







2016 Integrated Resource Plan Update

Tucson Electric Power (TEP)

UNS Electric, Inc. (UNSE)

2016 IRP Workshop
July 18, 2016

2016 IRP Workshop Topics

Victor Aguirre
Manager,
Resource Planning

- **Load Forecast**
- **Loads and Resources Update**
- **Current Renewable Projects**
- **New Technologies**
  - Battery Storage Project
  - Reciprocating Engines
  - Small Modular Reactors
  - Energy Imbalance Market Update

Jeff Yockey
Manager, Environmental and
Long-Term Planning

- **Portfolio Diversification**
- **Renewable Outlook**
- **Energy Efficiency Outlook**
- **Clean Power Plan Update**
- **U of A Water Study Update**

Mike Sheehan
Senior Director, Fuels and
Resource Planning

- **Forecast Assumptions**
- **Scenarios and Sensitivities**
- **Future Transmission Plans**
- **EV Case Study**
- **Future Operational Challenges**
- **Three Year Action Plans**









2016 Integrated Resource Plan Update

Victor Aguirre

Manager, Resource Planning

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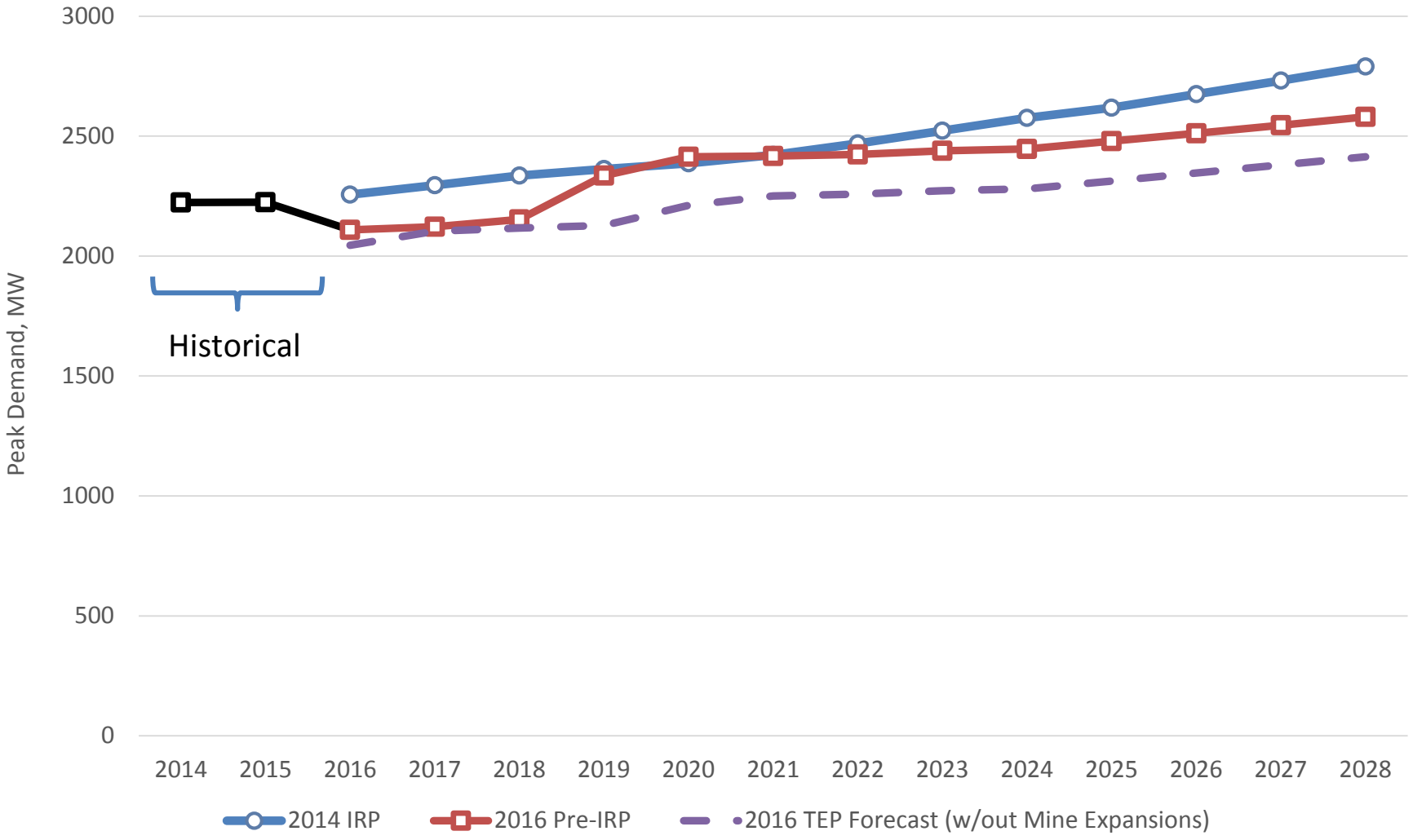
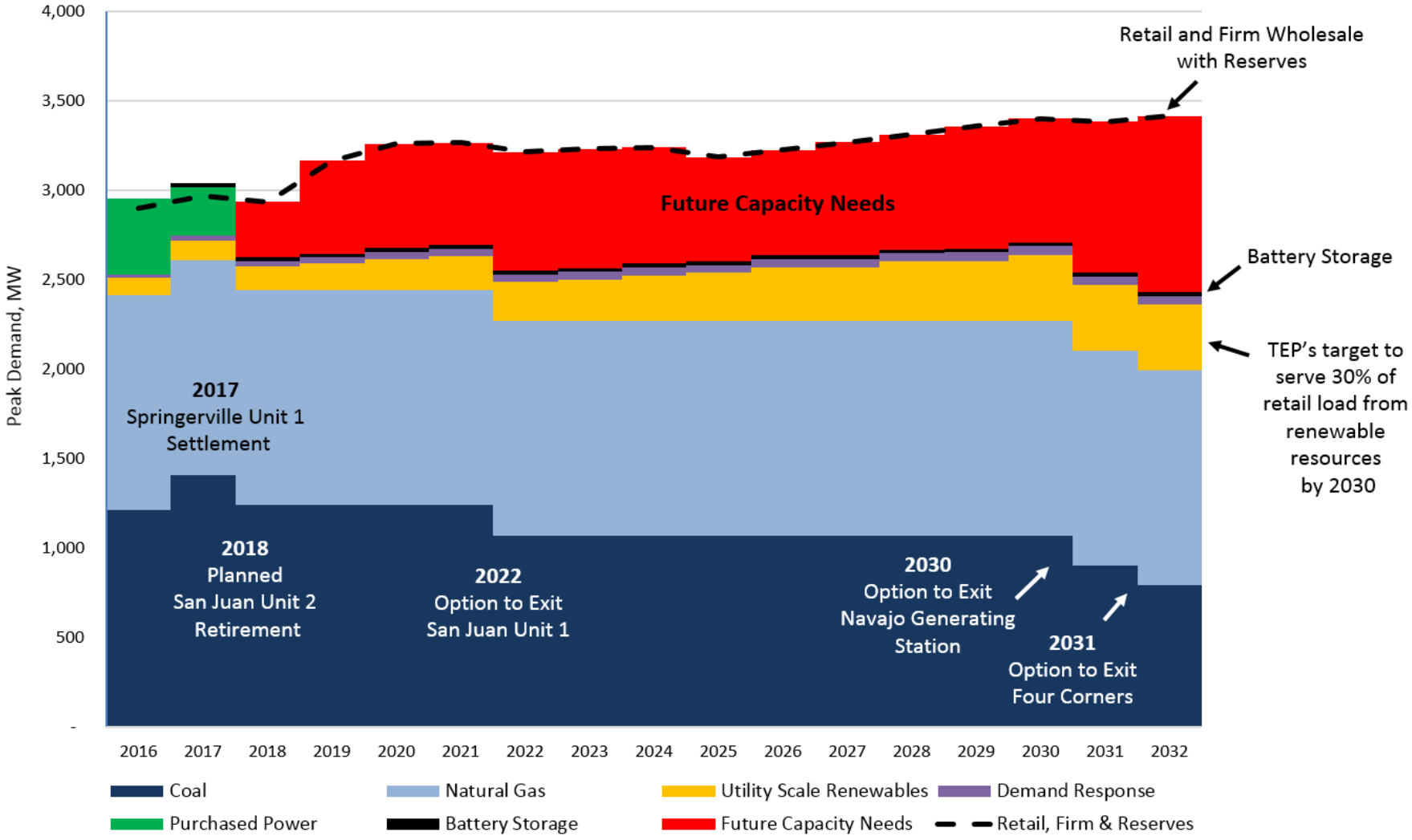
TEP Retail Load Forecast



TEP Loads & Resources



TEP Renewable Energy Portfolio

- Renewable Energy Standard (RES) requires 15% renewable energy supply by 2025
- TEP is ahead of schedule in achieving Arizona's RES requirement
- 280 MW_{AC} of solar and wind generation (PPA and owned)
- Red Horse – recent project (41 MW_{AC} Solar/30 MW Wind)
- Approximately 12,000 TEP customers with distributed solar generation in TEP's service area (~ 130 MW_{AC})

Amonix
Dual Axis Concentrated PV 1.2 MW

Avalon
Fixed PV
28.3 MW

Cogenra
SAT Concentrated Thermal PV
1.1 MW

E. ON.
Single Axis Tracking PV
4.8 MW

Gato Montes Solar
Fixed PV
4.9 MW

Macho Springs
Wind
50.4 MW

NRG Avra Valley
Fixed PV
25 MW

Picture Rocks Solar
Fixed PV
20 MW

Fort Huachuca
Fixed PV
13.6 MW

Solon Prairie Fire
Fixed PV
4.0 MW

Springerville
Fixed PV
5.1 MW

Areva Solar
Concentrated Solar Thermal
5.0 MW

Valencia Solar
Single Axis Tracking PV
10 MW

Solon UASTP 1
Single Axis Tracking PV
1.3 MW
500 kW of Lithium-Ion Battery Storage

Solon UASP 3
Fixed PV
4.0 MW

White Mountain Solar
SAT Concentrated Thermal PV
8.3 MW

New Technology - Review

- Energy Storage Systems (ESS)
  - DeMoss Petrie Battery Storage
  - University of Arizona Tech Park Battery Storage
- Reciprocating Internal Combustion Engines (RICE)
- Small Modular Nuclear Reactors (SMR)
- Energy Imbalance Market (EIM)

TEP Energy Storage Projects

- **2 Projects – Lithium-Ion Type Batteries**
- **NextEra Energy Resources**
  - 10 MW lithium nickel-manganese-cobalt battery system
  - DeMoss Petrie Substation
  - Operational by the end of 2016
- **E.On Climate & Renewables**
  - 10 MW lithium titanate oxide battery storage
  - Combined with 2 MW Solar PV
  - University of Arizona Tech Park
  - 2Q of 2017
- **Frequency Regulation**
- **Research**

NextEra Energy Resources 2015
The 10 MW energy storage project to be installed near Interstate 10 and West Grant Road could be similar to this NextEra Energy Frontier Battery Storage Project in Shabbona, Ill.

Reciprocating Engines

The LCEC Generation Plant

Inside the engine hall of a reciprocating engine power plant. The LCEC Generation Plant in Lovington, New Mexico is powered by five Wärtsilä gas-fired engines.

CHARACTERISTICS

- **Fast Start Times**
- **Flexible Run Time**
- **Reduced O&M**
- **Fast Ramping**
- **Less Ambient Performance Degradation**
- **Lower Gas Pressure Requirement**
- **Low Water Consumption**
- **Modularity**

APPLICABILITY

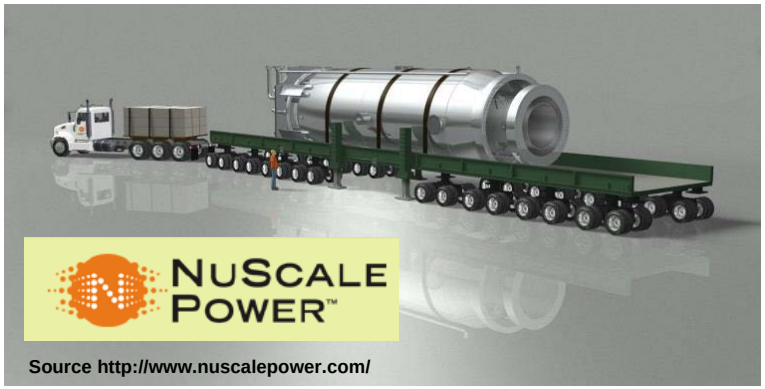
- **Increased Reliability (EFOR spread across multiple units)**
- **Renewable Integration Requirements**
  - **Variability**
  - **Intermittency Mitigation**
  - **Other Ancillary Needs**
- **Potential EIM Participation**
- **Long-Term Resource Diversification (Peaking)**

Source: http://lcecnet.coopwebbuilder.com/content/lcec-generation-llc

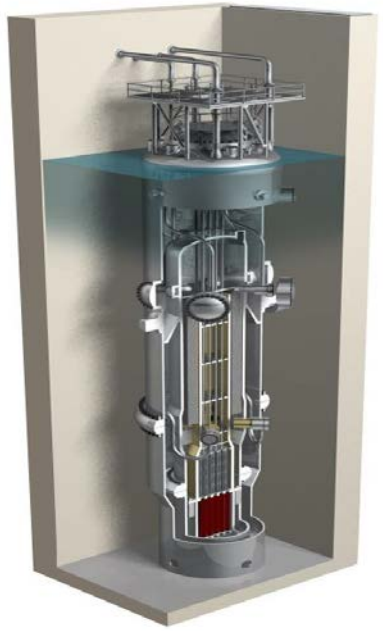
Small Modular Nuclear Reactors

- **Modular – Factory Built**
- **Passive Safety Features – Infinite Cooling**
- **Zero Emission**
- **Long-lead time**
- **Expensive**
- **Potential baseload resource to replace coal**
- **Outside of TEP planning horizon**

