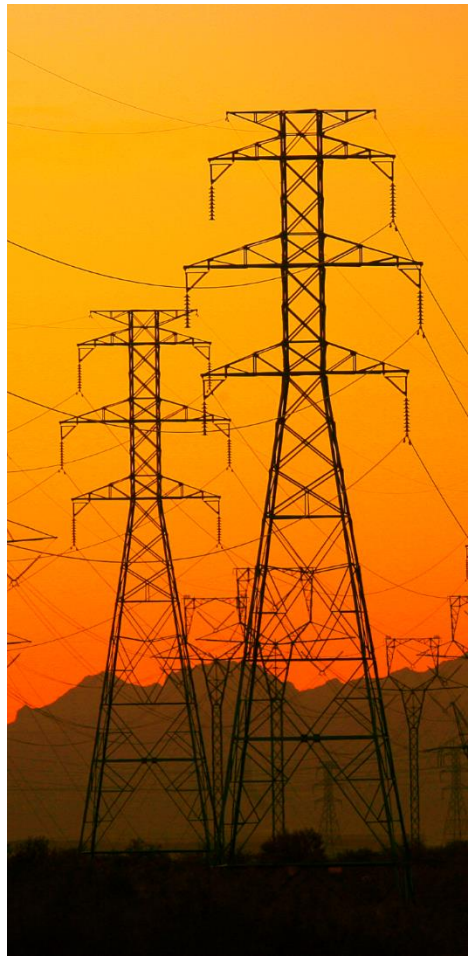
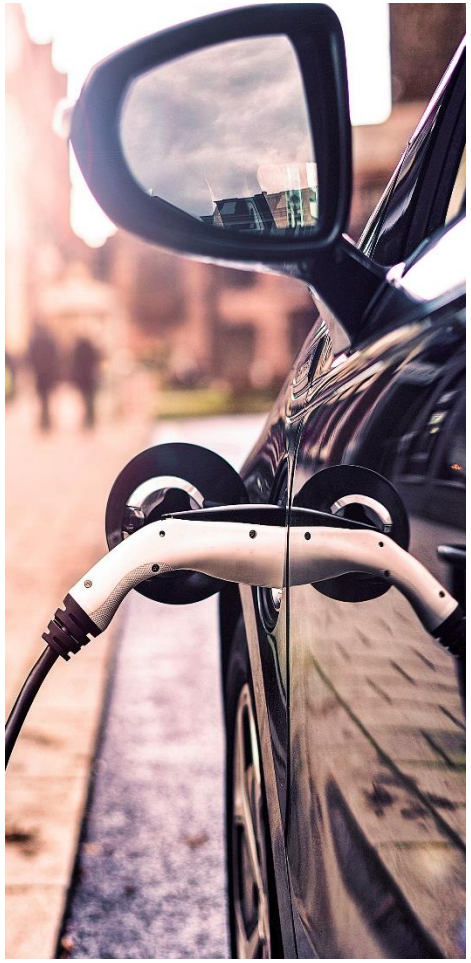


TEP Integrated Resource Plan

Advisory Council Meeting

Tucson Electric Power

July 18, 2019

Welcome

KEVIN SKINNER
CORPORATE TRAINING PROGRAM MANAGER

TEP
Tucson Electric Power

Modeling Overview

JEFF YOCKEY
DIRECTOR, RESOURCE PLANNING

TEP
Tucson Electric Power

Overview of Portfolio Cost Assessment

Portfolio and Scenario Assumptions

Plant Parameters

Fuel Price

Power Price

AURORA

Hourly Dispatch

Energy Efficiency

Load Profile

Distributed Generation

Generation

Fuel Expense

Purchase Power

Unit Stats

Emissions

Water

Non-Fuel Expense
- Capital
- Fixed O&M
- Taxes

Revenue Requirement

Reserve Margin

Carbon Compliance

Portfolio Cost (NPV)

Fixed Costs and Portfolio Net Present Value

- Aurora estimates TEP's operating / dispatch costs
- Capital and other fixed costs are estimated in a spreadsheet model that accounts for:
  - Asset depreciation
  - Cost of capital (debt and equity)
  - Fixed O&M
  - Capital improvements
  - Insurance and taxes
  - Renewable tax credits
  - Transmission and gas transportation costs
- For each portfolio, a net present value is determined for the total (operating + fixed) cost. Portfolios can then be compared on the basis of their cost and sensitivity to different market and regulatory conditions (scenarios)

Overview of Aurora

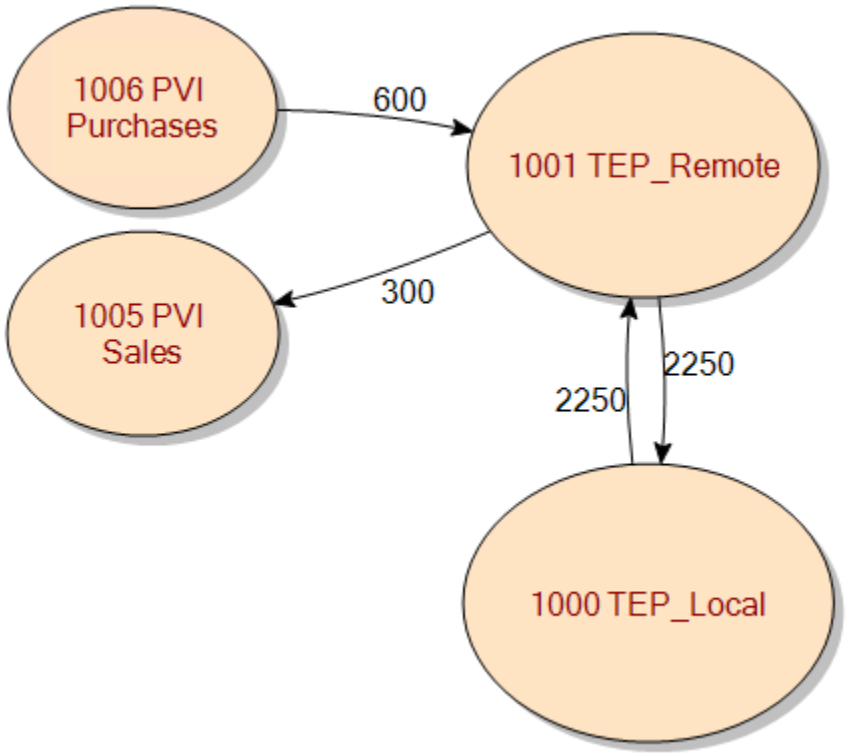
- Specifically designed for simulating electricity system dispatch and costs (minutes to years)
- Determines the least-cost dispatch subject to a variety of specifications and constraints

- Example specifications:
  - Electricity demand
  - Fuel prices and other O&M costs
  - Unit capacities and efficiencies
  - Unit emission rates
  - Planned and unplanned outages
  - Ramp rates and minimum up/down times
  - Demand side programs
  - Wholesale electricity market prices
  - Power contracts

- Example constraints:
  - Transmission limits
  - Ancillary service requirements (reserves)
  - Minimum renewable energy generation
  - Minimum fuel use (take or pay contracts)
  - Fuel limits (hydro, gas, storage)
  - Emission limits

AURORA

BY ENERGY EXEMPLAR



Status | Project Setup | Input Tables | Resources TEP

Change Set Window

File | Home | Location

New Folder

Clear Filter — Unfiltered

Save to Memory

- Change Sets Main
  - Base Case
  - High Economy
    - Time Series Annual
    - Time Series Monthly
  - High Technology
    - Time Series Annual
    - Time Series Monthly
- Unassigned Changes

Zonal Tables

Table Type	# of Records	In Study
Demand Hourly	8952	☑
Demand Monthly	14	☑
Demand Monthly Peak	1104	☑
Electricity Price	0	☑
Emission Price	7	☑
Emission Rate	135	☑
Fuel	27	☑
General Info	1	☑
Heat Rate Definitions	48	☑
Hubs	1	☑
Hydro Monthly	2	☑
Hydro Vectors	2	☑
Link	4	☑
Maintenance Schedule	159	☑
Operating Pools	2	☑
Portfolio Contract	35	☑
Portfolio Information	3	☑
Portfolio Resource	103	☑
Resource Groups	3187	☑
Resources	103	☑
Risk	756	☑
System Diagram	11	☑
Time Series Annual	143	☑
Time Series Generic	0	☑
Time Series Hourly	26304	☑
Time Series Monthly	492	☑
Time Series Weekly	22	☑

