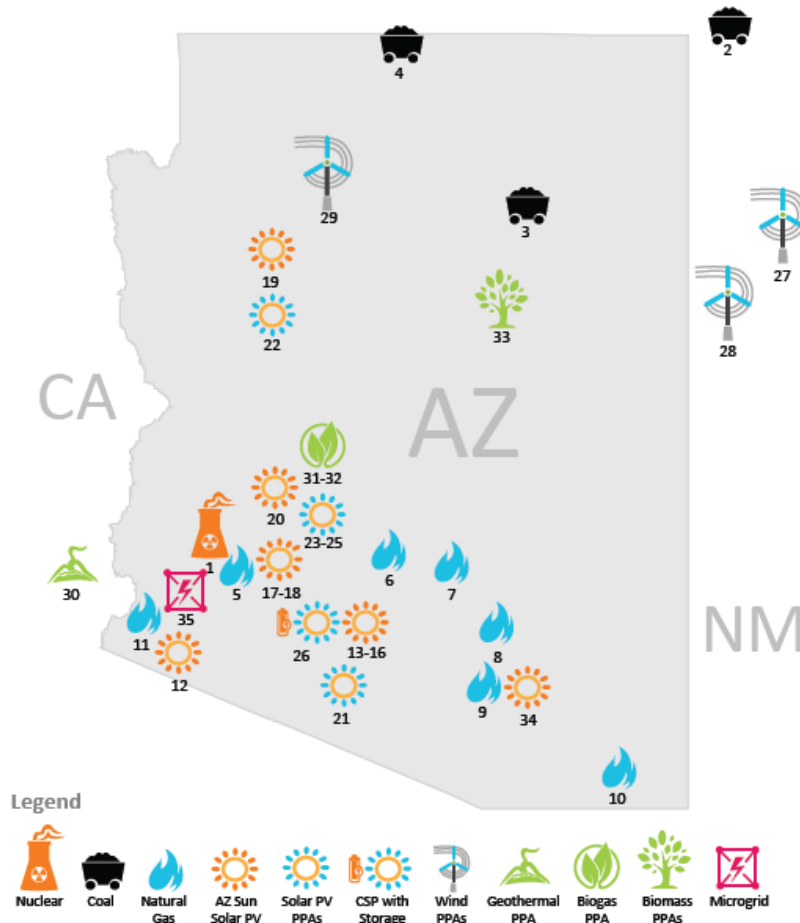


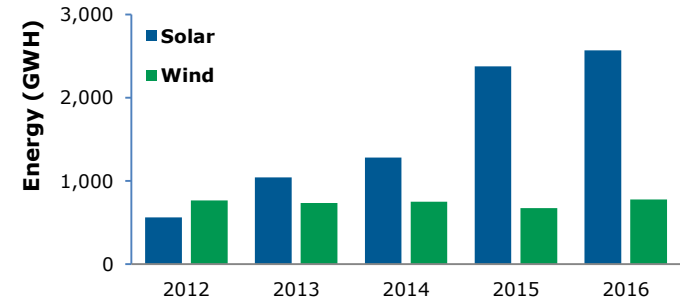
TABLE 2-1. APS EXISTING RESOURCES

TOTAL RESOURCES	9,327 MW
Nuclear	1,146 MW
Coal	1,672 MW
Natural Gas	4,183 MW
Owned Resources	3,106 MW
PPAs	1,077 MW
Microgrid	22 MW
Renewables	881 MW
Solar	562 MW
Owned Resources	237 MW
PPAs	325 MW
Wind (PPAs)	289 MW
Other (PPAs)	30 MW
Customer-Based	1,423 MW
Energy Efficiency	737 MW
Distributed Energy	660 MW
Demand Response	26 MW

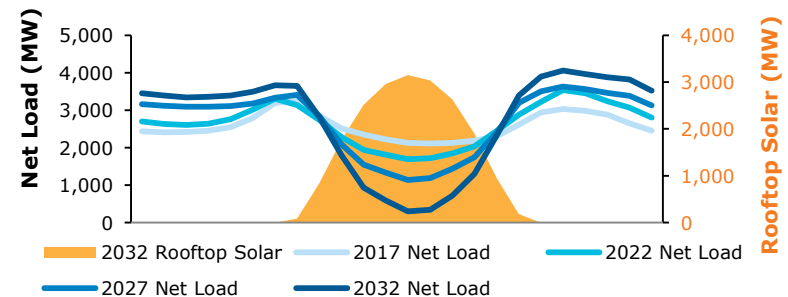
Evolving Load Patterns and Markets

- APS is ahead of renewable compliance with over 1 GW of solar resources
- APS net load shapes have changed due to increasing levels of renewable energy resources including non-curtailable rooftop solar
- Wholesale market prices have changed faster than expected due to renewable mandates in neighboring states
- APS requires a flexible resource portfolio to ensure reliable operations under rapidly changing system needs:
 - Flexible generation
 - Curtailable renewables
 - Targeted demand-side management