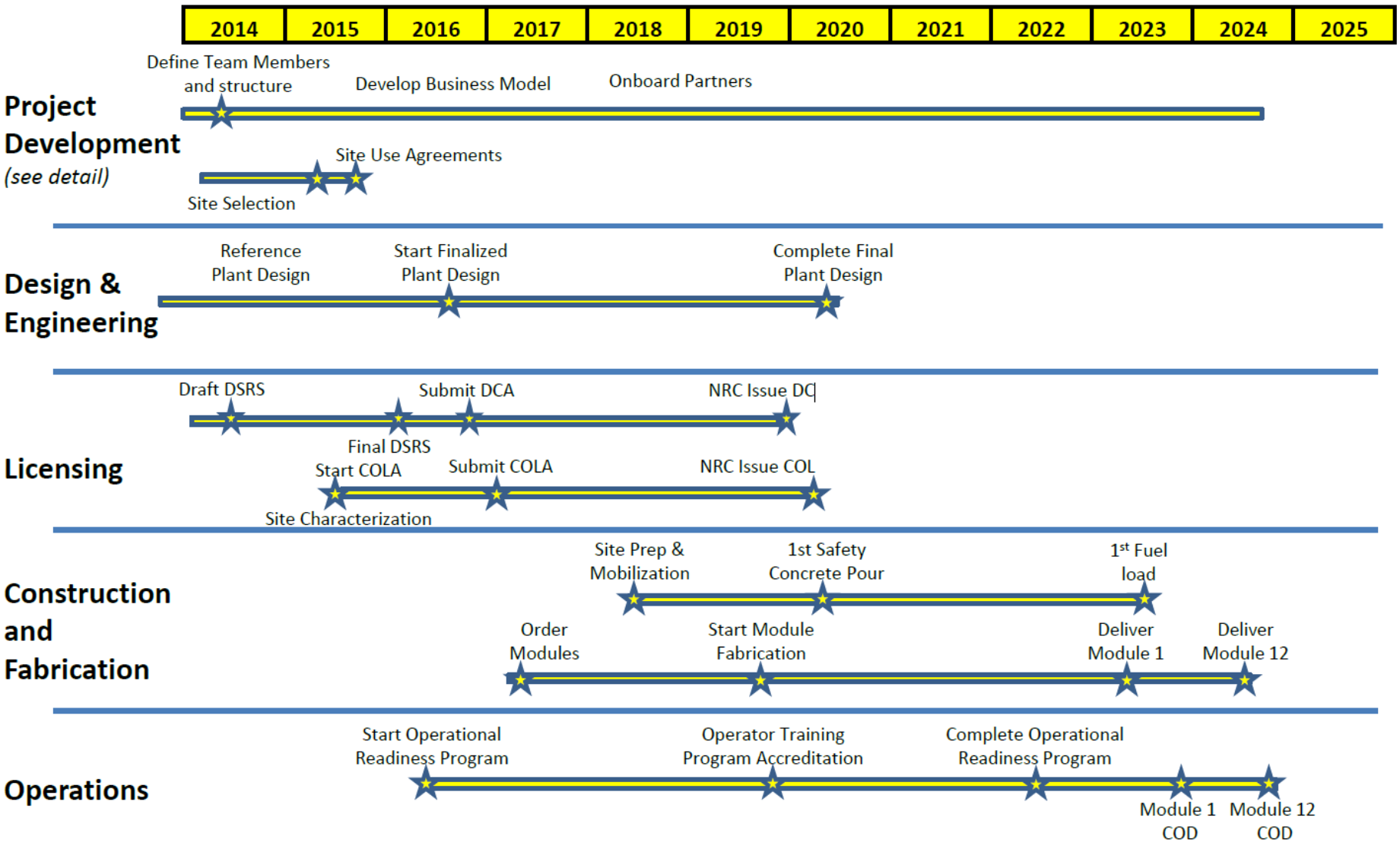
- **Utah Associated Municipal Power Systems (UAMPS) – Carbon Free Power Project (CFPP)**
  - 46 members in 8 states
  - Commercial Operation – 2025



Source http://www.nuscalepower.com/



Overall UAMPS CFPP Project Schedule



Energy Imbalance Market

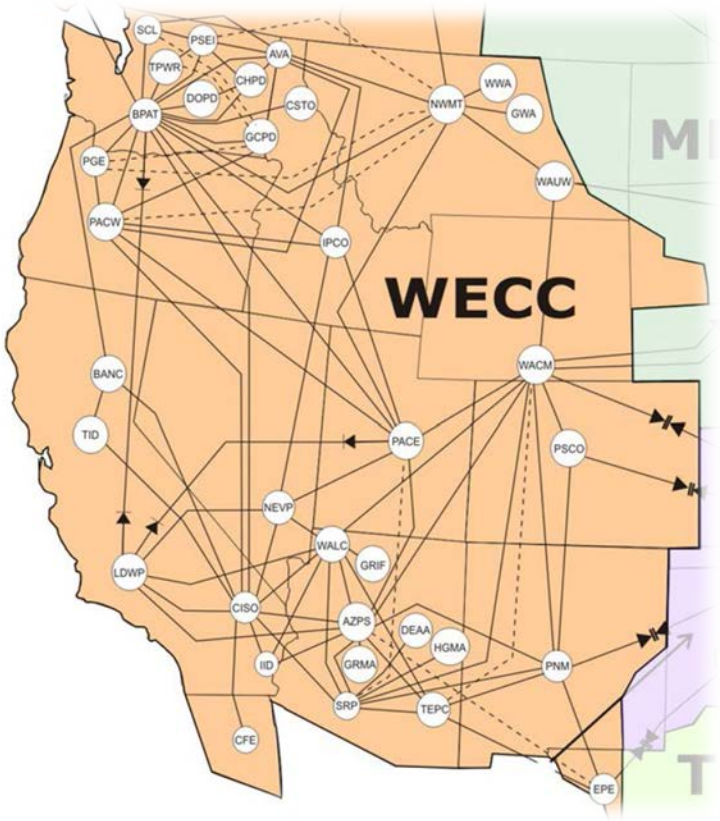
- **Studying Cost-Benefits of CAISO Energy Imbalance Market**

EIM Benefits

- Pool generation resources over a wider area
- Sub-hourly real-time energy market
- Automated region-wide dispatch
- Moderate intermittent resources/demand

EIM Status

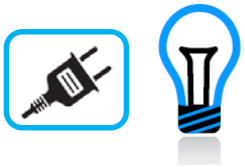
- E3 Consultant
- Initiated March 2016
- Data Collection – April - June 2016
- Analysis – June - August 2016
- Results – September 2016
- Next Steps



TEP's Future Resources Needs

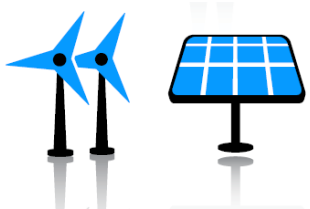
PORTFOLIO DIVERSITY

20 MW Battery Storage Technology



Fully Compliant with Arizona Energy Efficiency Standard 22% by 2020

Future Natural Gas Resources



Target 30% Renewables by 2030

2017 | **2021** | **2024** | **2028** | **2031**

Energy Imbalance Market

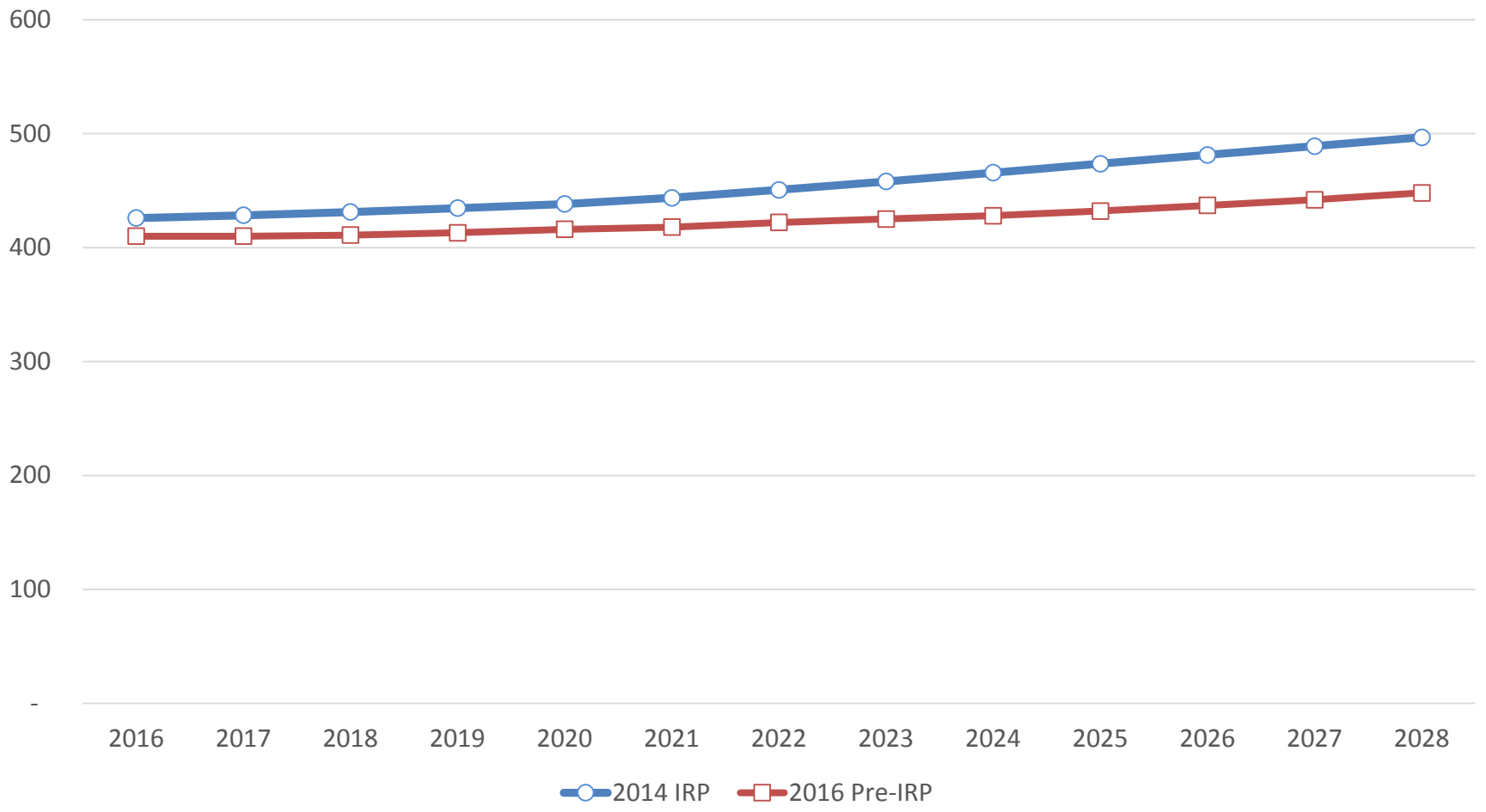
Regional Transmission Projects

Natural Gas Storage And Gas Infrastructure

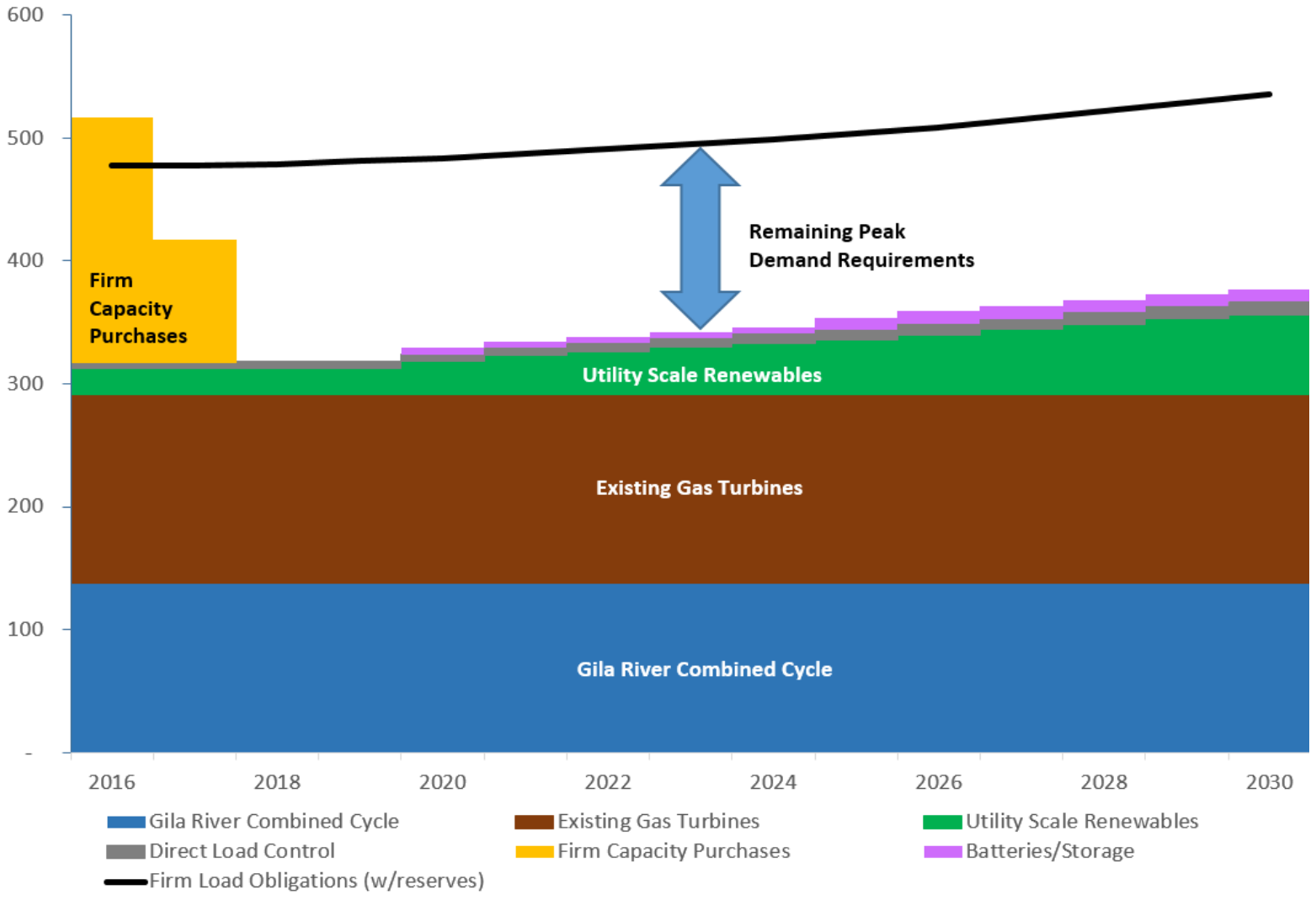
SMR Technology For Baseload Replacement

TECHNOLOGY REVIEW

UNSE Retail Load Forecast



UNSE Loads & Resources



UNSE Renewable Energy Portfolio

- Renewable Energy Standard (RES) requires 15% renewable energy supply by 2025
- UNSE is ahead of schedule in achieving Arizona's RES requirement
- 56 MW of solar and wind generation
- Red Horse Solar – In Service Summer 2016 (30 MW_{AC})
- GrayHawk Solar (PURPA) – Summer 2017 (46 MW_{AC})