Unit Dispatch

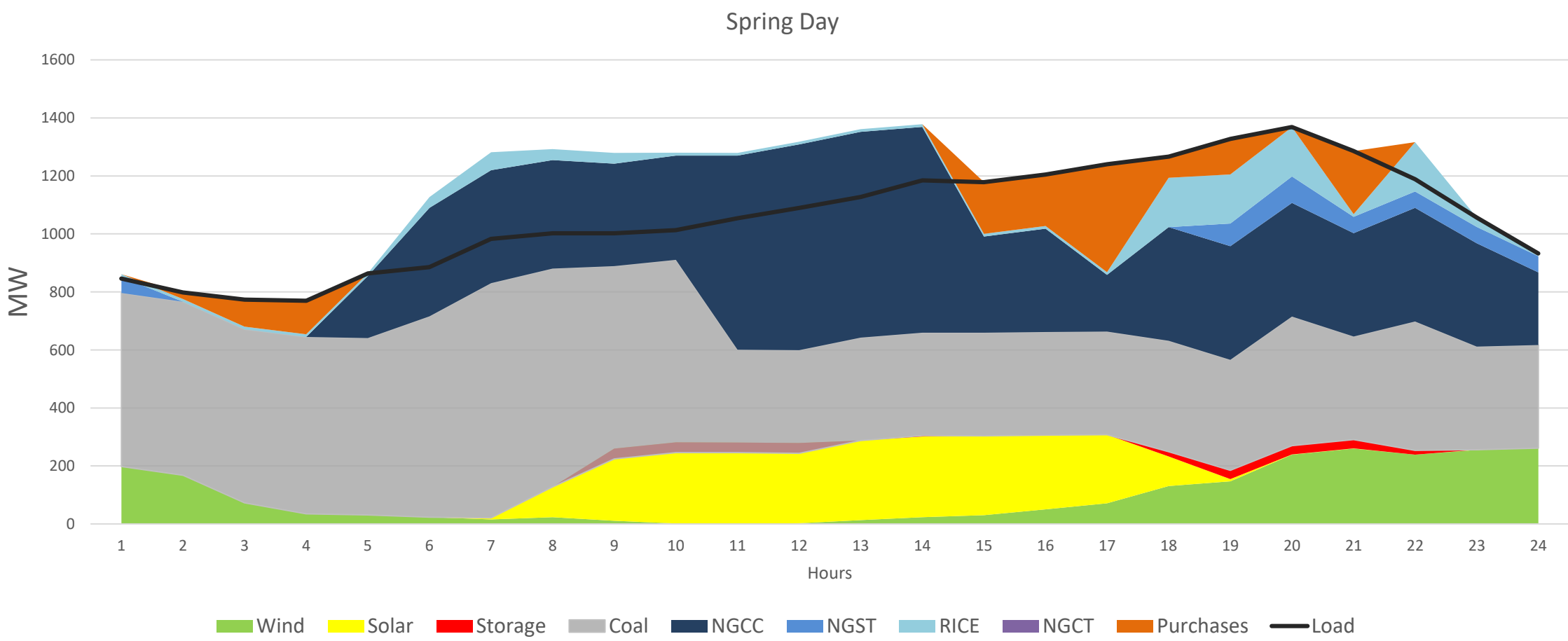
- To determine the least-cost dispatch, Aurora generally follows the process below for each hour of a simulation:
  - Distributed generation and other demand-side programs are applied to determine the net demand
  - "Must run" thermal units are dispatched at their lowest possible capabilities. (Hence, this generation appears at the bottom of the "resource stack.")
  - Because they have no fuel costs and very low variable O&M costs, renewable units are generally the cheapest and second type of resource to be dispatched. These will be dispatched at their maximum capabilities (subject to solar and wind availability in the hour), unless curtailment is necessary to avoid over generation.
  - The remaining net load for the hour is met through a least-cost combination of wholesale market purchases, further dispatch of must-run units, and dispatch of cycling and non-cycling units.
    - Dispatch Cost = **Fuel Cost** + VOM + Startup Cost (if not already operating)

      Fuel Cost = Fuel Price * Unit Efficiency (heat rate) * Unit Generation (dispatch)

Unit Commitment

- By nature of their design, many common generation technologies (e.g., coal, nuclear, and larger natural gas units) cannot turn on and off by the hour. They are either physically incapable or incur significant startup costs when doing so.
- Such units are designated "non-cycling" and are assigned minimum up times, minimum down times, start-up costs, and shut-down penalties.
- Non-cycling units must be "committed" before they are eligible for dispatch. Aurora will commit a unit if: 1) it has been off for its min down time, and 2) it is profitable to operate over its min up time, given its startup and dispatch costs and an "internal" price forecast generated by Aurora specifically for commitment decisions.
- Once committed, a non-cycling unit must generate at least its minimum generation for at least its min up time. After such time, Aurora will shut down a unit when its unprofitability exceeds its start-up costs (plus any shut-down penalty).

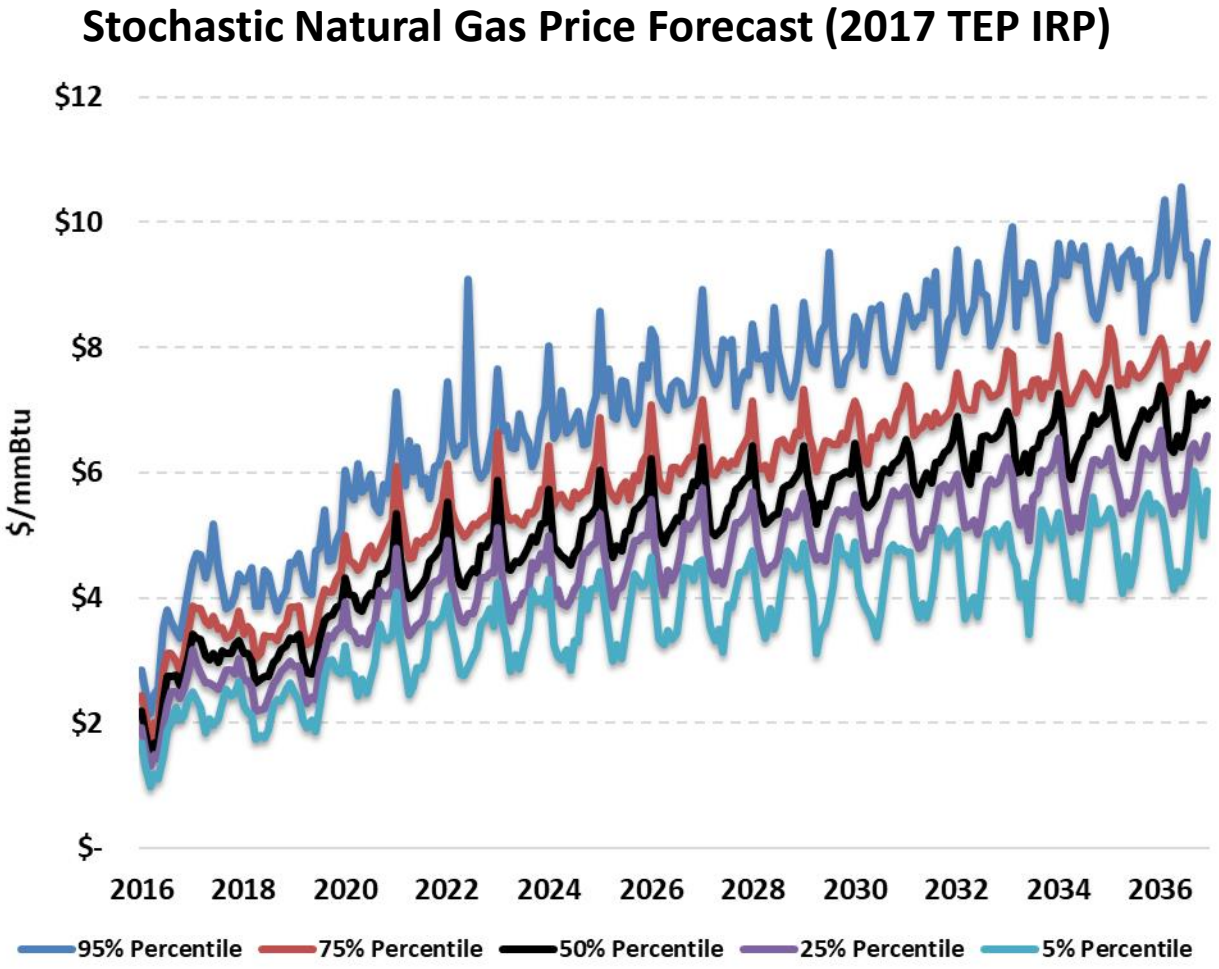
Daily Dispatch Profile



NGCC=Natural Gas Combined Cycle | NGST=Natural Gas Steam | NGCT=Natural Gas Combustion Turbine | RICE=Reciprocating Internal Combustion Engine

Other Aurora Capabilities

- Long-term capacity expansion
  - Least-cost build-out and retirement pathway given specific requirements
- Risk studies
  - Evaluate how model outputs (costs, emissions, etc.) are affected by uncertainty in the inputs
  - Input values can be stochastically varied or demand, unit outages, renewable generation, and fuel prices
- Marginal cost studies
- Wholesale electricity price forecasts
- Market valuation of electricity assets



Technology and Cost Projections

Tucson Electric Power

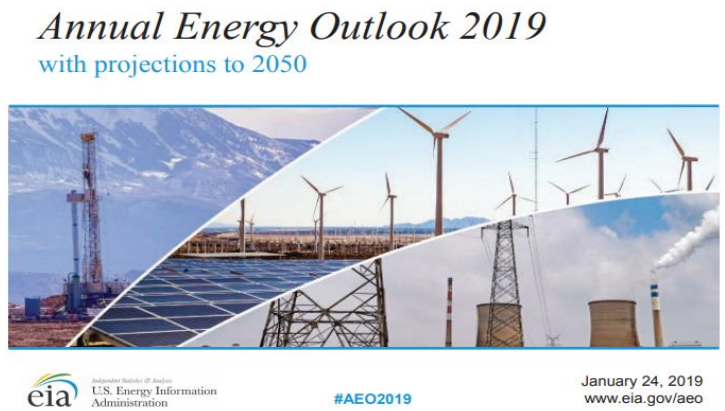
Technology Cost and Performance Projections