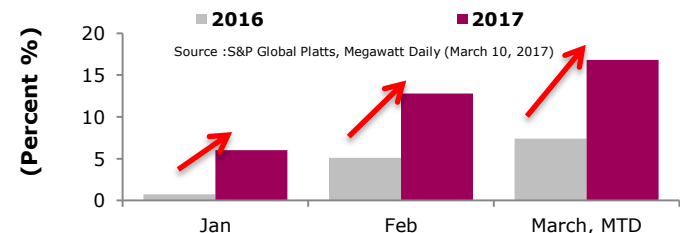
APS Renewable Energy



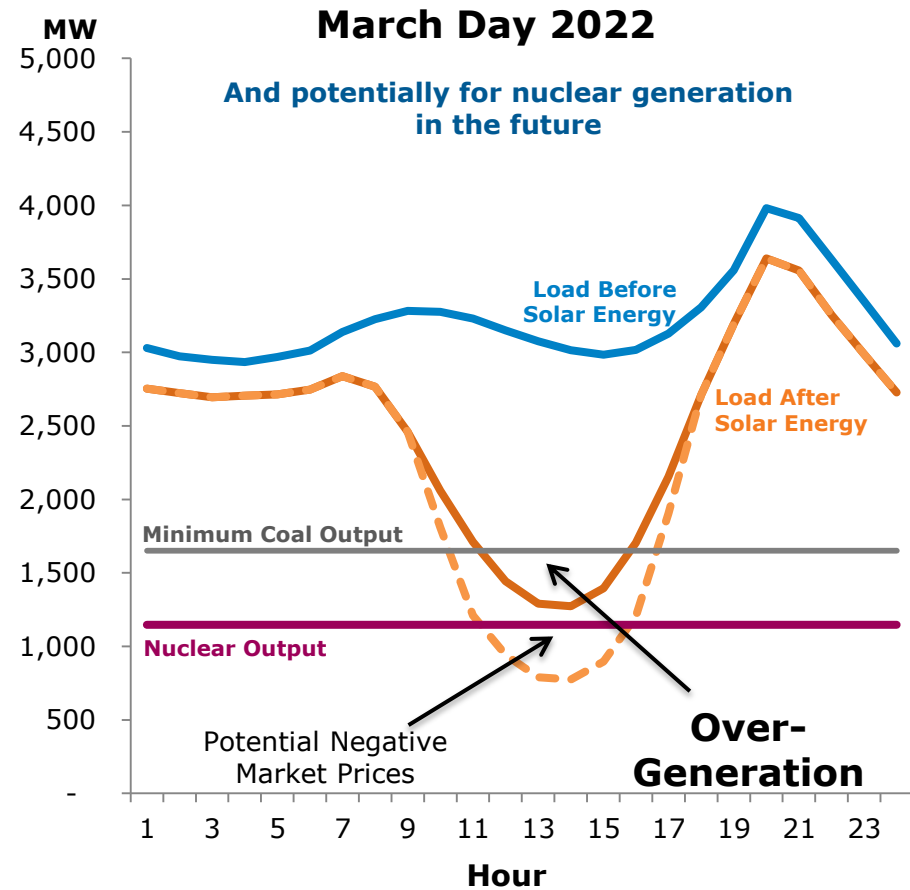
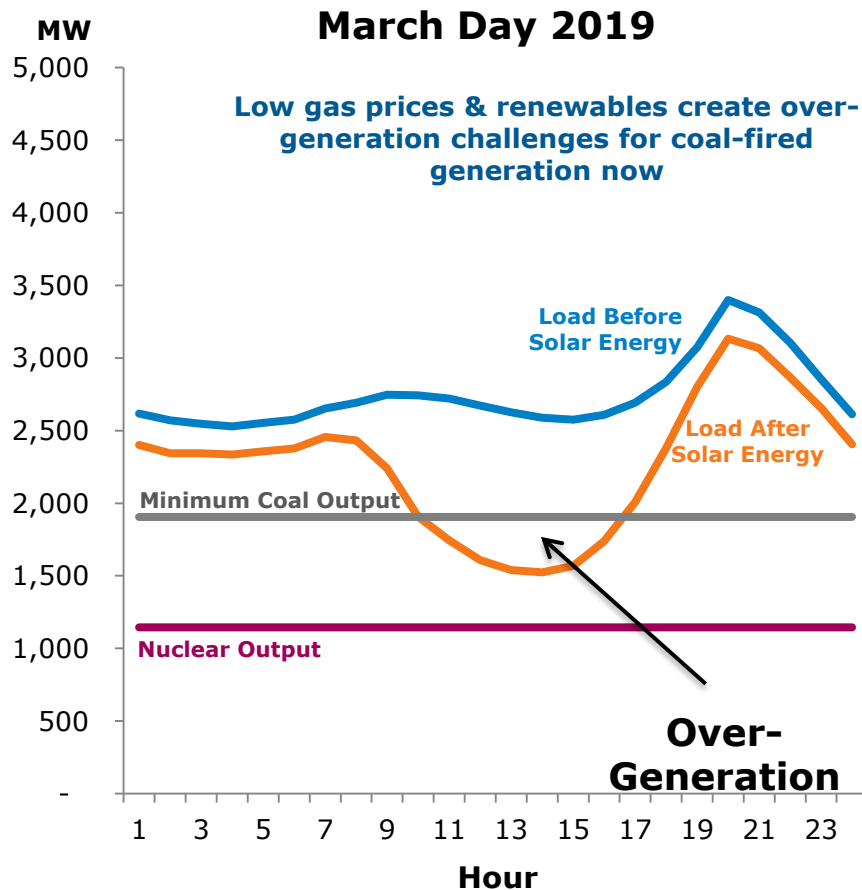
APS Evolving Load Shape Non-Summer Illustration