Black Mountain Solar
Fixed PV
8.9 MW

Red Horse Solar
Fixed PV
30 MW

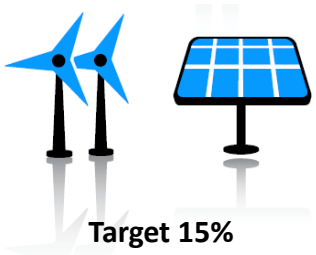
La Senita
Single Axis PV
0.98 MW

Kingman Wind & Solar
Wind & Fixed PV
10.2 MW

- Approximately 2,000 UNSE customers with distributed solar generation in UNSE's service area (~ 21 MW_{AC})

UNSE's Future Resources Needs

PORTFOLIO DIVERSITY



Target 15% Renewables by 2018

Fully Compliant with Arizona Energy Efficiency Standard 22% by 2020

Future Natural Gas Resources

2016 | **2019** | **2021** | **2023** | **2026** | **2030**

Energy Imbalance Market

Battery Storage Technology

Regional Transmission Projects

Natural Gas Storage

RICE

TECHNOLOGY REVIEW









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Manager of Environmental and

Long-Term Planning

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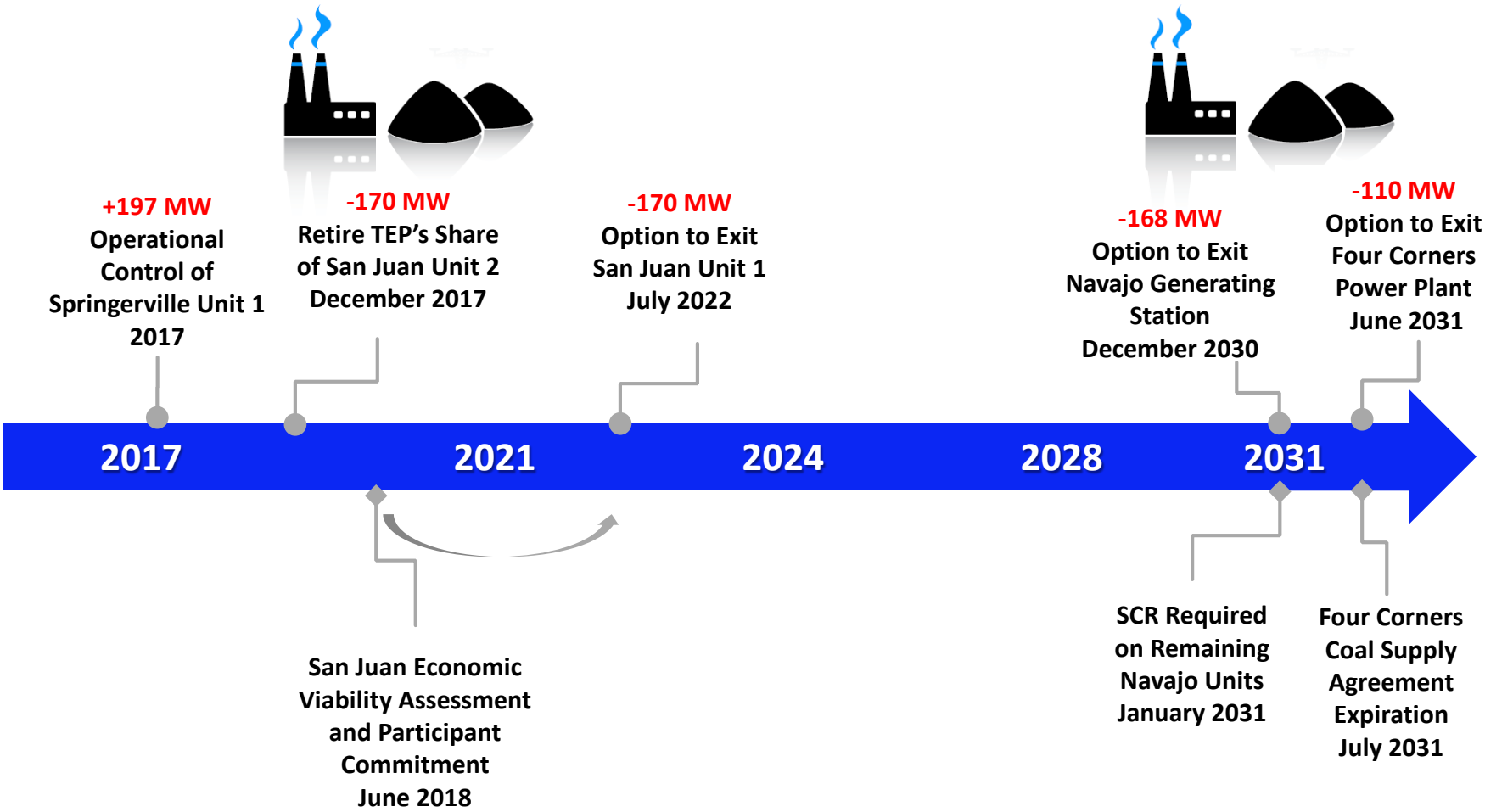
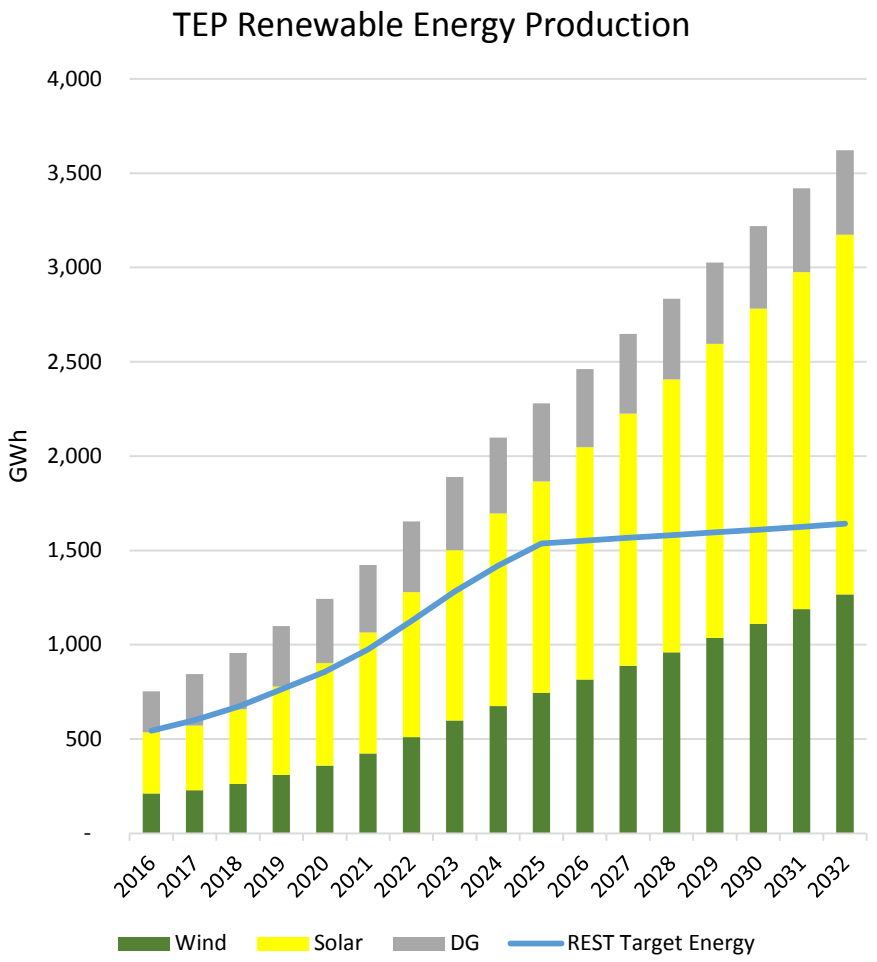
Coal Diversification Strategy



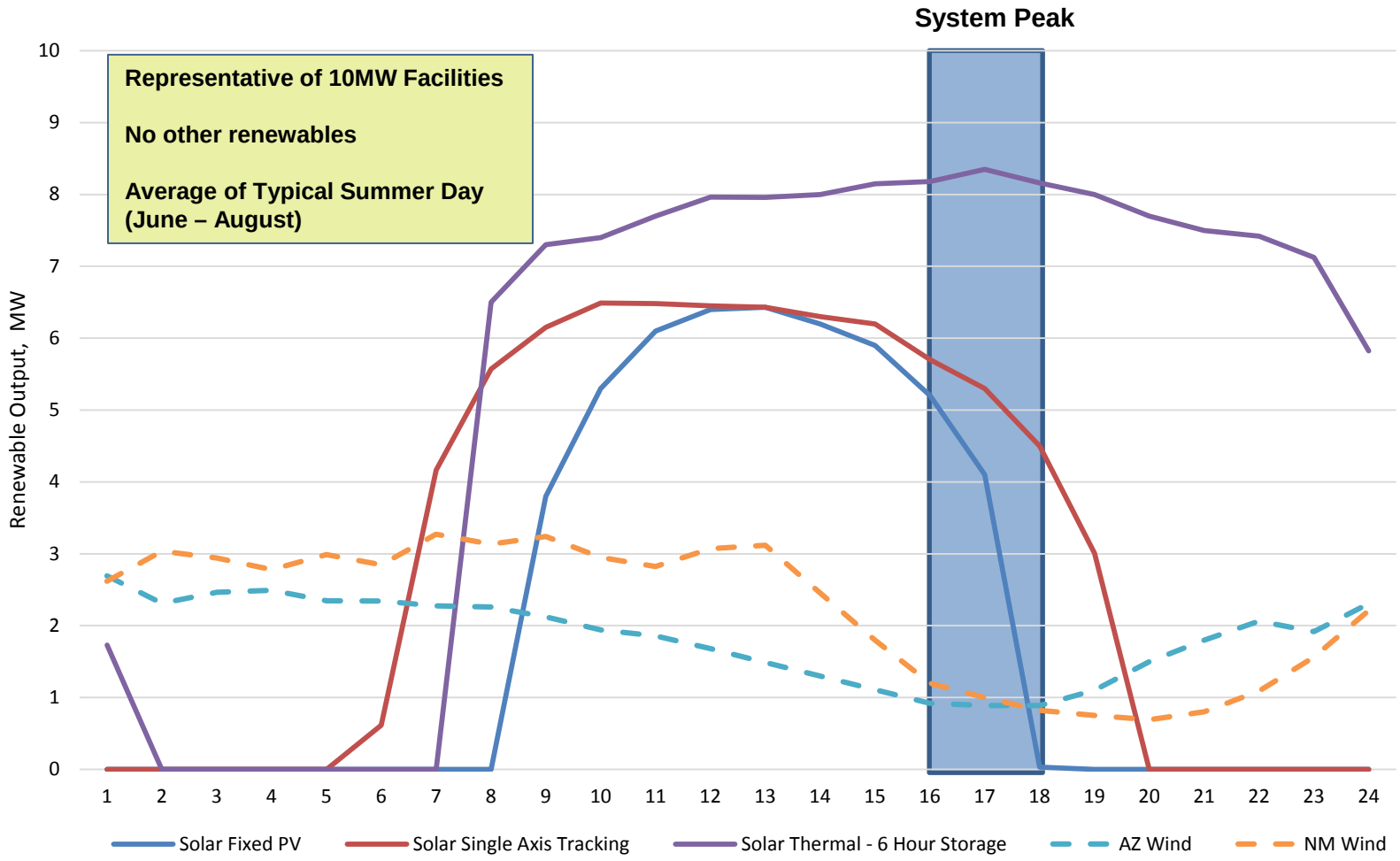
Assumptions – Renewable Energy

Renewable Energy

- **TEP - 30% Renewable Energy by 2030**
  - Exceed REST requirements for total renewable energy
- **UNSE - Meet REST requirements for total renewable energy <u>early</u>**
- **Meet REST requirements for distributed generation**
- **Regulatory Rate Reform**
- **Diversification of RE Portfolio**
  - Mix of distributed generation, community solar, and wind