- Wood Mackenzie
  - An industry leading research, analysis and consulting firm
  - Requires a subscription: North American Power and Renewables Subscription
  - The North America Power and Renewables subscription includes a Long-Term Outlook (LTO), which is a comprehensive integrated forecast of energy demand and supply
- National Renewable Energy Laboratory (NREL)
  - The National Renewable Energy Laboratory is a national laboratory of the U.S Department of Energy, Office of Energy Efficiency and Renewable Energy
  - Annual Technology Baseline (ATB) workbook documenting detailed cost and performance data (both current and projected) for both renewable and conventional technologies.
  - The ATB data are freely available for use
- U.S. Energy Information Administration(EIA)
  - Statistical and analytical agency within the U.S. Department of Energy.
  - EIA's information is issued daily, weekly, monthly, annually, and periodically as needed or as requested
  - Annual Energy Outlook (AEO) provides long-term energy projections for the United States

Wood Mackenzie

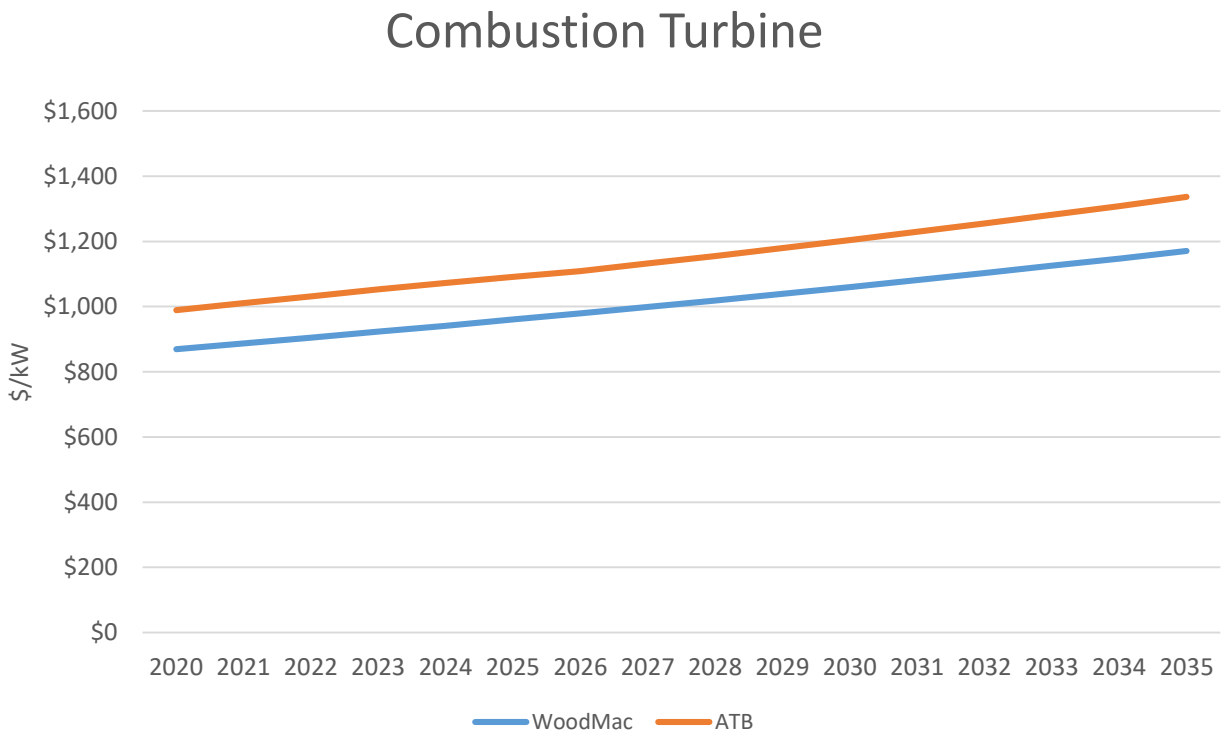
2018 Annual Technology Baseline (ATB)

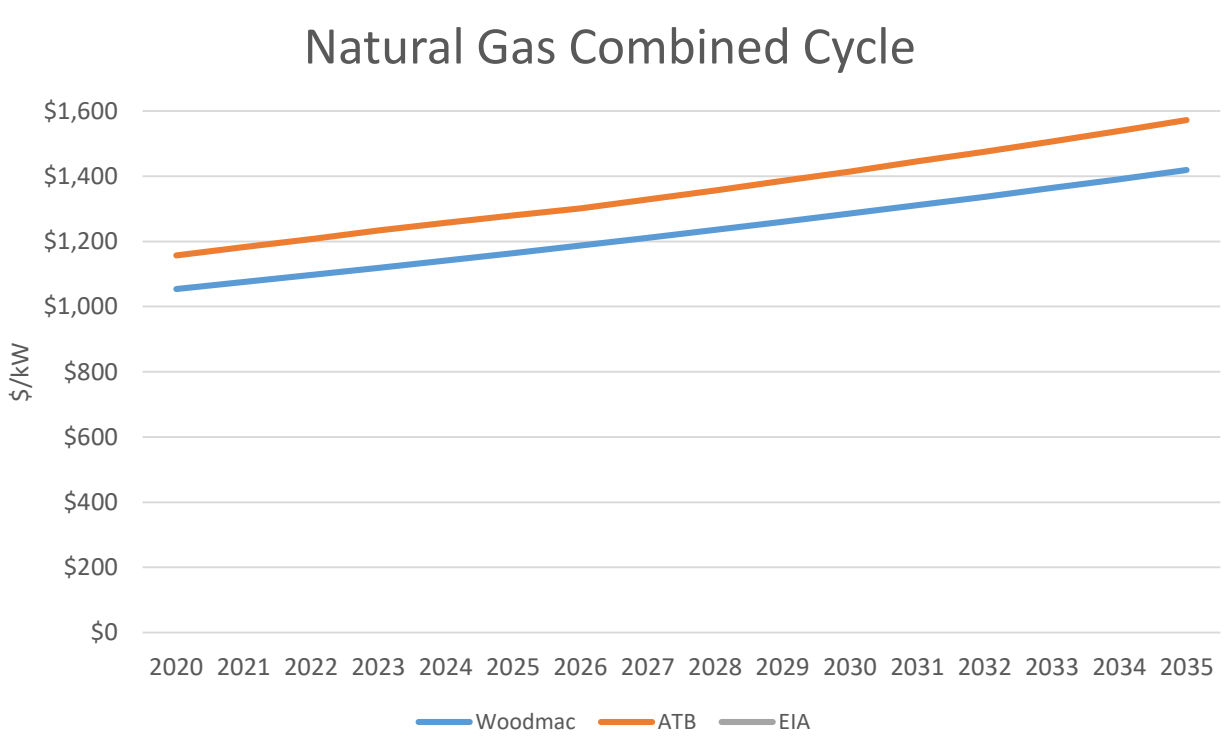
NREL
NATIONAL RENEWABLE ENERGY LABORATORY



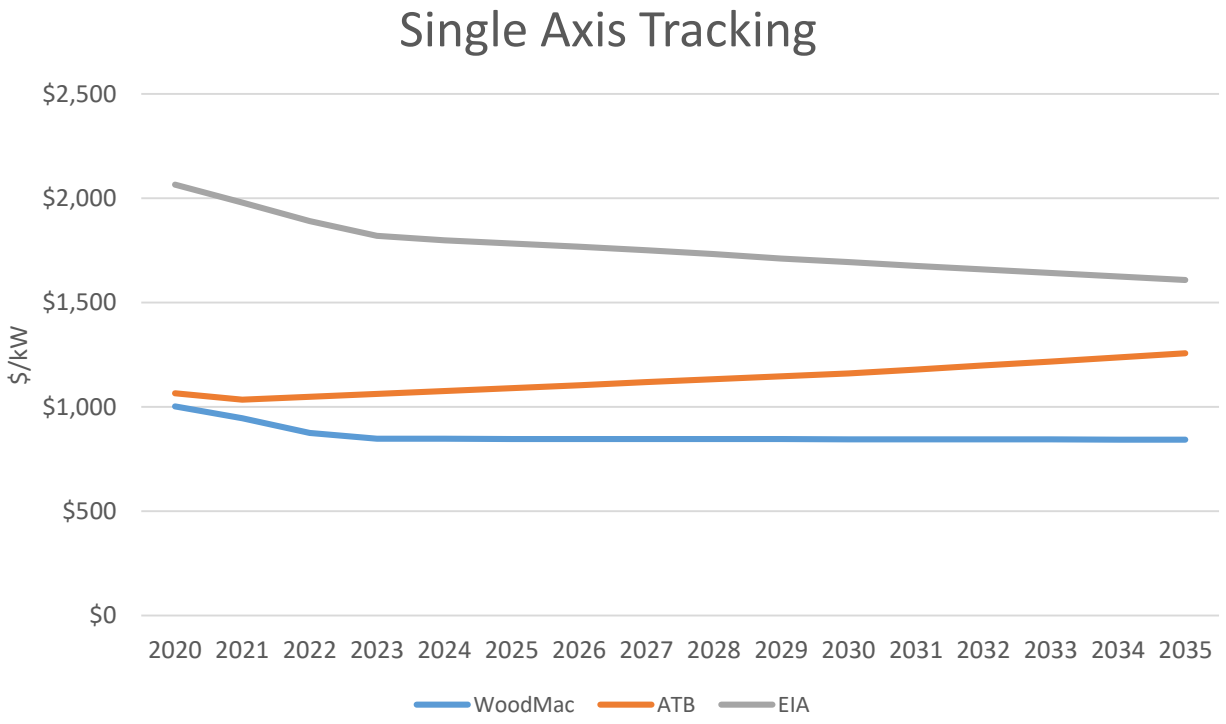
https://my.woodmac.com/ | https://atb.nrel.gov/ | https://www.eia.gov/outlooks/aeo/