Frequency of Real Time Negative Prices

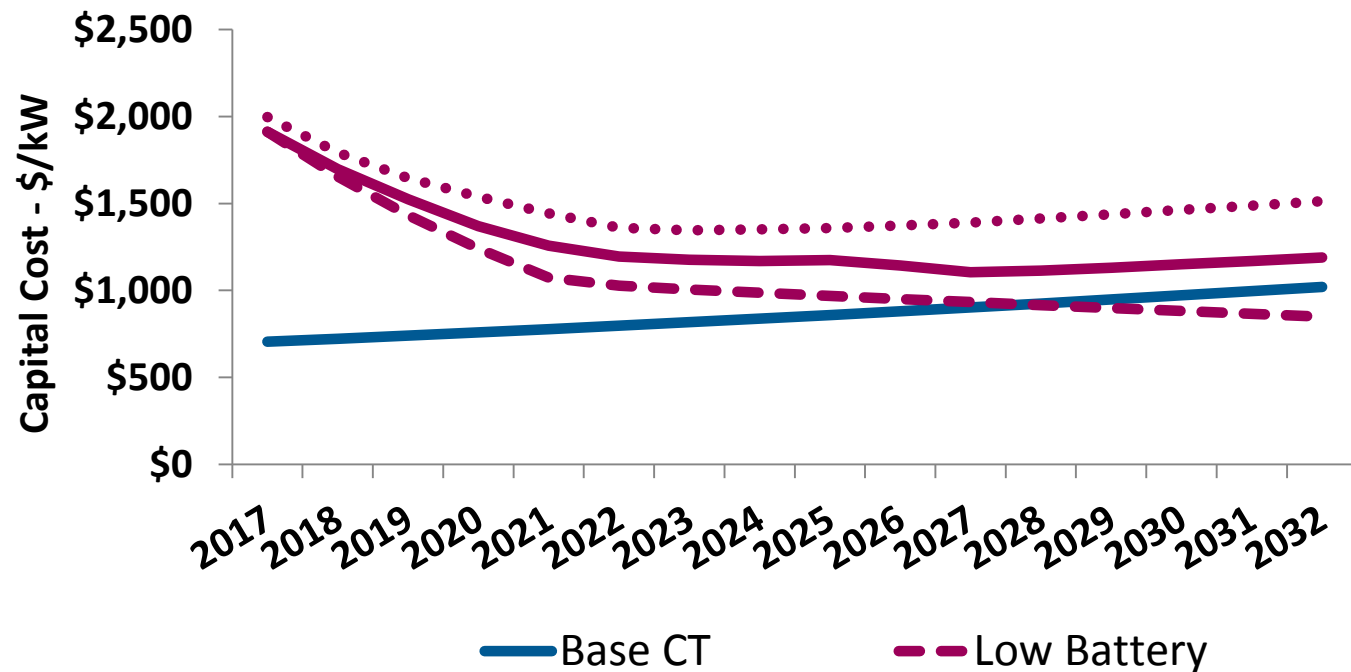


APS Non-Summer Net Load Curves & Low Gas Prices Predict Challenges for Baseload



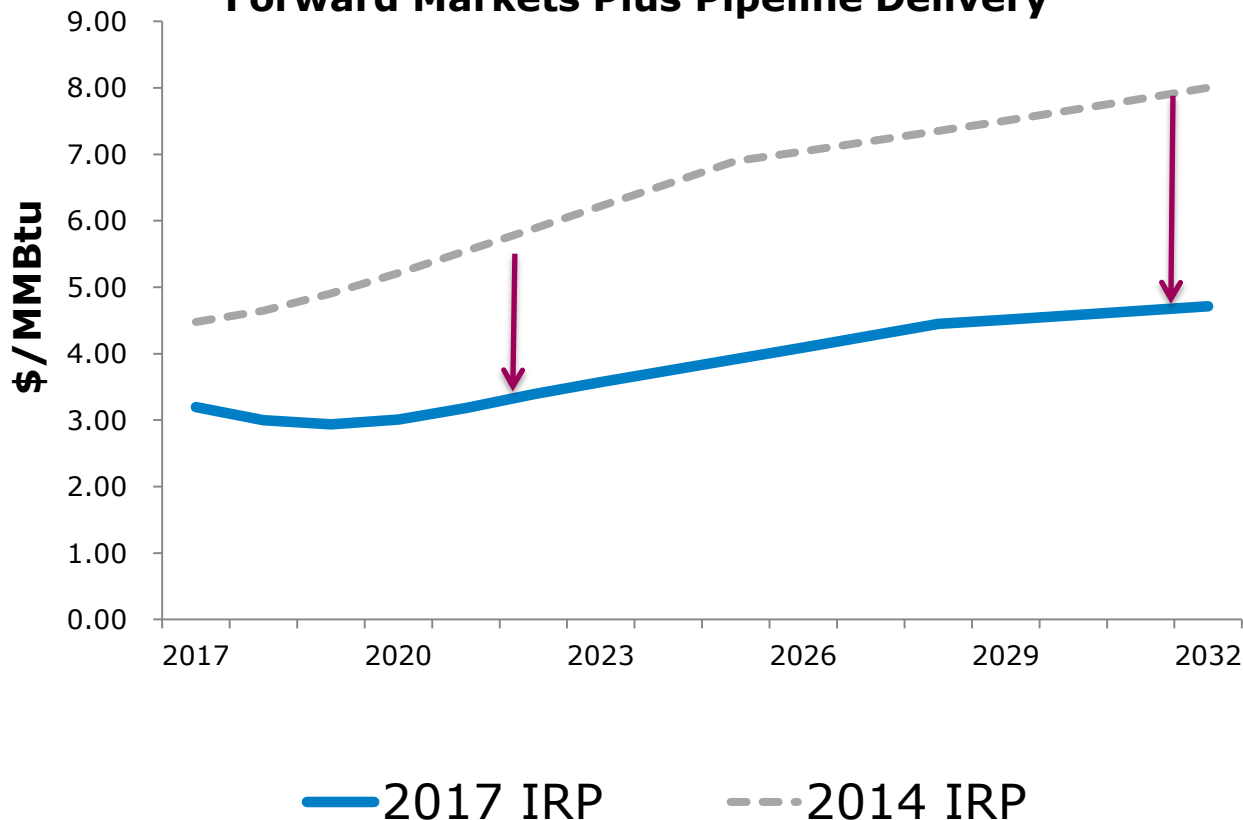
2017 IRP Energy Storage Costs

- 100 MW 4-hour Battery in 2024