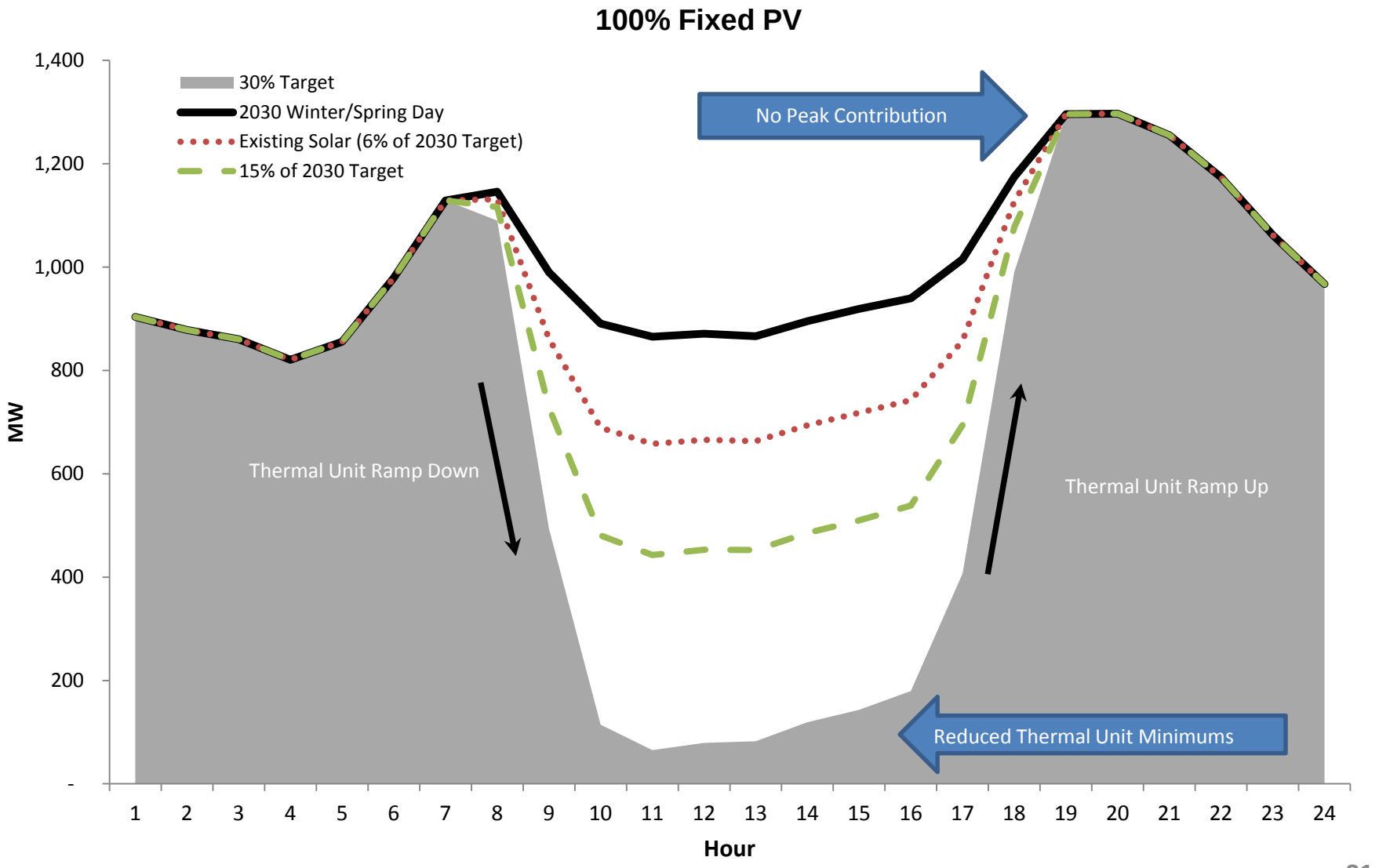


Renewable Contribution to Peak Capacity

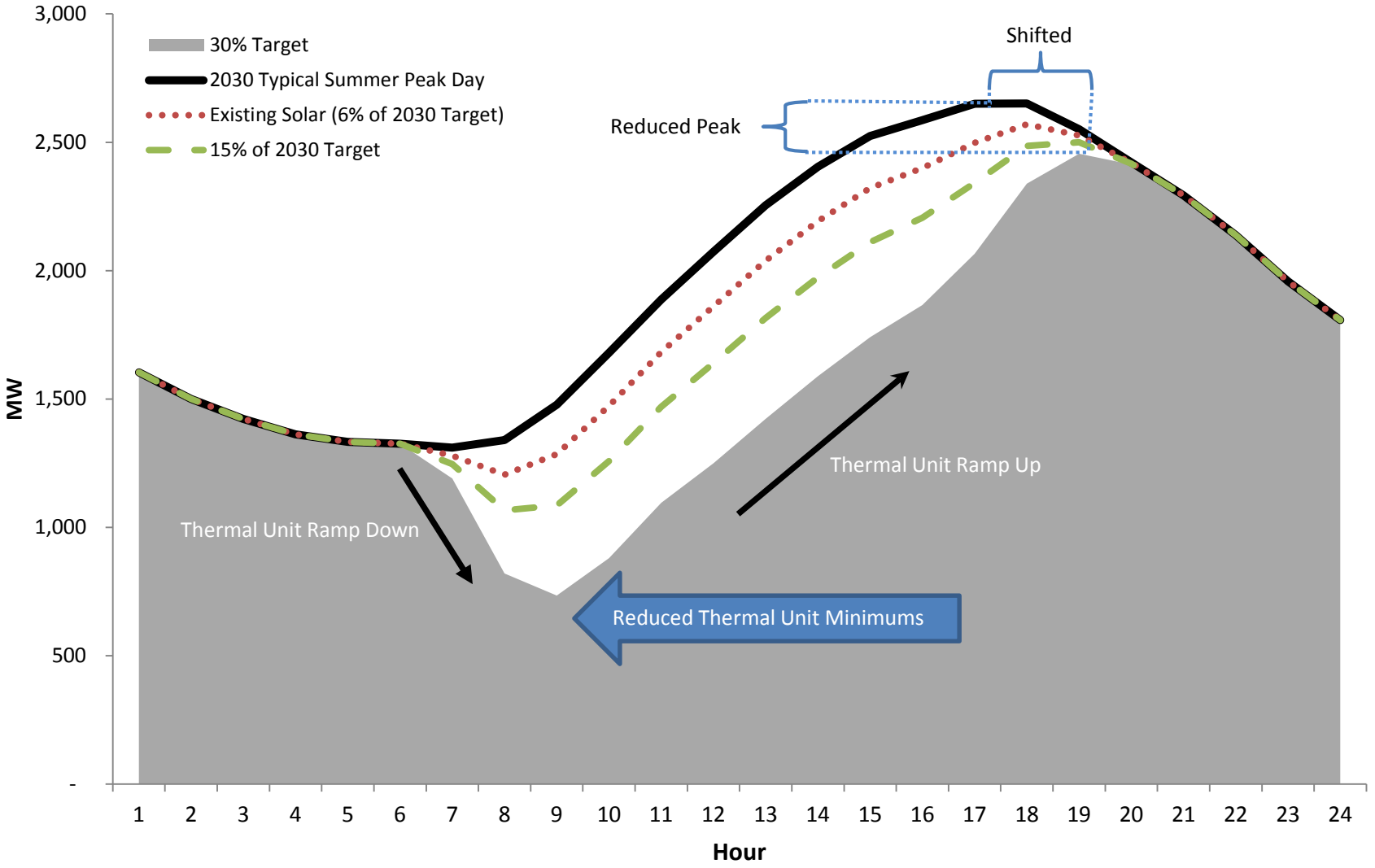


Technology	NM Wind	AZ Wind	Solar PV (Fixed)	Solar PV (Single-Axis)	Solar CSP (Storage)
Annual Capacity Factor	38%	30%	17%	24%	38%
System NCP Peak Factor	9%	9%	33%	51%	83%

TEP Duck Curve



Adjustments to Peak



Energy Efficiency

- **Meet EE Standard through 2020**
- **Further growth between 2020-2032?**
  - Program Adoption
  - Rate Incentives
  - In-home Technology
- **Assess EM&V under the CPP**
- **Leverage Clean Energy Incentive Program (CEIP)**
  - Low Income Communities

Common Practice Baseline

Persistence

Annualized Savings

Building Codes

Clean Power Plan

- Regulates CO_2 from existing power plants based on best system of emission reduction, "BSER"
- States set standards through implementation plans
- BSER Establishes emission goals for two subcategories of power plants
- State goals derived based on proportional generation

CO_2 Rate (lbs/MWh)	2022-2024	2025-2027	2028-2029	2030+
Subcategorized Rate - Steam EGUs	1,671	1,500	1,308	1,305
Subcategorized Rate - NGCC	877	817	784	771
State Rate - Arizona	1,263	1,149	1,074	1,031
State Rate - New Mexico	1,435	1,297	1,203	1,146
State Rate - Navajo Nation	1,671	1,500	1,380	1,305

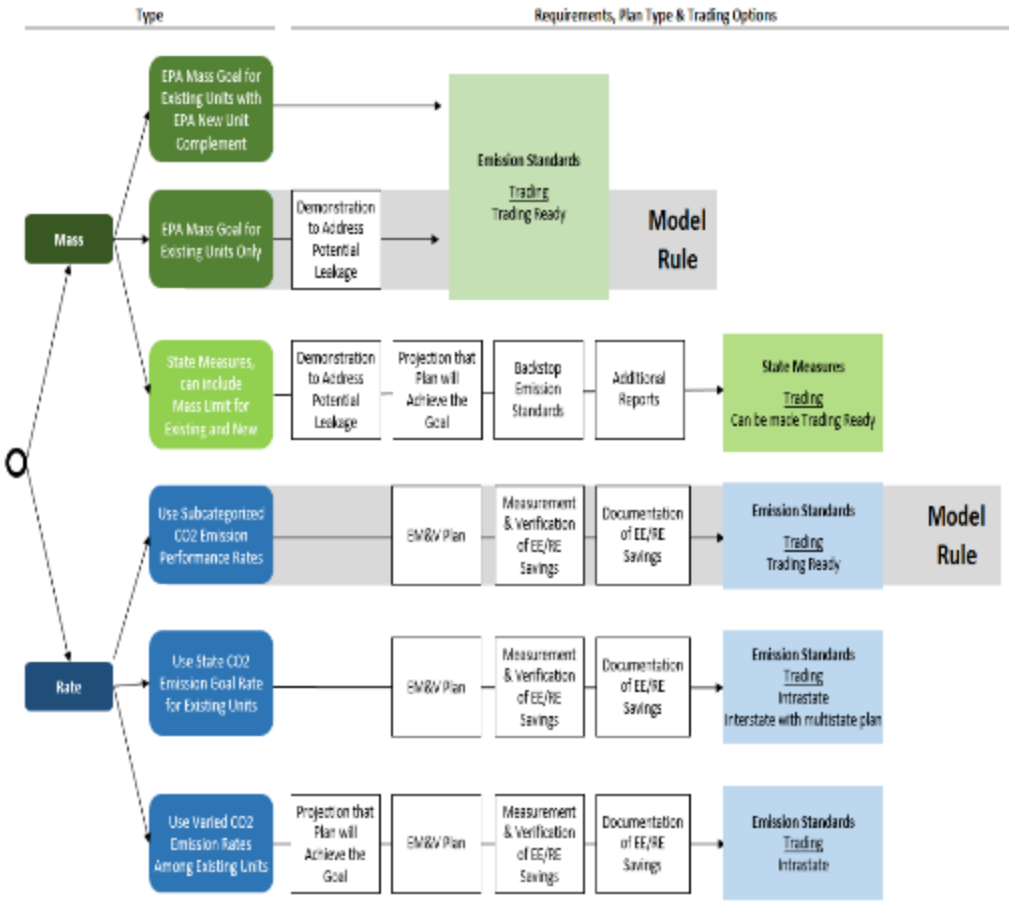
- Rate goals converted to total mass goals (i.e. short tons of CO_2) for each state

Clean Power Plan

- **Timing of CPP Implementation uncertain due to litigation**
  - Supreme Court stayed rule in February pending litigation in the DC Circuit Court
  - DC Circuit Court to hear oral arguments in September 2016, en banc
    - Ruling possible in late 2016
  - Appeal to Supreme Court a near certainty
    - Decision in late 2017 or early 2018
- **All deadlines to be shifted in proportion to the length of the litigation**
- **States individually electing whether to proceed with, slow, or stop CPP planning**

Clean Power Plan

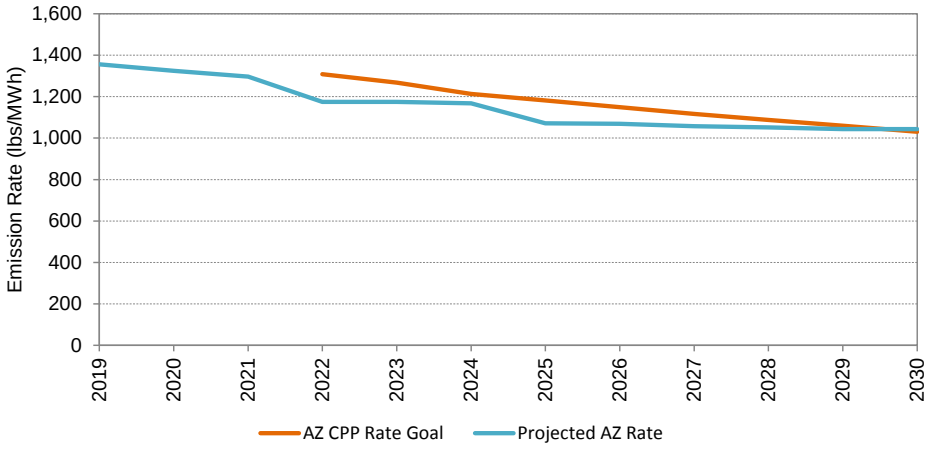
- **Navajo Nation**
  - Coal retirements
  - No existing NGCC
  - Limited energy efficiency
  - Point to mass-based
- **New Mexico**
  - Coal retirements
  - Point to mass-based
- **Arizona**
  - Proceeding slowly
  - Evaluating rate vs. mass



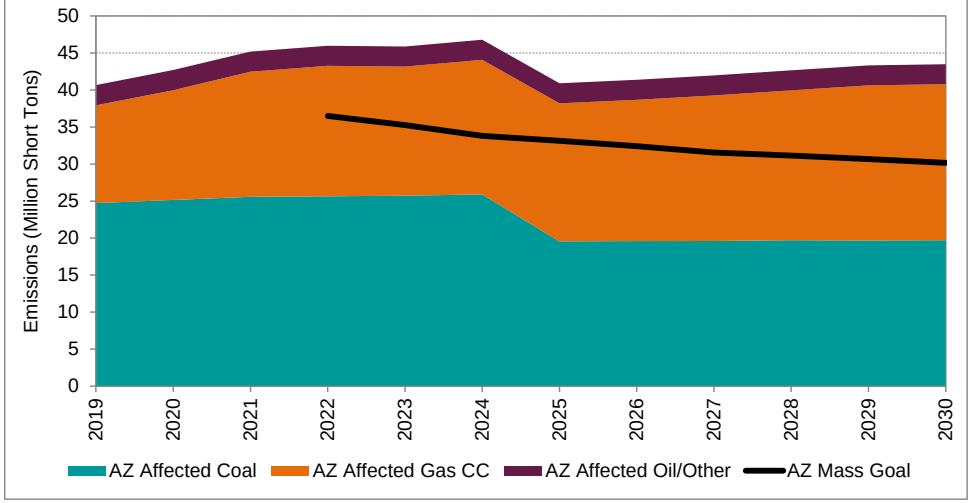
Summary of Base Case State Rate and Mass Analysis
Coal Reduction and ERCs from Renewables and Efficiency Position Arizona for Compliance Under Rate Goal

- This analysis suggests that Arizona is well positioned for rate approach based on the Base Case outlook due to increased reliance on gas expected and significant energy efficiency and new renewables.
- Arizona meets CPP interim goal under a rate-based approach – falls slightly short of meeting final goal.
  - ERCs banked during interim period could be used to meet compliance with final goal.
- On a mass basis, Pace Global projects a net annual allowance deficit that would equate to retiring another ~1,900 MW of coal to comply by 2030.