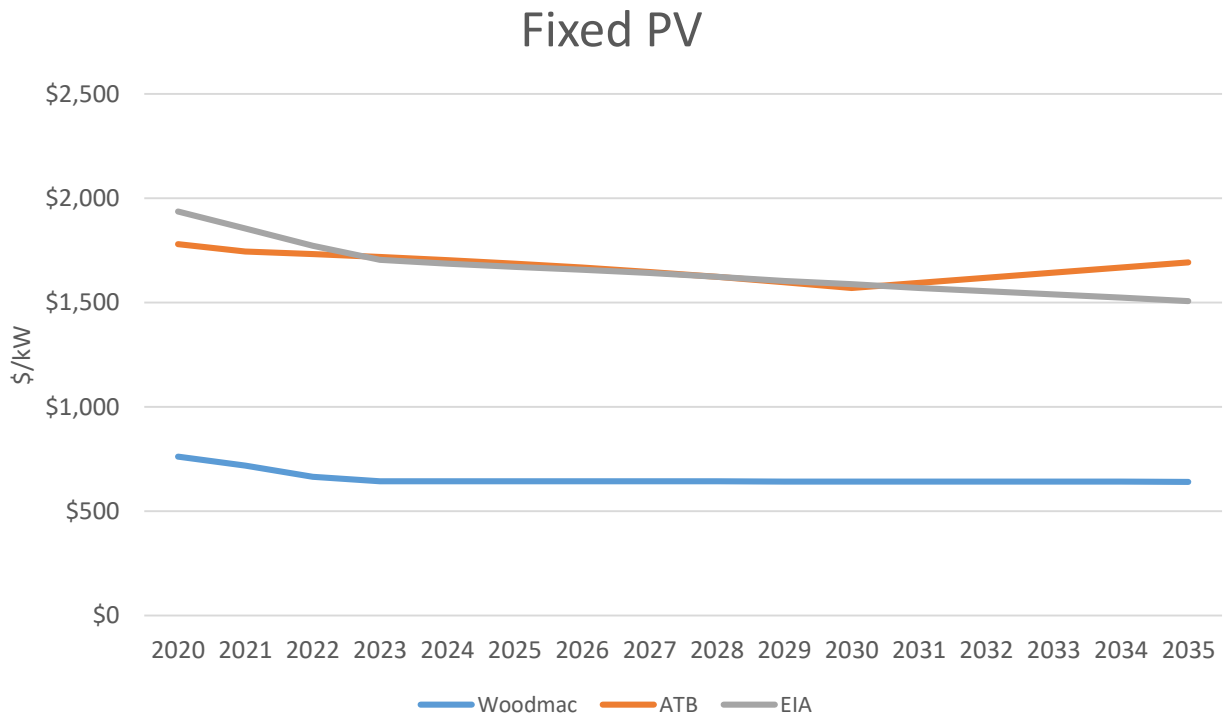
Fossil CapEx Forecast



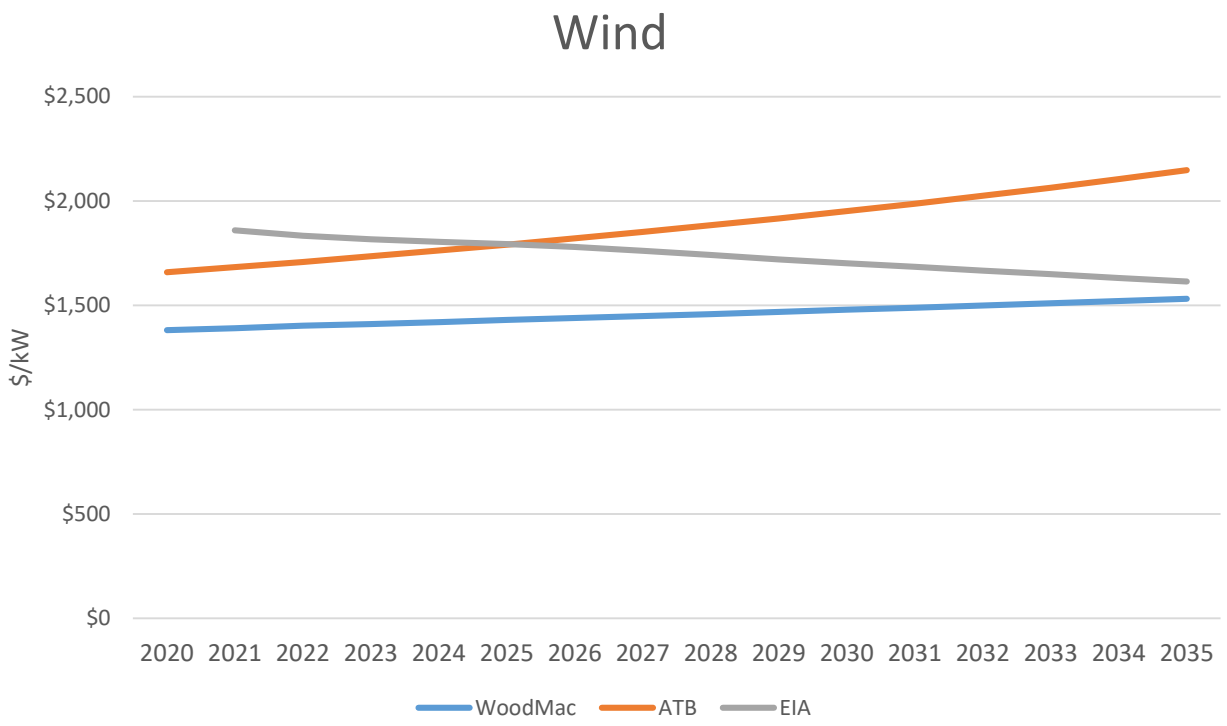


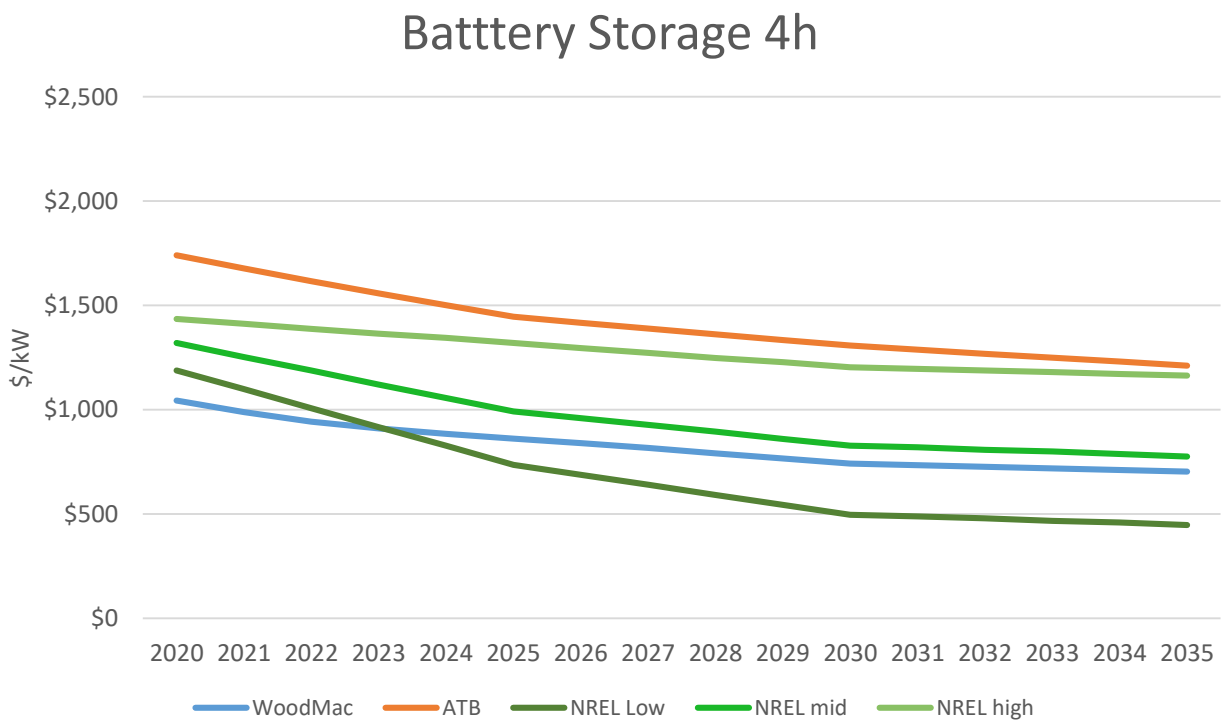
Solar CapEx Forecast





Wind and Battery CapEx Forecast





NREL - https://www.nrel.gov/docs/fy19osti/73222.pdf

Phase Out of Federal Tax Incentives

Production Tax Credit (PTC)