- 500+ MW Grid Scale Batteries over the planning period
- Capacity and arbitrage value drive battery adoption



Low Natural Gas Prices

**Gas Price Forecast
Forward Markets Plus Pipeline Delivery**

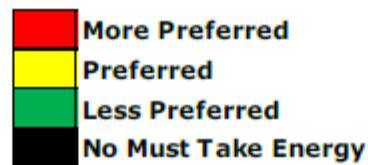
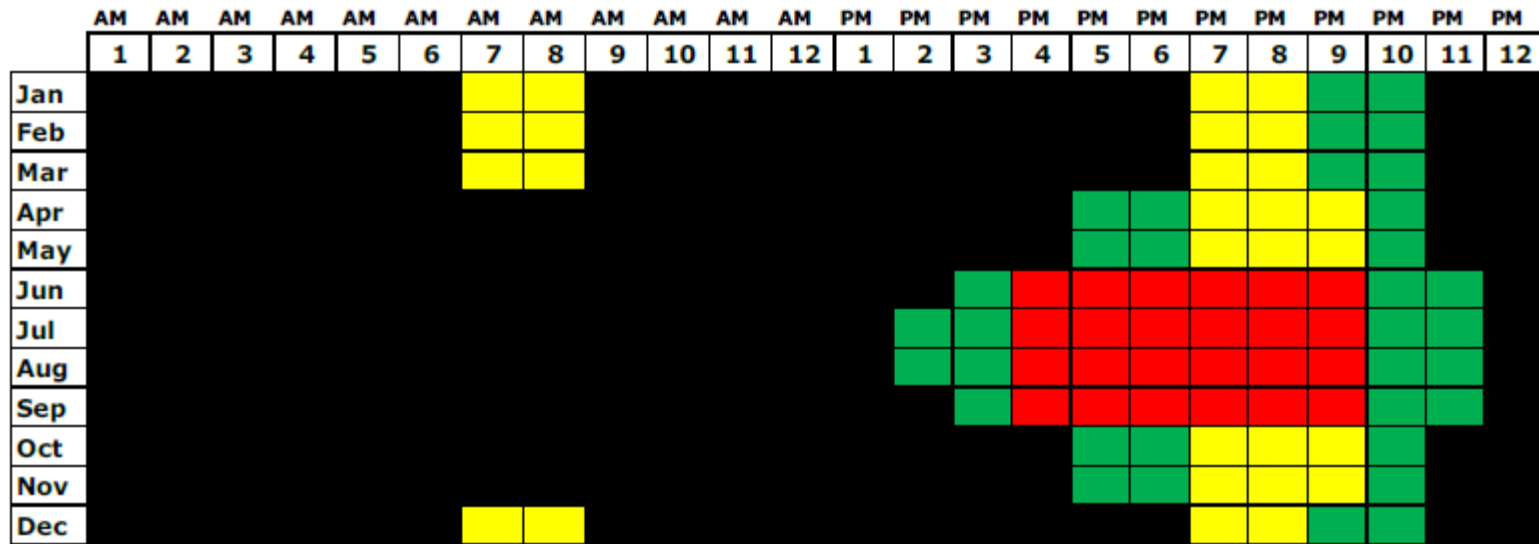