AZ Rate v. CPP Rate Goal

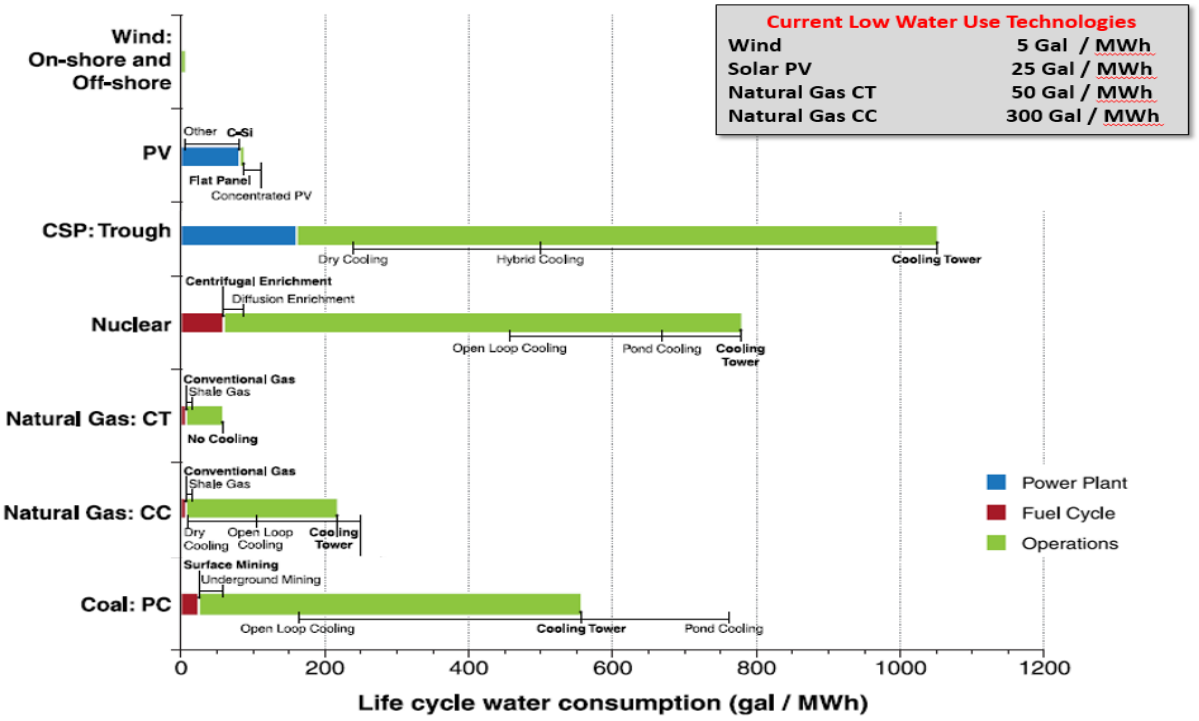


AZ Emissions v. CPP Mass Goal



Report Available on http://www.azdeq.gov/node/1206

Resource Diversification Water Use



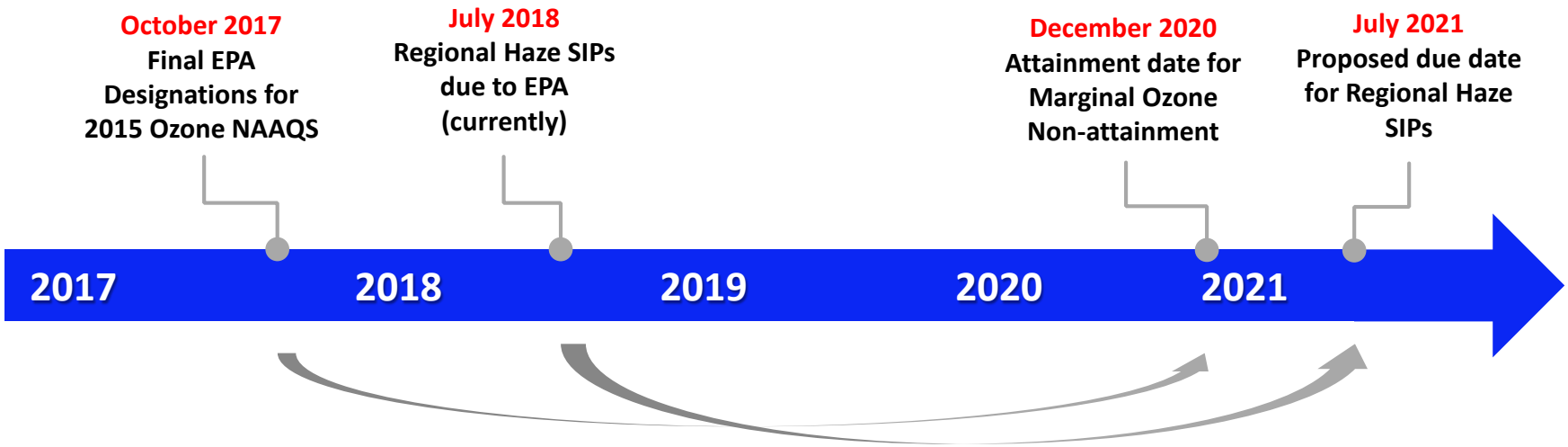
Resource Diversification to Result in Lower Water Use Overall

Thematic Area	Qualitative Risk Assessment					Adaptation or Analysis Action
	Description of Key Risk/Cost and/or Benefit	Timescale & Intensity Short	Medium	Long	Confidence	
Water					HIGH	

Qualitative Risk Assessment with University of Arizona

Other Environmental Impacts

- **2015 Ozone NAAQS**
  - Standard lowered to 0.70 ppm
  - Could impact permitting for new gas generation
- **Regional Haze**
  - EPA proposal to adjust state plan deadlines from July 2018 to July 2021
  - Springerville and other sources to be evaluated for emission reductions to achieve “reasonable progress”











2016 Integrated Resource Plan Update

Mike Sheehan

Senior Director of Fuels and Resource Planning

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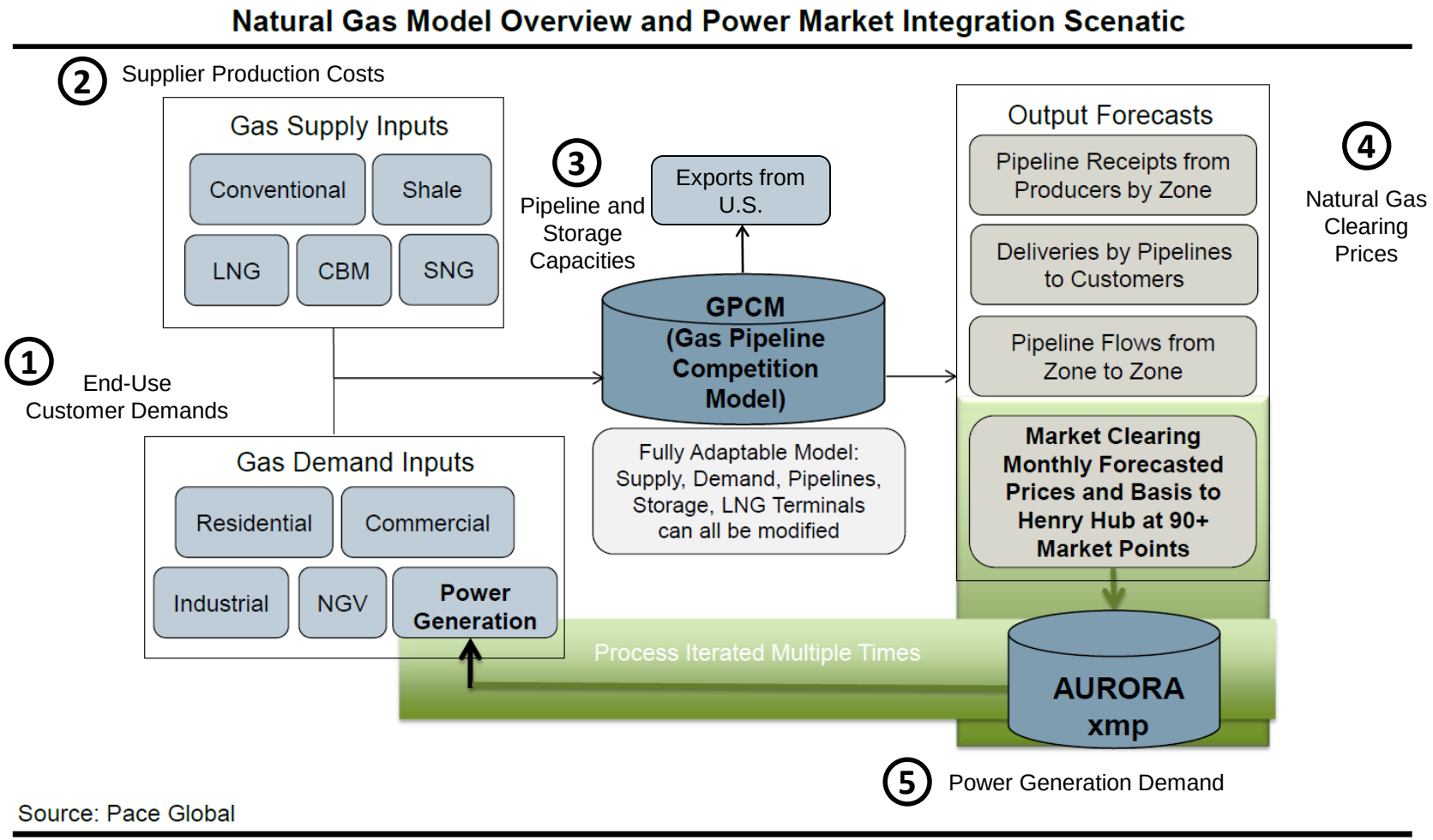
Resource Planning Data Assumptions

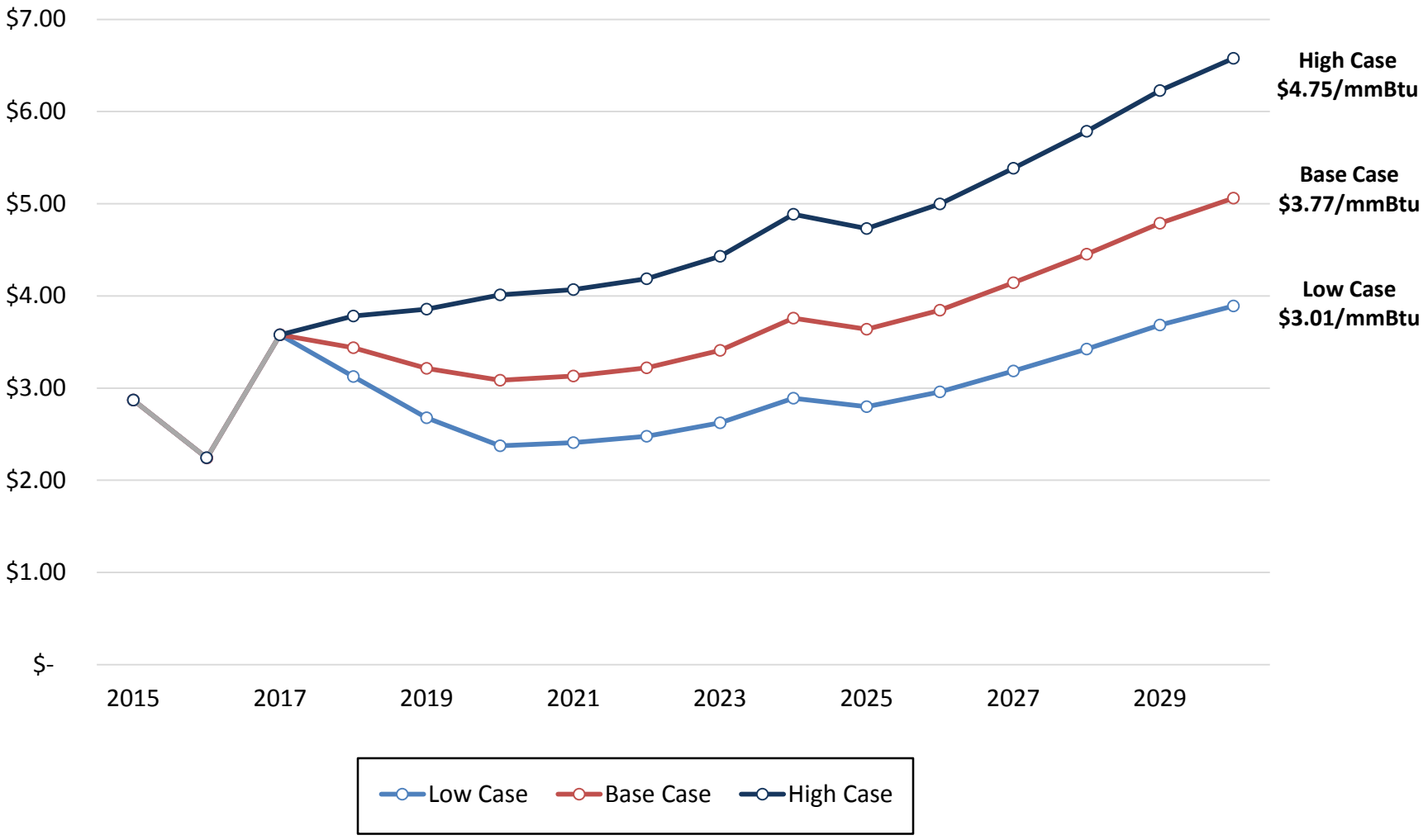
- **Future Resource Assumptions**
  - PACE Global
  - Wood MacKenzie
  - Electric Power Research Institute (EPRI)
  - Black & Veatch
  - National Renewable Energy Laboratory (NREL)
  - IHS CERA
  - National Energy Technology Laboratory (NETL)
  - Request for Proposals (RFPs)

- **Independent Third-Party Data Sources**
  - Avoid internal biases
  - In-depth analysis behind data
  - Forward thinking outcomes

Natural Gas Fundamental Supply & Demand Model



Forward Permian Natural Gas Prices



Scenarios and Sensitivities

Portfolios

1. Energy Storage Case
2. Small Nuclear Reactor Case
3. Full Coal Retirement Case
4. High Energy Efficiency Case
5. High Renewables Case
6. Market Reference Case

Sensitivities

1. Natural Gas Prices
2. Wholesale Power Prices
3. Retail Load and Demand
4. CO_2 Compliance

Combined Scenario Planning

Combined Scenarios	Load Growth	Natural Gas Prices	Coal Retirements	Environmental Compliance Costs	Capital Costs
Environmental Regulation	Low	High	Full	High	Moderate
Technology Evolution	Moderate	Moderate	Moderate	Low	High
Economic Turmoil	Low	Low	Low	Low	Moderate

Electric Vehicles (EVs)

Tesla Model 3:

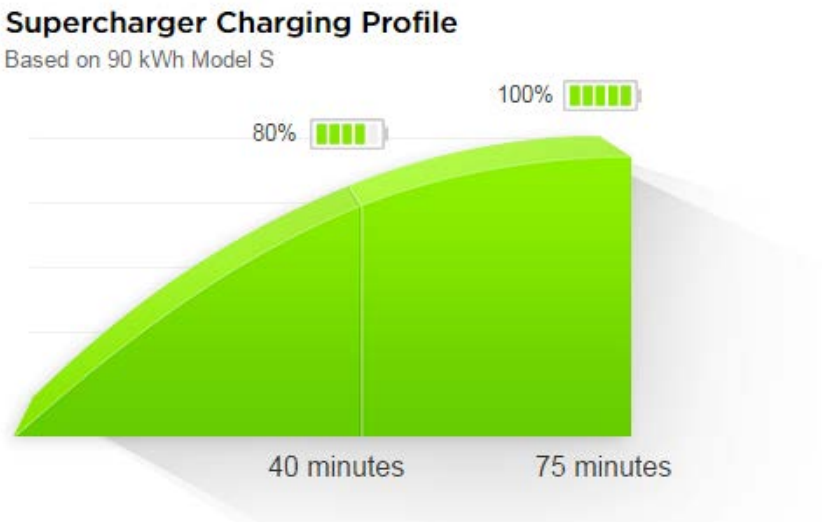
Does it signal an Electric Car Revolution?