- $23/MWh credit for each unit of generation
- Annual inflation-adjustment
- Applies for 10 years after the date the facility is placed in service
- Safe harbor

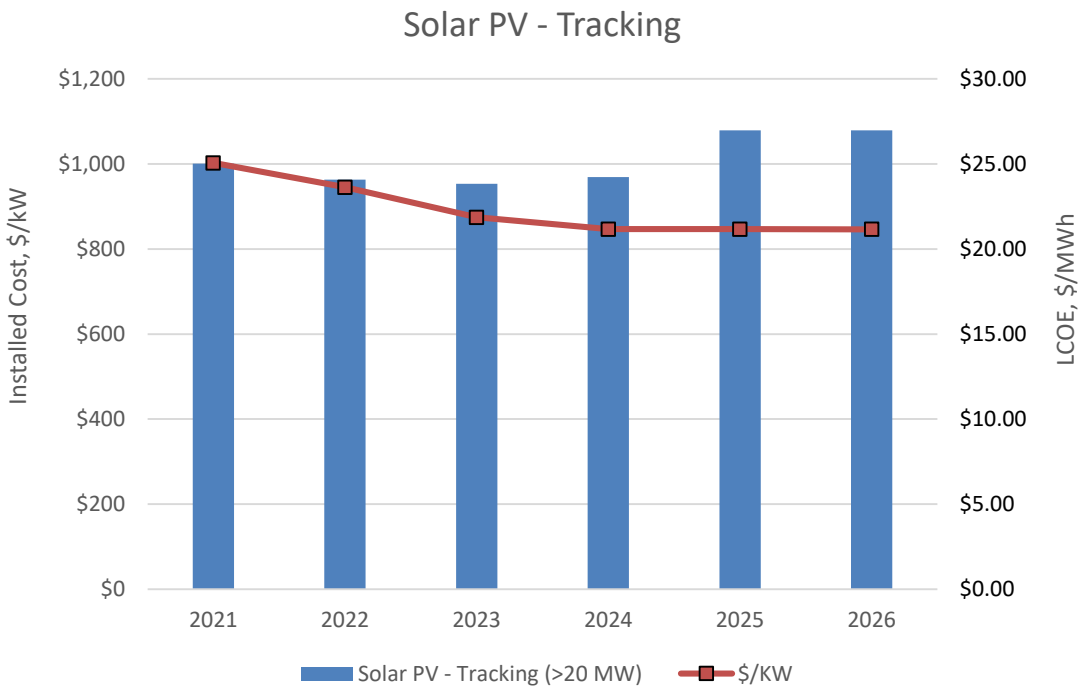
Investment tax credit (ITC)

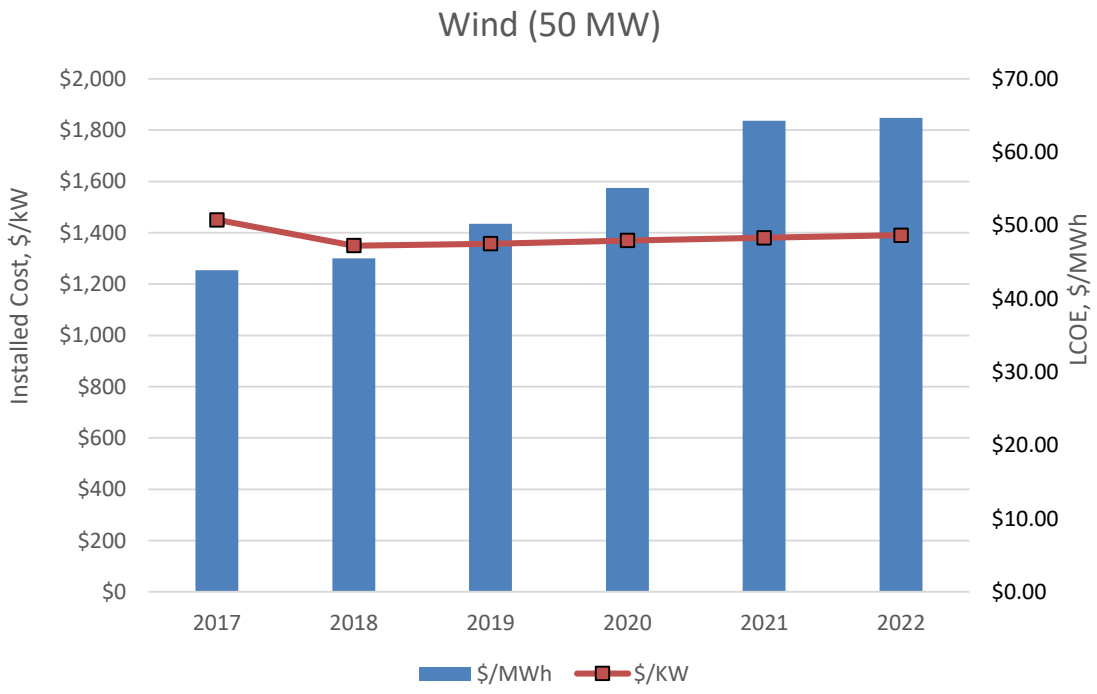
- Deducts the percentage from the cost of installing a solar energy system from federal taxes
- Credit is amortized over the life of the asset

Year Construction Commences (1)	PTC Available	ITC Available
2017	PTC amount is reduced by 20%	30% Deduction
2020	PTC amount is reduced by 40%	30% Deduction
2019	PTC amount is reduced by 60%	30% Deduction
2020	PTC no longer available	26% Deduction
2021		22% Deduction
2022+		10% Deduction

(1) Must achieve commercial operation within four years.

Impacts of Tax Credits





Candidate Resources

- Future resources to be modeled
  - Reliable cost data
  - Successfully deployed at TEP
  - Successfully deployed at similar utilities for similar purposes
  - Particular interest to stakeholders

- Future resources not being considered
  - Conventional hydroelectric
  - Coal
  - Integrated gasification combined cycle
  - Small modular nuclear reactors
  - Geothermal

Table 6 - Resource Matrix

Category	Type	Zero or Low Carbon Potential	Level of Deployment by Utilities	Local Area Option	Interconnection Difficulty	Dispatchability
Load Modifying Resources	Energy Efficiency	Yes	High	Yes	None	None
	Direct Load Control	Yes	Medium	Yes	Low	High
	Distributed PV Solar Generation	Yes	Medium	Yes	Medium	None
Grid Balancing/ Load Leveling Resources	Reciprocating Engines	No	Low	Yes	Medium	High
	Combustion Turbines	No	High	Yes	Medium	High
	Batteries (Li-ion)	(1)	Low	Yes	Medium	High
	Batteries (Flow)	(1)	Low	Yes	Medium	High
	Pumped Hydro	(1)	High	No	High	High
Load Serving Renewable Resources	Wind	Yes	Medium	No	High	Low
	Solar PV	Yes	Medium	Yes	Medium	Low
	Solar Thermal	Yes	Low	Yes	Medium	(2)
Load Serving Conventional Resources	Combined Cycle (NGCC)	No	High	Yes	Medium	High

(1) Emissions associated with storage can vary from zero to levels greater than conventional fossil depending on what resource is on the margin during charging and discharging.

(2) Natural gas hybridization or thermal storage could allow resource to be dispatched to meet utility peak load requirements.