- Favorable outlook, stable long-term price forecast, low emissions
- Flexible generation, meets peak demand and integrates variable energy resources

2017 RFP – Resource Evaluation

Appendix A

Time of Day Relative Net Load Heat Map



Evolving World: Driving New Investments in Technology



Drivers for Change

- Traditional grid built for one-way flow technology
- Advancements (storage, home energy management)
- Changing customer needs and demands
- Increased distributed solar energy which does not align with peak

The Modern Grid

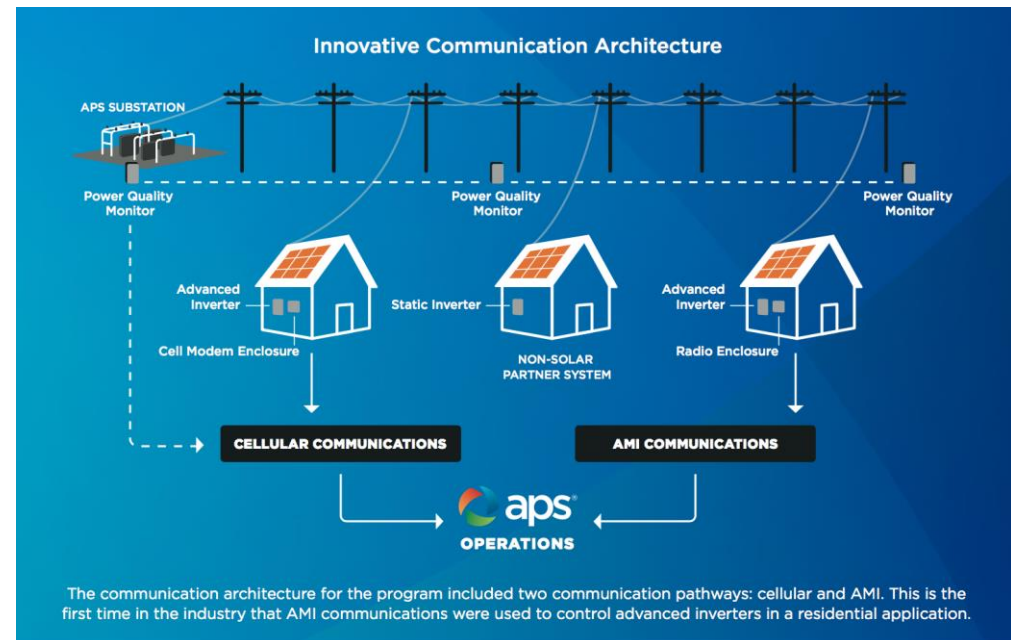
- New technologies to enable two-way flow
- Proactive vs. reactive operations and maintenance
- Modern rate structure
- Smarter, more flexible real-time system operations
- Support consumer products and services

APS Laying the Foundation

- Solar R&D initiatives
- Smart meters fully deployed
- Evaluating storage/customer-sited technology
- Microgrid development
- Software upgrades for distribution operations and customer service

Distributed Energy Resources

- Solar Partner Program (SPP)
 - 10 MW of solar owned and operated by APS
 - Research & Development
 - west-facing
 - advanced inverters
 - capital deferment
 - secure communications infrastructure
 - voltage and power quality management
- Award winning advanced inverter research
 - Distributech – solar integration project of the year
 - GTM – grid edge project of the year
 - Edison Award finalist