Cost - The base version of the Model 3 will be produced at $35,000.

Performance - 0-60 in less than 6 seconds in the base version.

Range - The base model with a 50-60 kWh battery - 215 miles per charge.

Charging - Supercharging to near full capacity in 40 minutes compared to multiple hours with other EVs. Regular charging in 5-6 hours from a home charger.



Note: Data based on Wood-MacKenzie Electric Vehicle Case Study and www.teslamotors.com

Tesla Electric Vehicle and Li-ion Battery Production

Tesla's Giga Factory **in Nevada plans to produce 50 GWh of lithium ion batteries for EVs & Energy Storage Systems by 2020.**

AA battery sized lithium-ion battery

Panasonic
3.7 V 3400 mAh

7104 Individual Cells

- 16 modules
- 1 module : 6 groups of 74 cells

Li Nickel-Manganese Aluminum Oxide Battery

Tesla's Model S

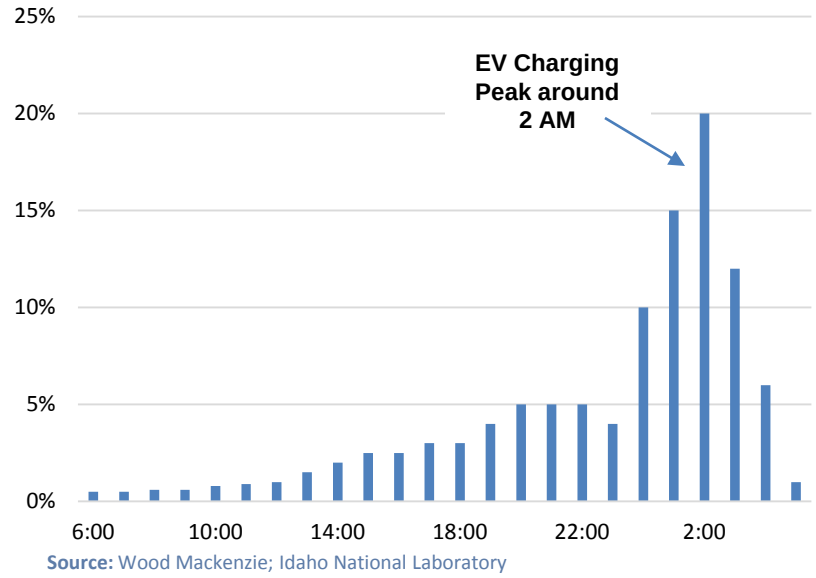
Wait and See…It is only this kind of large scale manufacturing that can drive the costs down for Li-ion technology

Department of Chemistry *University of Arizona*

Jeffrey Pyun Department of Chemistry & Biochemistry, University of Arizona Department of Chemical & Biological Engineering Seoul National University, World Class University Program

EV Charging Infrastructure and Incentives

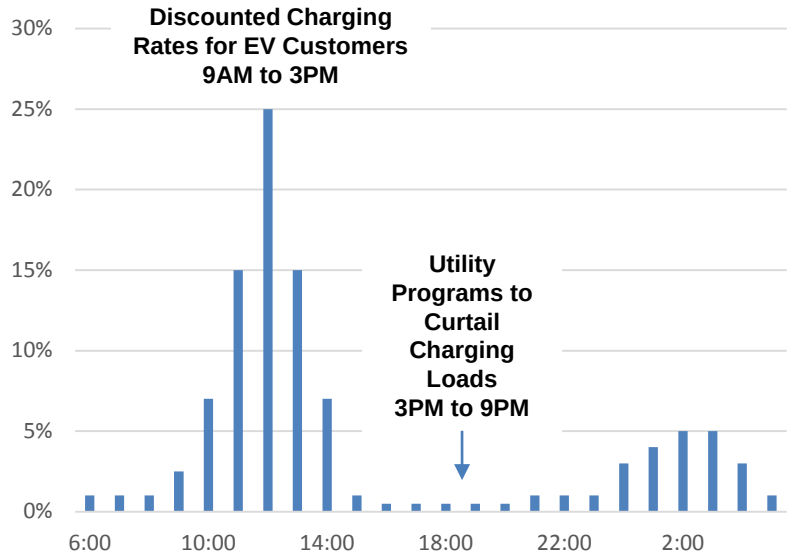
Today's EV Charging Profile



Source: Wood Mackenzie; Idaho National Laboratory

- Current battery technology has 85% of EV owners charging overnight at home.
- Results in off-peak reliance of predominately coal, natural gas and wind generation resources.

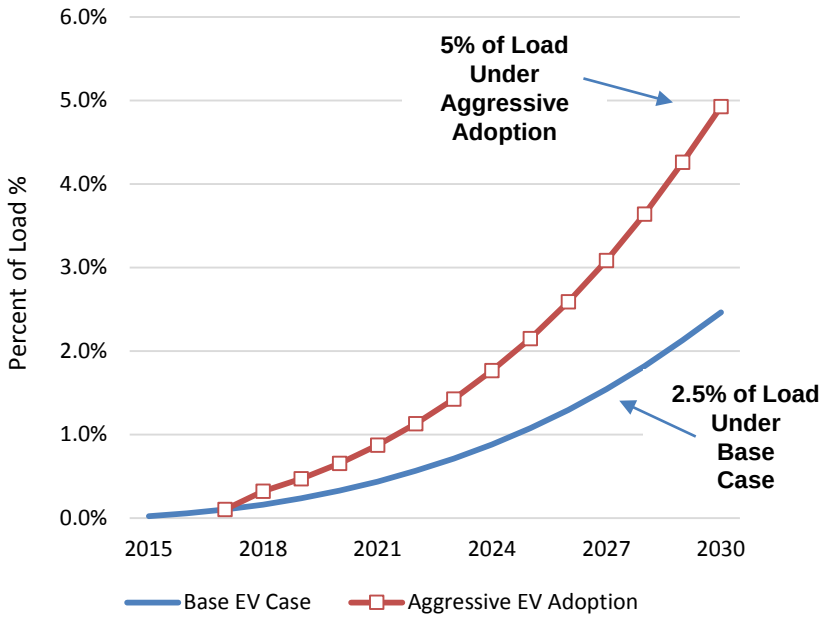
Future EV Charging Profiles



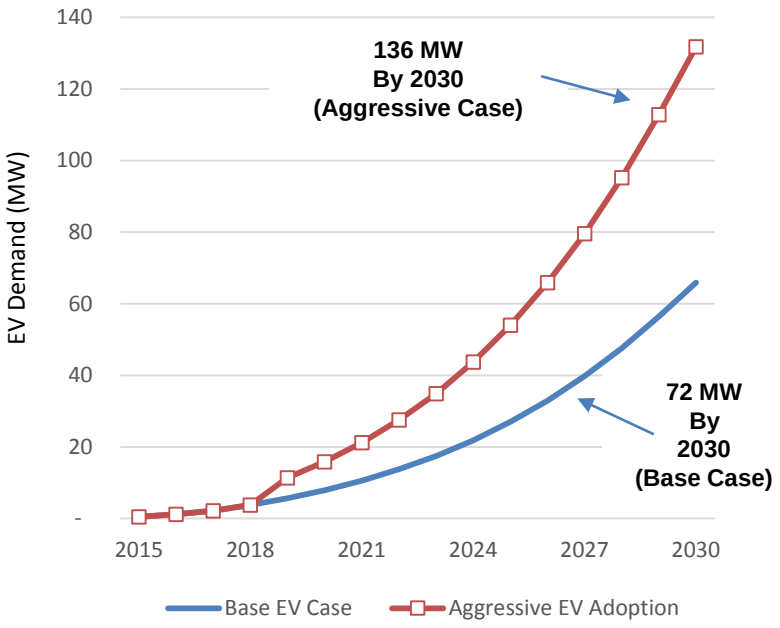
- Workplace incentives to charge during the day to utilize solar generation resources.
- Maximizes carbon reduction in the transportation sector while reducing the "duck-curve" effects in power generation sector.

EV Scenarios for TEP

TEP EV Penetration Scenario



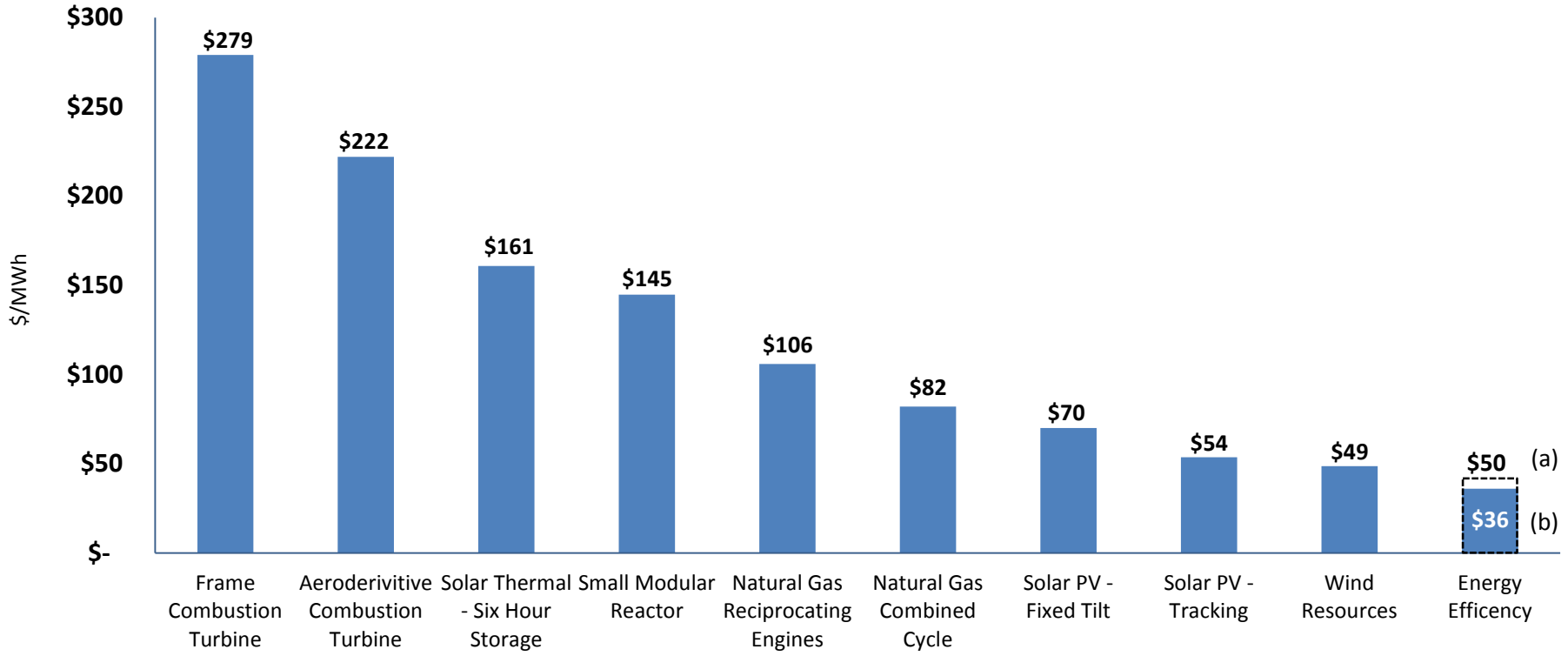
EV Demand (MW)



Source: Adapted from Wood Mackenzie Long-Term Forecast Assumptions - 2016

- Implementation of new TOU rates, demand response and direct load control strategies for EVs
- Promotion of workplace charging systems and Level 3 charging stations sourced from renewables
- Incremental EV load growth could help creates volumetric opportunities to reduce overall customer rates

2016 Levelized Cost of Energy ($/MWh)



Assumptions:

The LCOE analysis assumes 43.5% debt at 5.2% interest rate and 56.5% equity at 10% cost for both conventional and renewable generation technologies based on 2016 in-service date. A levelized natural gas price of $3.77 per MMBtu is assumed for all applicable natural gas technologies. All solar resources reflect the investment tax credit changes associated with the December 2015 Consolidated Appropriations Act. Wind resources represent on-shore technologies and assume all production tax credits based on the December 2015 Consolidated Appropriations Act. Analysis does not reflect potential impact of evolving regulations/rules promulgated pursuant to the EPA's Clean Power Plan. The LCOE reflects interconnected bus bar costs and excludes reliability–related costs (i.e., system integration and backup capacity costs associated with renewables) and potential social and environmental externality costs. Energy efficiency notes (a) Estimates per National Action Plan for Energy Efficiency; (b) Costs based on Arizona total and program administrator cost of saved electricity for various initiatives in 2012 dollars. Source: Lawrence Berkeley National Laboratory (LBNL) Demand-Side Management (DSM) Program Database for the period 2009 to 2013.