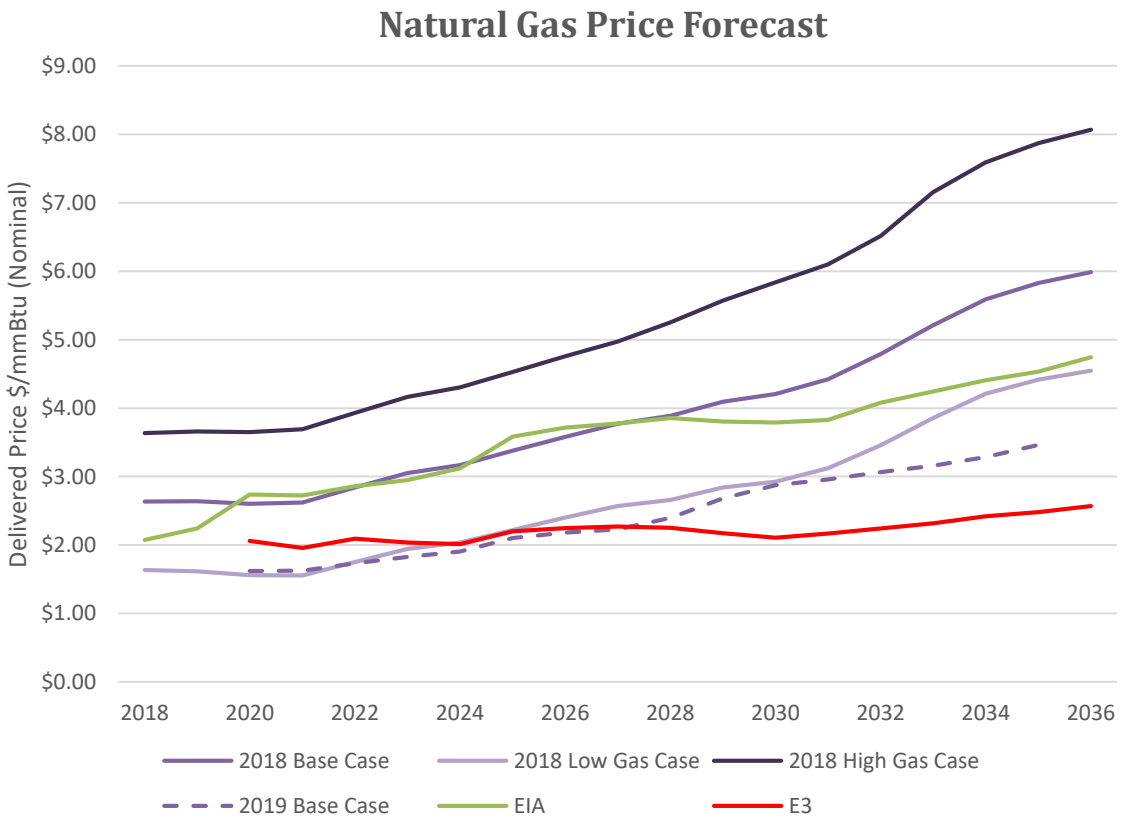
TEP Preliminary Integrated Resource Plan, p. 50

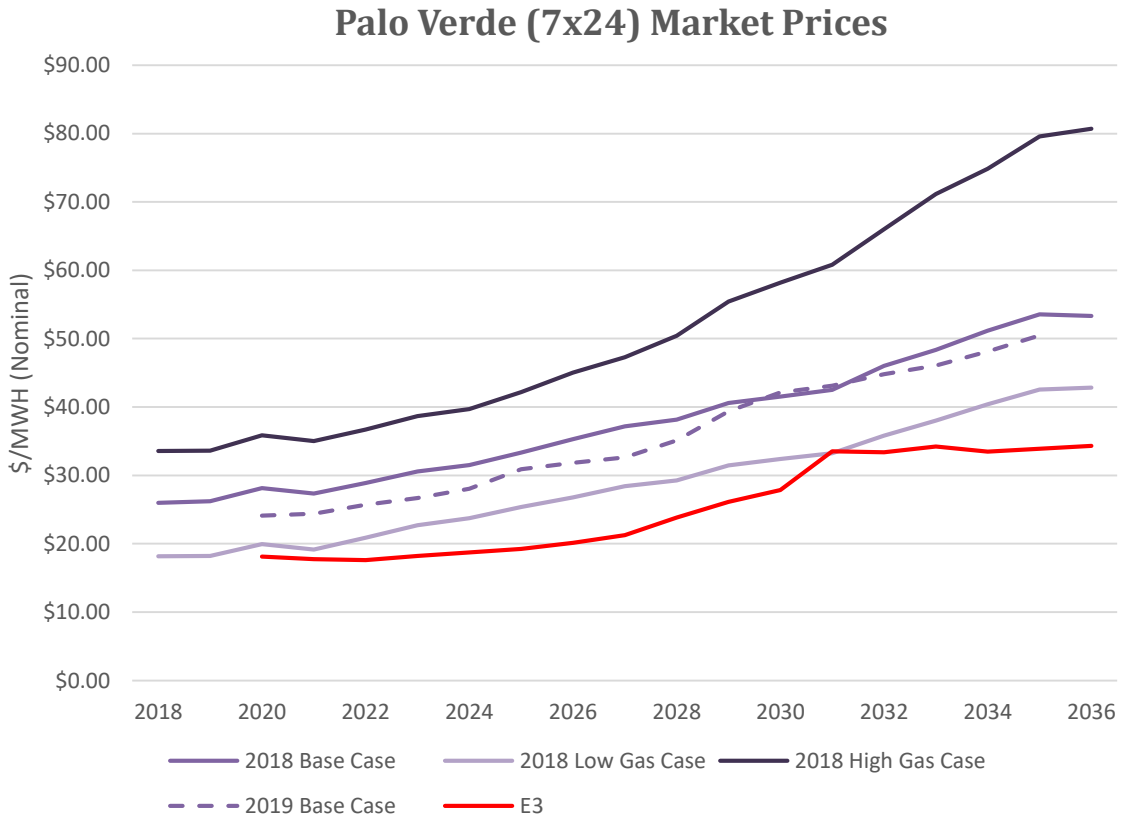
Market Projections

Tucson Electric Power

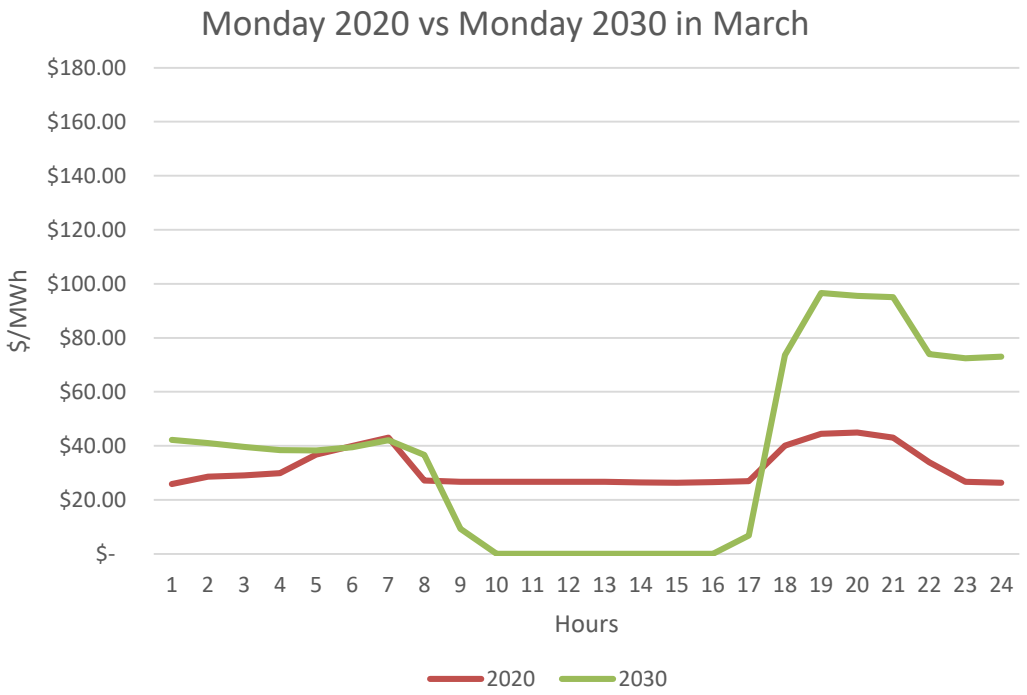
Market and Gas Forecast

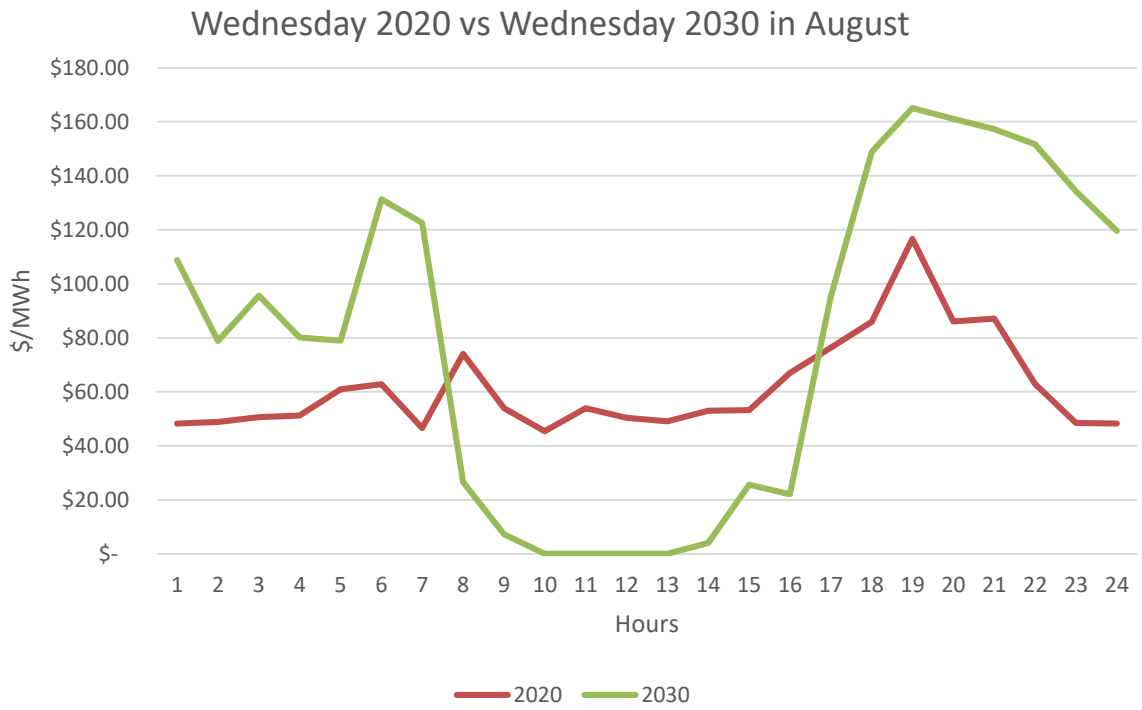
- Need integrated forecast with Gas, Power & Carbon Pricing