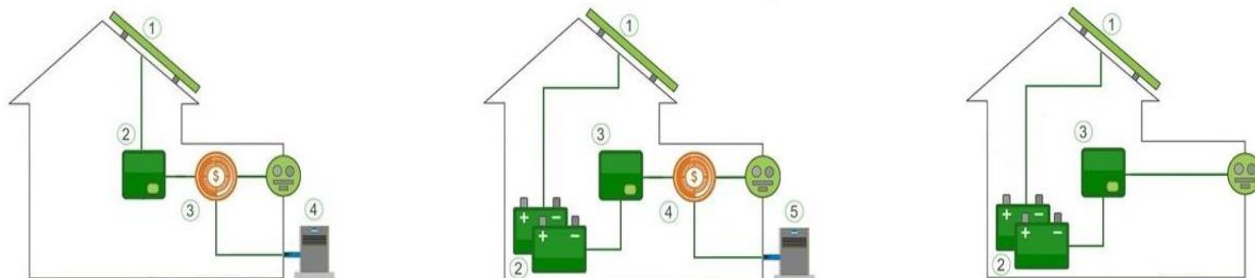
APS Utility-Scale Project – BESS for SPP (Installed)

- Test capabilities of Battery Energy Storage Systems (BESS) to improve power quality on high penetration SPP feeders
- Evaluate interoperability with smart inverters, IVVC and Cap banks on separate SPP feeders over 2017 test plan
- Installed two AES BESS rated at up to 2MW/2MWh in Q1 2017; first BESS located at a substation, second BESS located on a separate feeder near the middle of the circuit
- Battery location and communications evaluation is essential



Solar Innovation Study (SIS)

- 75 customer home energy management and rate research and development program
- APS owns and operates combinations of solar, battery storage, home energy management systems, load controllers, HVAC, and automated thermostats
- Examine the integration of customer-sited advanced technologies with demand-based rates
- Understand how these devices integrate to enable peak demand reduction & smoothing

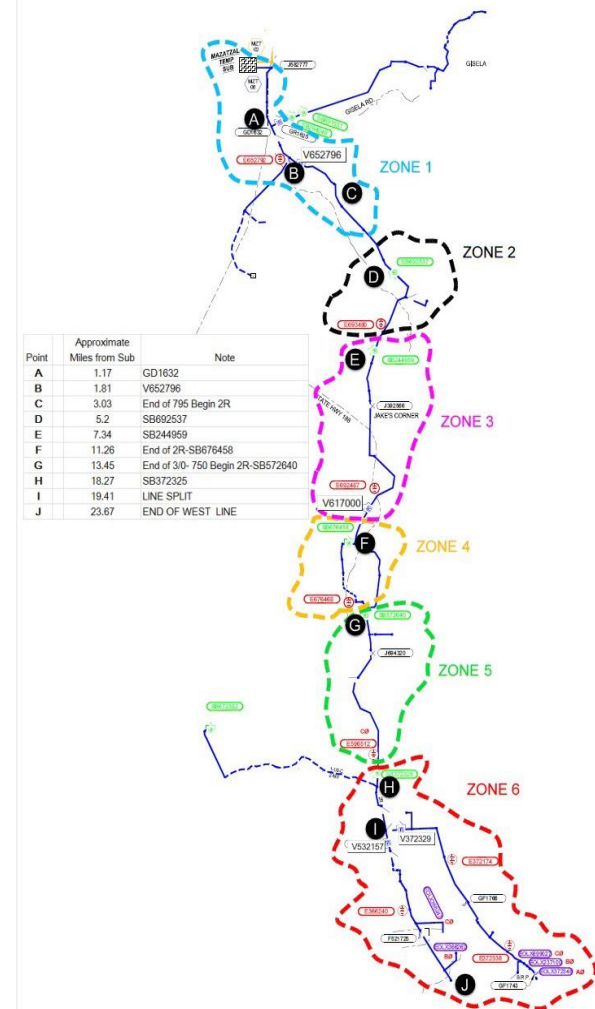


Other Customer Pilots and Programs

- Demand Response Energy Storage Load Management (DRESLM):
 - Grid-interactive water heaters
 - Smart thermostats
 - Residential, C&I, and intermediate batteries
- Demand Side Management (DSM) programs being re-evaluated for peak reduction

APS Utility-Scale Project – DESS for Punkin Center

- Projected load growth to cause overloads in summer of 2018
- Unique circumstances related to load growth, terrain, and incremental need
- Defer 16.5 mile 21kV line rebuild by keeping highest phase below 85% rating
- Initial installation of 2MW (8 MWh) in 1H 2018 at existing APS-owned land
- Auto control from feeder head through EMS and can be manually dispatched by DOC
- Additional capacity to be added as load growth appears in >5 year