Conventional Technologies

Plant Construction Costs	Units	Frame Combustion Turbine	Aeroderivative Combustion Turbine	Natural Gas Reciprocating Engines	Small Modular Reactor (SMR)	Natural Gas Combined Cycle (NGCC)
Project Lead Time	Years	4	4	2	12	4
Installation Years	First Year Available	2020	2020	2018	2028	2020
Peak Capacity , MW	MW	75	45	20	300	550
Plant Construction Cost	2016 $/kW	$770	$1,200	$1,070	$6,000	$1,135
EHV/Interconnection Cost	2016 $/kW	$30	$50	$30	$400	$165
Total Construction Cost	2016 $/kW	$800	$1,250	$1,200	$6,400	$1,300
Operating Characteristics						
Fixed O&M	2016 $/kW-Yr	$13.25	$12.50	$17.50	$29.30	$16.50
Variable O&M	2016 $/MWh	$3.75	$3.50	$12.50	$5.00	$2.00
Gas Transportation	2016 $/kW-Yr	$16.80	$16.80	$16.80	-	$16.80
Annual Heat Rate	Btu/kWh	10,500	9,800	8,000	10,400	7,200
Typical Capacity Factor	Annual %	8%	15%	45%	85%	50%
Expected Annual Output	GWh	53	59	79	2,234	2,409
Fuel Source	Fuel Source	Natural Gas	Natural Gas	Natural Gas	Uranium	Natural Gas
Unit Fuel Cost	$/mmBtu	$3.77	$3.77	$3.77	$0.90	$3.77
Net Coincident Peak	NCP%	100%	100%	100%	100%	100%
Water Usage	Gal/MWh	150	150	50	800	350
Levelized Cost of Energy	$/MWh	$279	$222	$106	$145	$82

Renewable Technologies

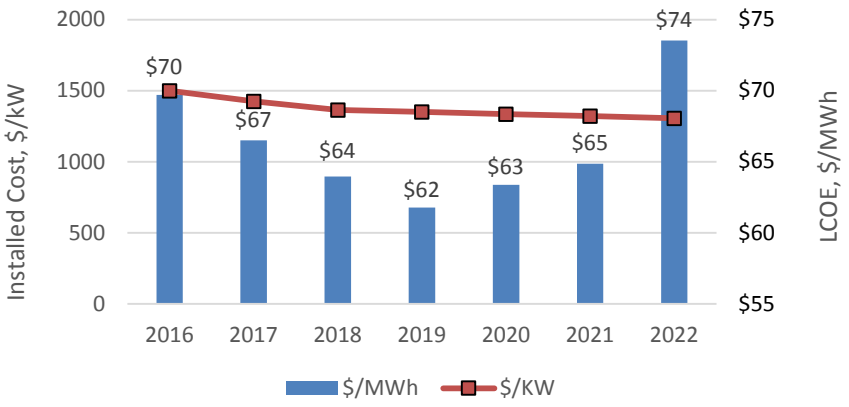
Plant Construction Costs ($2016)	Units	Solar Thermal 6 Hour Storage (100 MW)	Solar Fixed PV (20 MW)	Solar Single Axis Tracking (20 MW)	Wind Resources (50 MW)
Project Lead Time	Years	4	2	2	2
Installation Years	First Year Available	2020	2018	2018	2018
Peak Capacity	MW	100	20	20	50
Plant Construction Cost	2016 $/kW	$9,800	$1,450	$1,700	$1,250
EHV/Interconnection Cost	2016 $/kW	200	50	50	200
Total Construction Cost	2016 $/kW	$10,000	$1,500	$1,750	$1,450
Operating Characteristics					
Fixed O&M	2016 $/kW-Yr	$80.00	$10.00	$13.00	$40.00
Typical Capacity Factor	Annual %	50%	25%	32%	33%
Expected Annual Output	GWh	438	44	56	145
Net Coincident Peak	NCP%	85%	33%	51%	13%
Water Usage	Gal/MWh	800	0	0	0
ITC	Percent	30%	30%	30%	-
PTC	$/MWh	-	-	-	$23.00
Levelized Cost of Energy	$/MWh	$161	$70	$54	$49

Levelized Cost of Energy and Storage Technologies

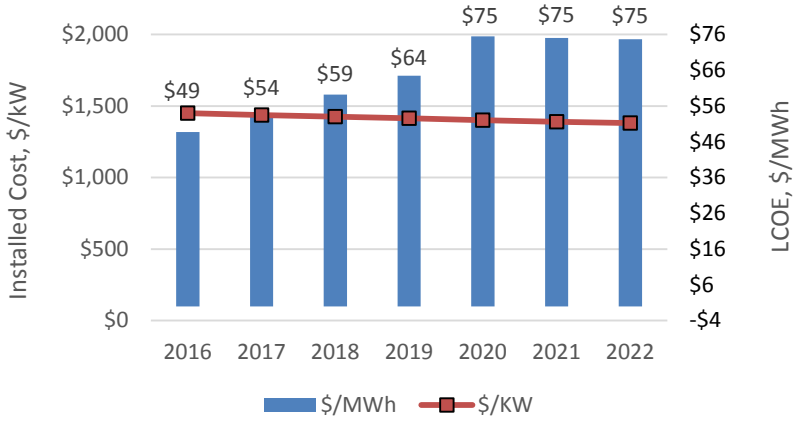
- **Levelized Cost of Energy**
  - https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-90/
- **Levelized Cost of Storage Technologies**
  - https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-10/

Renewable Resources
Technology Innovation Curves and Renewable Tax Credits

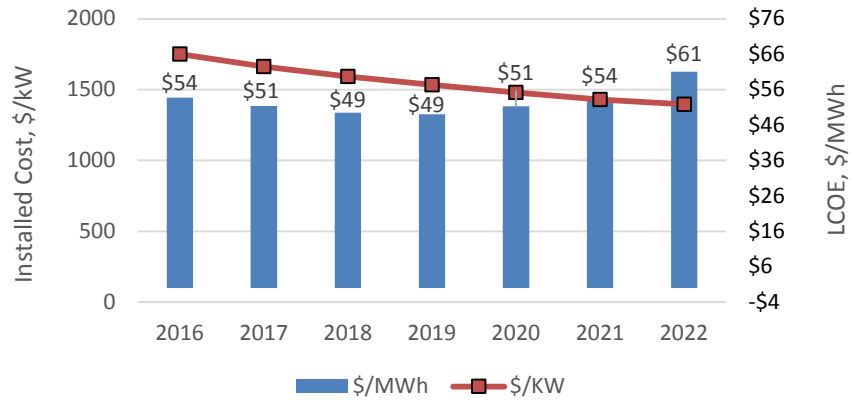
Solar PV - Fixed Tilt (20 MW)



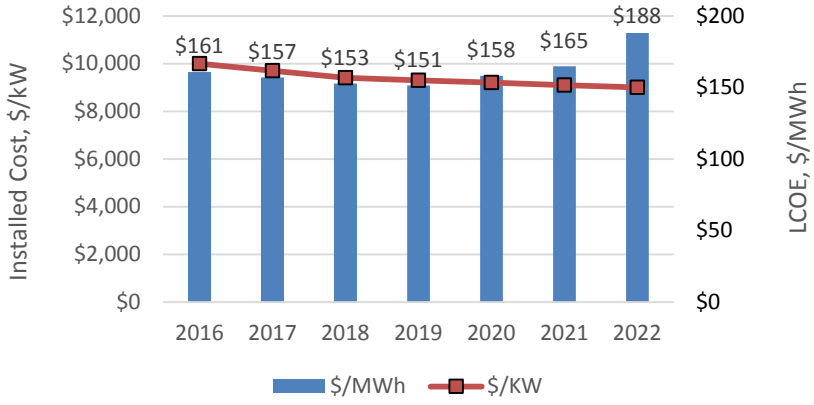
Wind (50 MW)



Solar SAT - Tracking (20 MW)



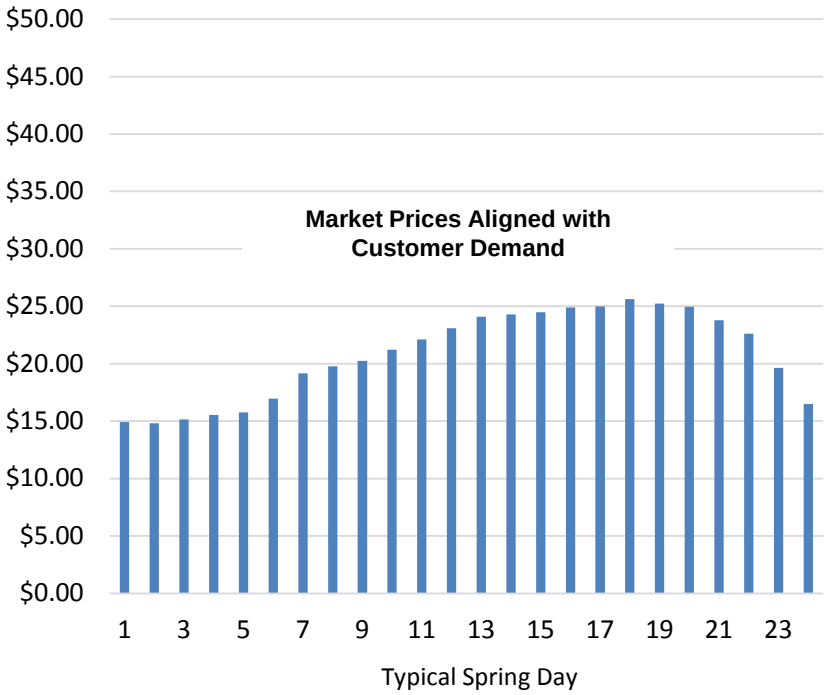
Solar Thermal - 6 Hour Storage (100 MW)



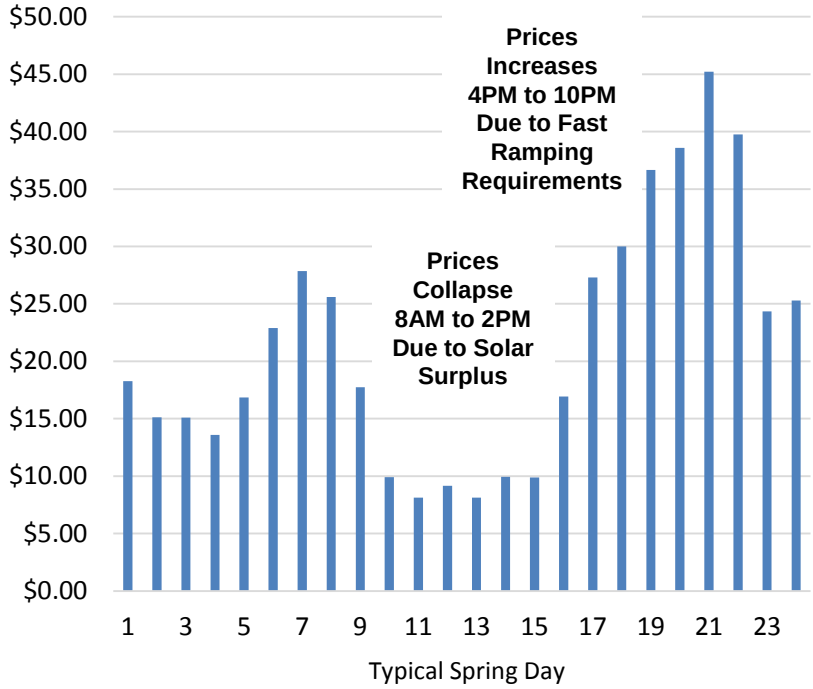
Note: *Utility projects which have commenced construction before December 31, 2021 may still qualify for the 30, 26 or 22 percent ITC if they are placed in service before December 31, 2023. The Treasury and IRS are currently drafting guidance which will inform solar developers of which percentage of ITC they will qualify for depending on when they started their project*

Solar Penetration Impacts on Hourly Wholesale Power Prices

Historical Hourly Price Curves ($/MWh)



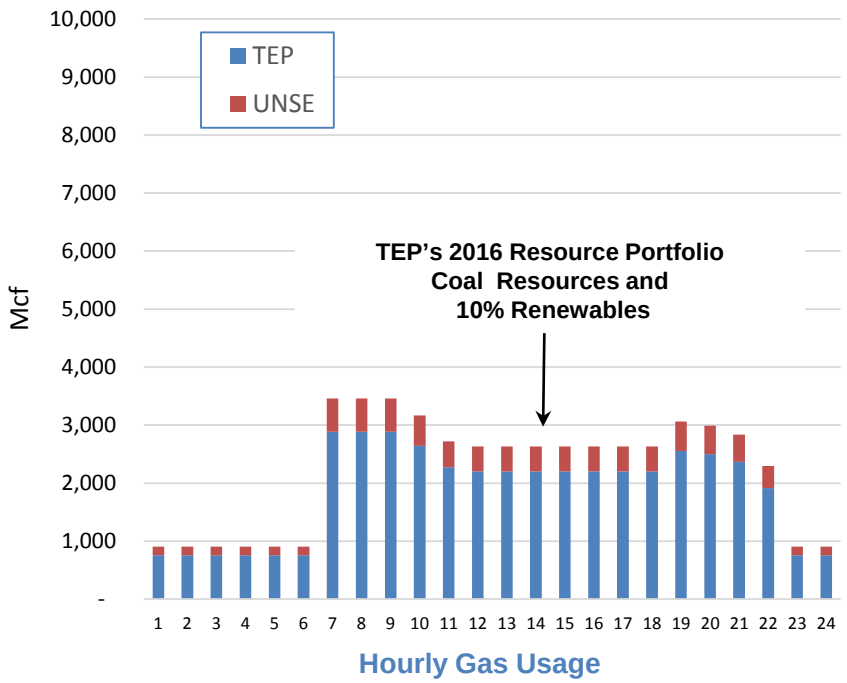
CAISO Spring 2016 Price Curves ($/MWh)



Wholesale power prices are in process of undergoing a fundamental hourly price shift to accommodate the integration of solar resources