Midday Pricing





Advisory Council Member Feedback

KEVIN SKINNER
CORPORATE TRAINING PROGRAM MANAGER

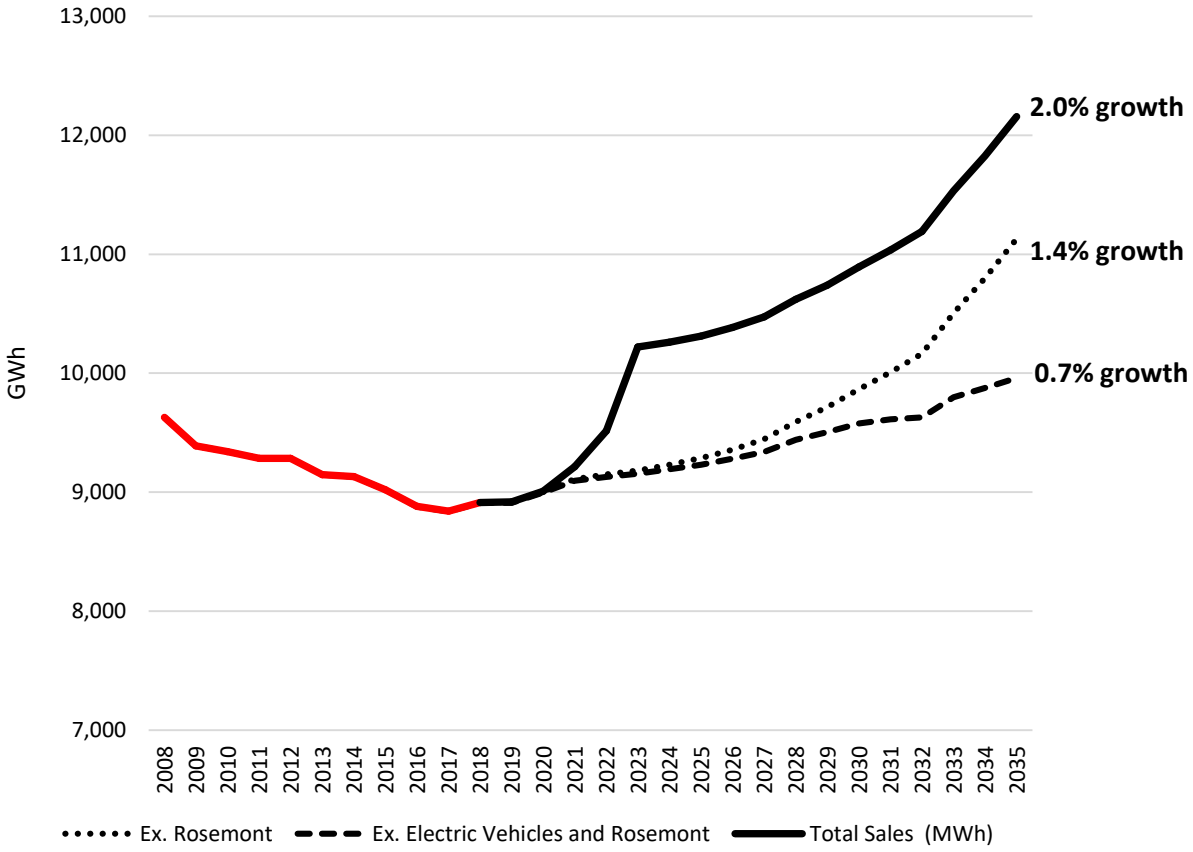
TEP
Tucson Electric Power

May Meeting - Uncertainty Summary

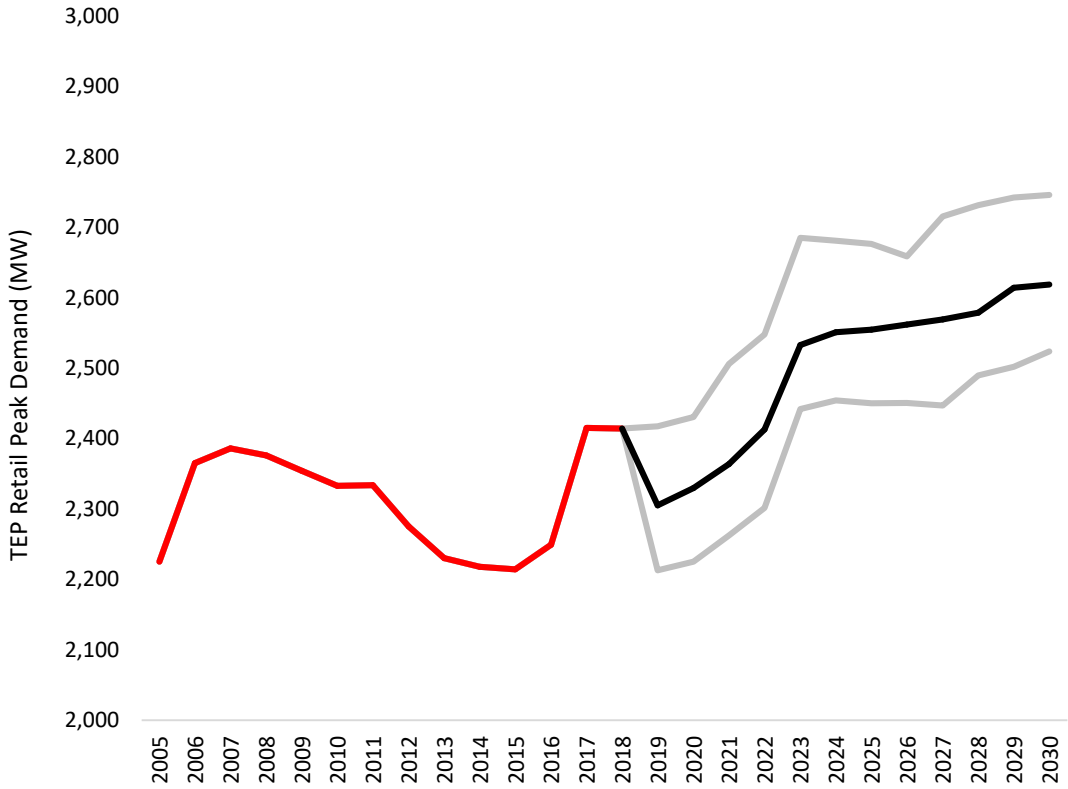
- The future is uncertain and strong forecasting tools do not change that
- Avoid “big bets” – decisions involving significant expense yet which do not perform well across all reasonably foreseeable futures
- The timing of resource acquisitions can have a significant impact on the cost effectiveness of those decisions
- Diversification helps mute the impact of unfavorable future outcomes and provides opportunity to take advantage of favorable future outcomes