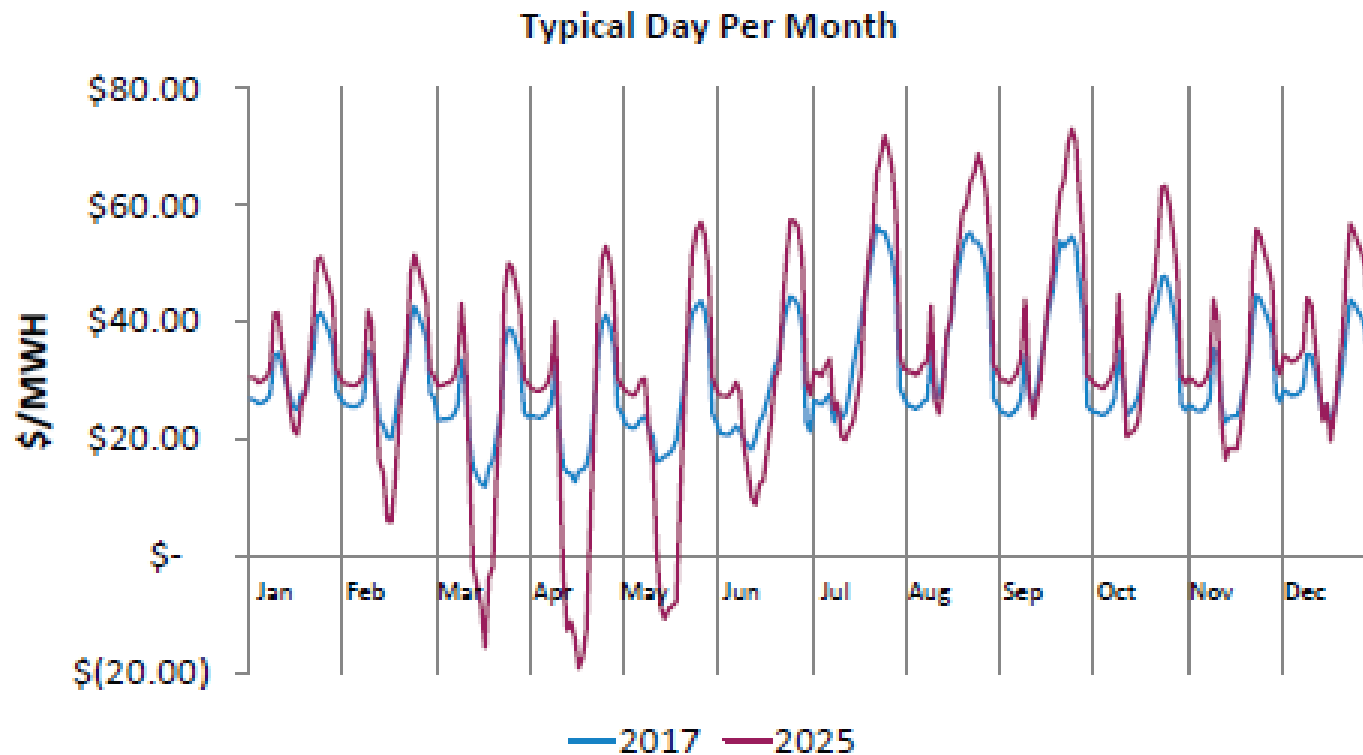


A Proactive Approach to Evaluating Many Energy Storage Opportunities

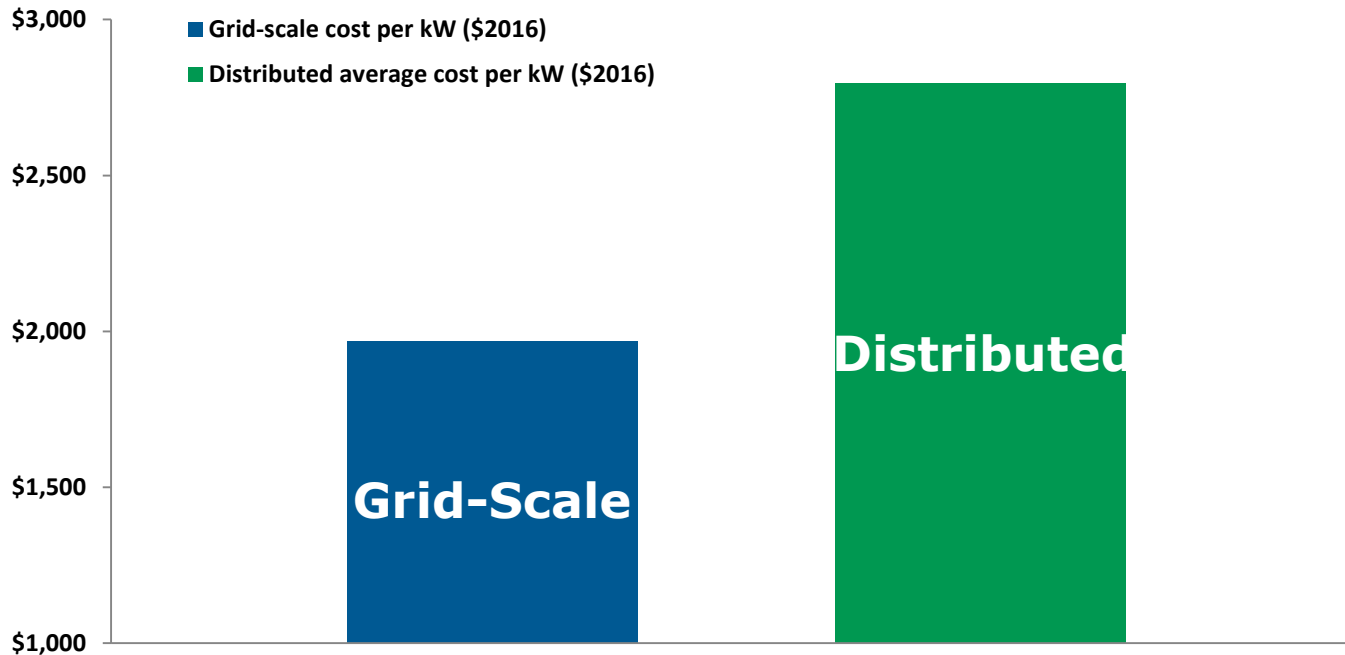
- Grid Scale - capacity and energy arbitrage drive value of grid scale storage
 - Significant potential in non-summer months
- Distribution level storage resources based on unique circumstances
 - Distribution deferral
 - Additional opportunities may exist as energy storage system costs decline
 - Compare resource solutions– smart inverters for power quality and control vs. distribution battery
 - Communications system evaluation
 - Mobile resources
- Distributed/customer resources
 - DRESLM – water heaters, batteries, thermostats
 - SIS - Evaluations under different price stimulus and customer resources