Future Natural Gas Infrastructure Requirements

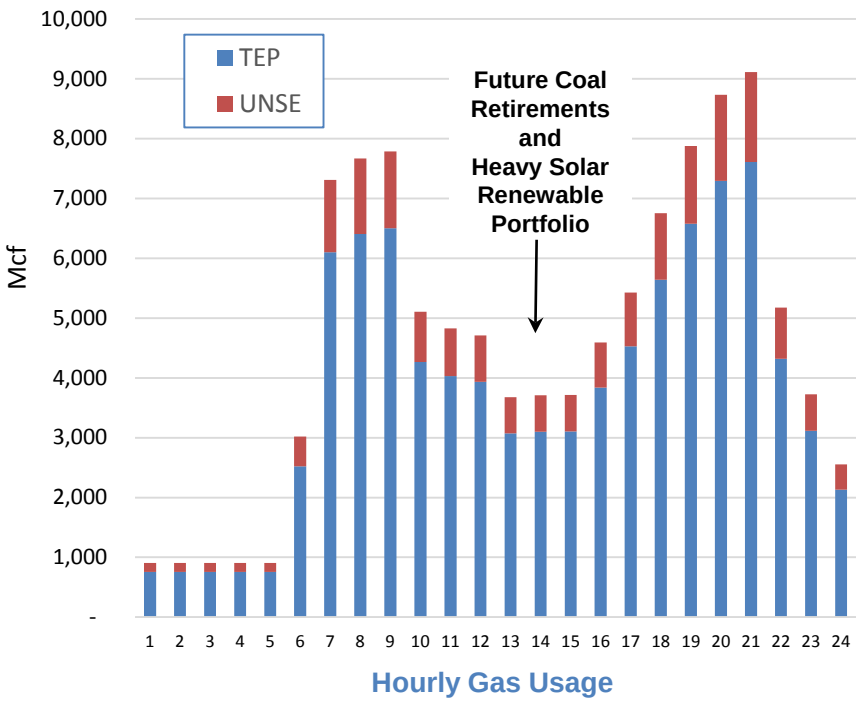
2016 Daily Natural Gas Usage (Mcf)



Peak Hour Usage	3,400 Mcf
Max Ramp Up	2,500 Mcf
Max Ramp Down	(1,400) Mcf

Average Summer Daily Usage 75,000 Mcf

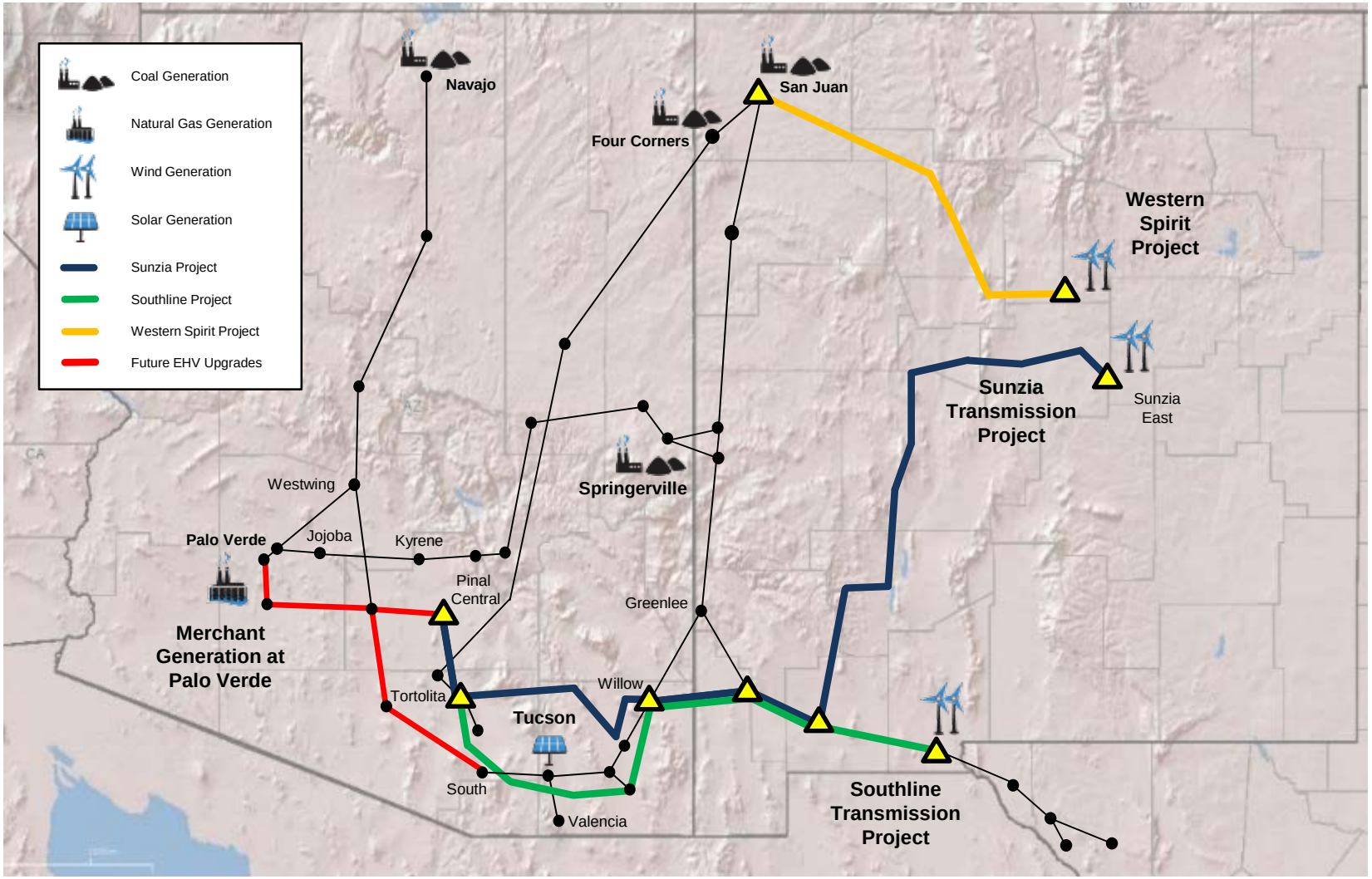
2032 Daily Natural Gas Usage (Mcf)



Peak Hour Usage	9,100 Mcf
Max Ramp Up	4,300 Mcf
Max Ramp Down	(3,900) Mcf

Average Summer Daily Usage 175,000 Mcf

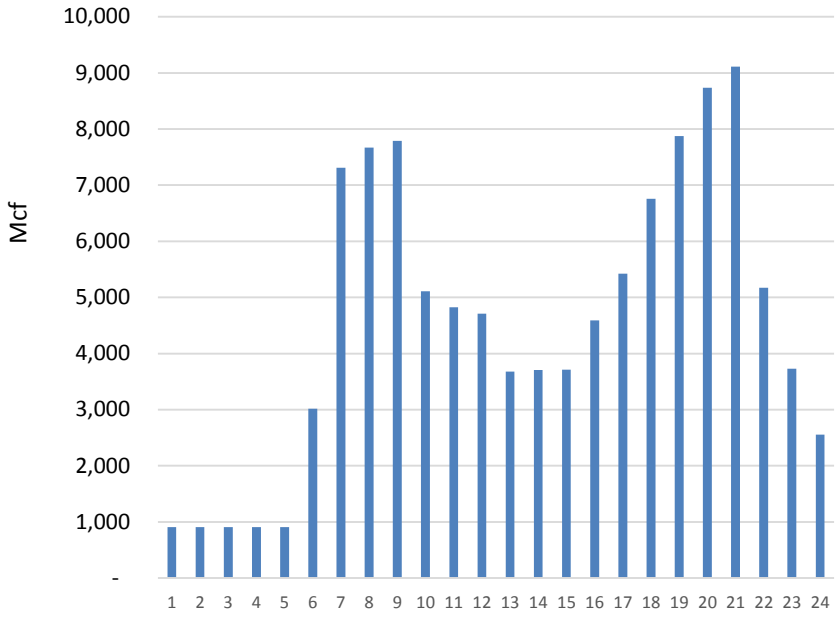
Future Regional Transmission Projects



Renewable Portfolio Diversification

2032 Heavy Solar Portfolio

80% Solar and 20% Wind

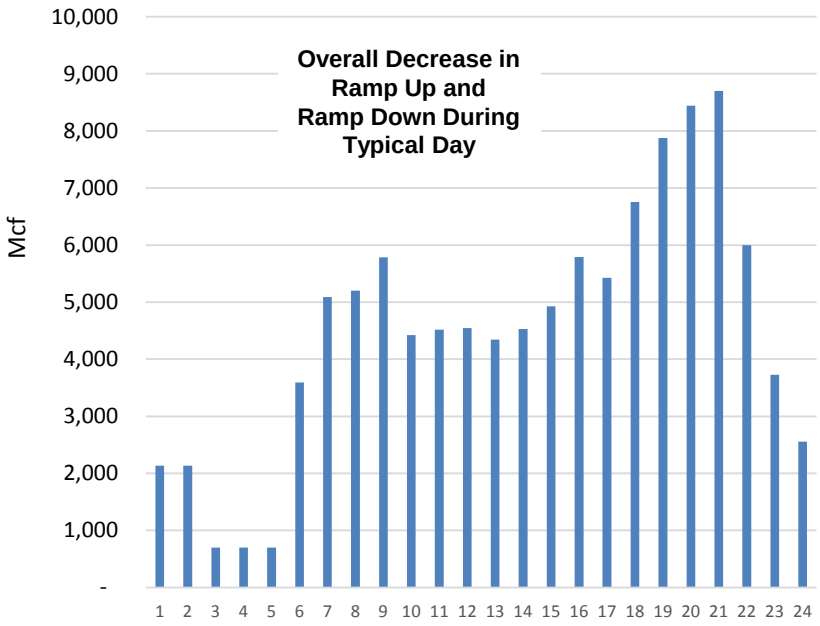


Hourly Gas Usage

Peak Hour Usage	9,100 Mcf
Max Ramp Up	4,300 Mcf
Max Ramp Down	(3,900) Mcf

2032 Balanced Solar / Wind Portfolio

50% Solar and 50% Wind

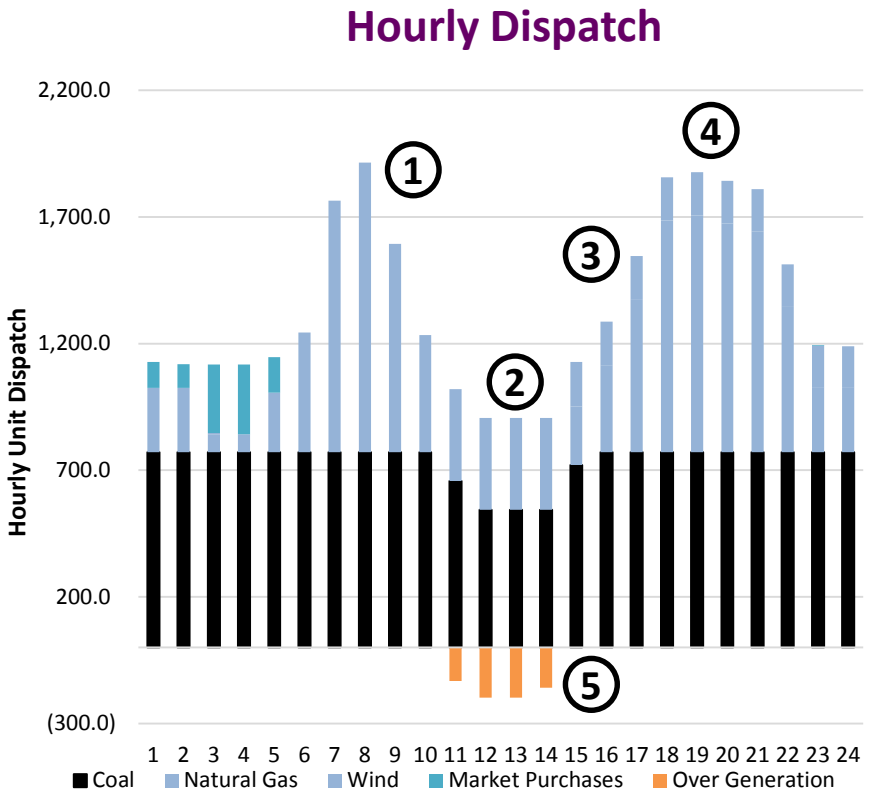


Hourly Gas Usage

Peak Hour Usage	8,800 Mcf
Max Ramp Up	3,400 Mcf
Max Ramp Down	(2,800) Mcf

2017 IRP Portfolio Diversification Strategy

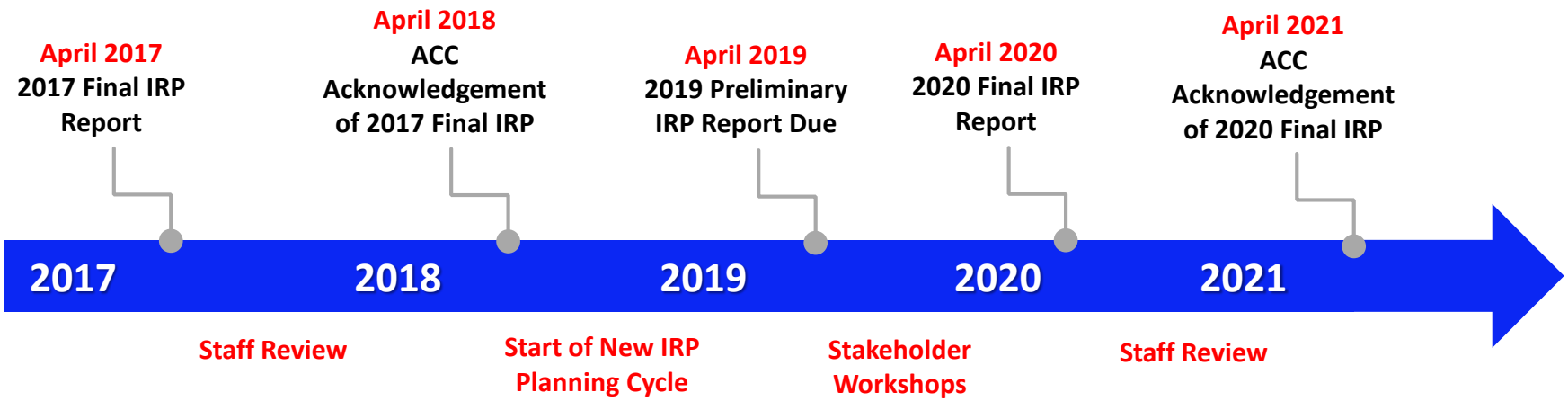
- **Compliance with Clean Power Plan**
- **Fast Ramping Natural Gas Resources**
- **Renewable Portfolio Diversification**
- **Energy Storage Technologies**
- **Regional Transmission and Imbalance Markets**
- **Natural Gas Storage**
- **Demand Response Programs**
- **Energy Efficiency**
  - Low Income Programs
  - Clean Power Plan Compliant
- **Improvements in Rate Design**



1 – Downward Ramping
2 – Minimum Generation
3 – Upward Ramping
4 – Peak Shift
5 – Over-Generation

Future IRP Requirements

- **TEP and UNSE Support a Three-Year Planning Cycle**



- **Three Year Action Plans**
  - Provides detailed overview on Company's near-term initiatives
  - Need to have a process to change plans between IRP planning cycles
  - Acknowledgement that these updates may be competitively sensitive

Planning to Meet Future Operational Requirements