June Meeting - Load Forecast

Load Forecast



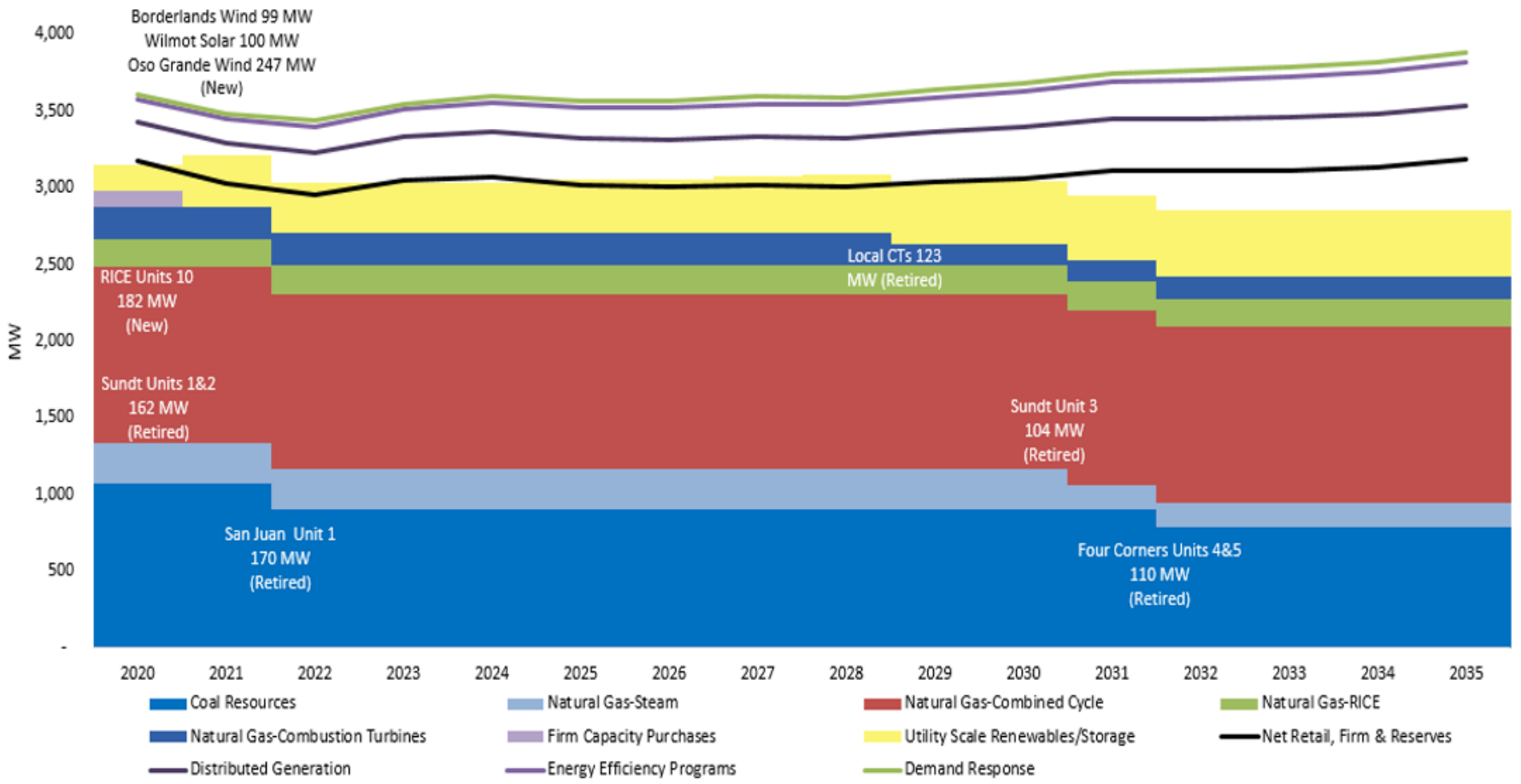
Peak Demand Forecast



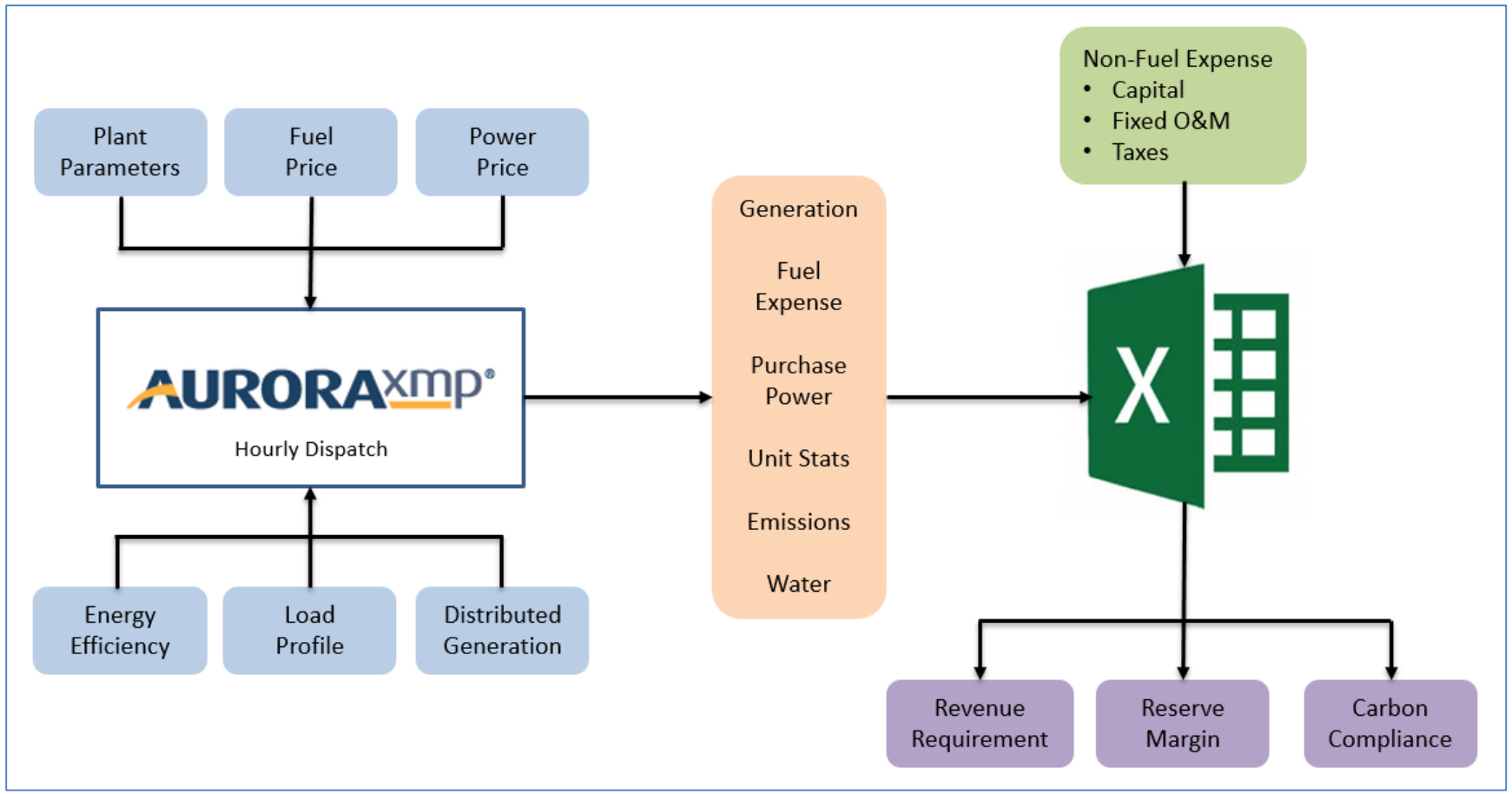
June Meeting - Resources Overview

New Resources

- Borderlands Wind (2020)
- Wilmot Solar and Storage (2020)
- Oso Grande Wind (2020)
- RICE (2020)
- Gila River Unit 2 (2019)



July Meeting - Modeling Assumptions



July Meeting - Price Forecast

New Resources Cost Factors

Year	Gas CT - Aero	Gas CT - Frame	Gas NGCC - Conventional, Wet Cooled	Reciprocating Engines	Nuclear	Solar Thermal - Six Hour Storage	Solar PV - Fixed Tilt (1-20 MW)	Solar PV - Tracking (>20 MW)	Wind - Onshore	Battery Storage
2017	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2018	1.013	1.013	1.013	1.013	1.013	0.930	0.917	0.917	1.005	0.796
2019	1.034	1.034	1.034	1.034	1.034	0.863	0.855	0.855	1.014	0.751
2020	1.054	1.054	1.054	1.054	1.054	0.793	0.802	0.802	1.023	0.707
2021	1.075	1.075	1.075	1.075	1.075	0.788	0.756	0.756	1.030	0.670
2022	1.097	1.097	1.097	1.097	1.097	0.783	0.699	0.699	1.038	0.639
2023	1.119	1.119	1.119	1.119	1.113	0.777	0.677	0.677	1.045	0.616
2024	1.141	1.141	1.141	1.141	1.129	0.771	0.677	0.677	1.052	0.598
2025	1.164	1.164	1.164	1.164	1.146	0.764	0.677	0.677	1.059	0.583
2026	1.187	1.187	1.187	1.187	1.162	0.757	0.677	0.677	1.066	0.568
2027	1.211	1.211	1.211	1.211	1.179	0.749	0.676	0.676	1.073	0.553
2028	1.235	1.235	1.235	1.235	1.196	0.741	0.676	0.676	1.080	0.535
2029	1.260	1.260	1.260	1.260	1.213	0.731	0.676	0.676	1.087	0.519
2030	1.285	1.285	1.285	1.285	1.231	0.722	0.676	0.676	1.095	0.503
2031	1.311	1.311	1.311	1.311	1.248	0.736	0.675	0.675	1.103	0.497
2032	1.337	1.337	1.337	1.337	1.266	0.751	0.675	0.675	1.110	0.492
2033	1.364	1.364	1.364	1.364	1.284	0.766	0.675	0.675	1.118	0.487
2034	1.391	1.391	1.391	1.391	1.303	0.781	0.674	0.674	1.126	0.482
2035	1.419	1.419	1.419	1.419	1.321	0.797	0.674	0.674	1.134	0.477

Base Year: 2017

TEP Preliminary Integrated Resource Plan, Appendix B

Next Steps

Future Agenda Items

- August
  - Revenue requirement
  - Resource adequacy
- September
  - Energy efficiency / DSM
  - Demand response
- October
  - Greenhouse gas emission reductions

Next Meeting

- Monday, August 19??

Questions