APPENDIX

Palo Verde Hub Market Price Forecast



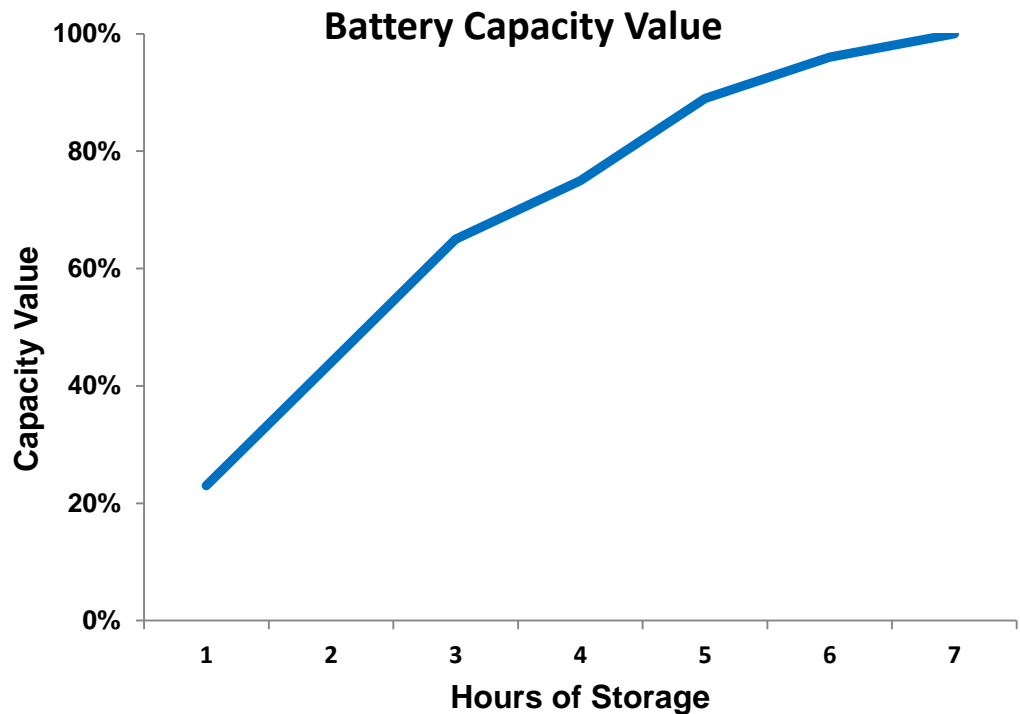
Grid-Scale vs. Behind-The-Meter Energy Storage Cost Estimates (\$/kw – 2016)



Data Source: IHS for grid-scale cost, manufacturers' estimate average for distributed -scale cost

Capacity Value Energy Storage

- APS system peak days cover a significant number of hours
- Approximately 7 hours of storage required to achieve 100% capacity contribution



Energy Storage & Gas Burn

- Energy storage has a relatively small impact on total daily summer gas burns
- Some opportunity to reduce gas infrastructure with battery development
- Non-summer gas savings may be achieved during solar production hours

