# TEP IRP Analysis

TEP IRP Workshop, May 2020

Prepared by Strategen Consulting for Southwest Energy Efficiency Project (SWEEP)

# Southwest Energy Efficiency Project (SWEEP)

- Non-profit public interest organization, founded 2001
- Advances policies and programs to stimulate greater energy efficiency in six western U.S. states
- Advances energy efficiency in the buildings, transportation, industrial and utility sectors


SWEEP

www.swenergy.org

# STRATEGEN

## Strategen is a mission-driven professional services firm dedicated to decarbonizing the grid

### ASSOCIATIONS

Strategen co-founded and manages the California Energy Storage Alliance (CESA) and the Global Energy Storage Alliance (GESA). Through these organizations, Strategen's policy work has been pivotal in building the energy storage industry in California, the US, and around the world.

### CONSULTING

Since 2005, Strategen Consulting provides analysis and insight to public sector leaders, utilities, developers, and global corporations helping them to achieve transformational and sustainable clean energy strategies.

### EVENTS

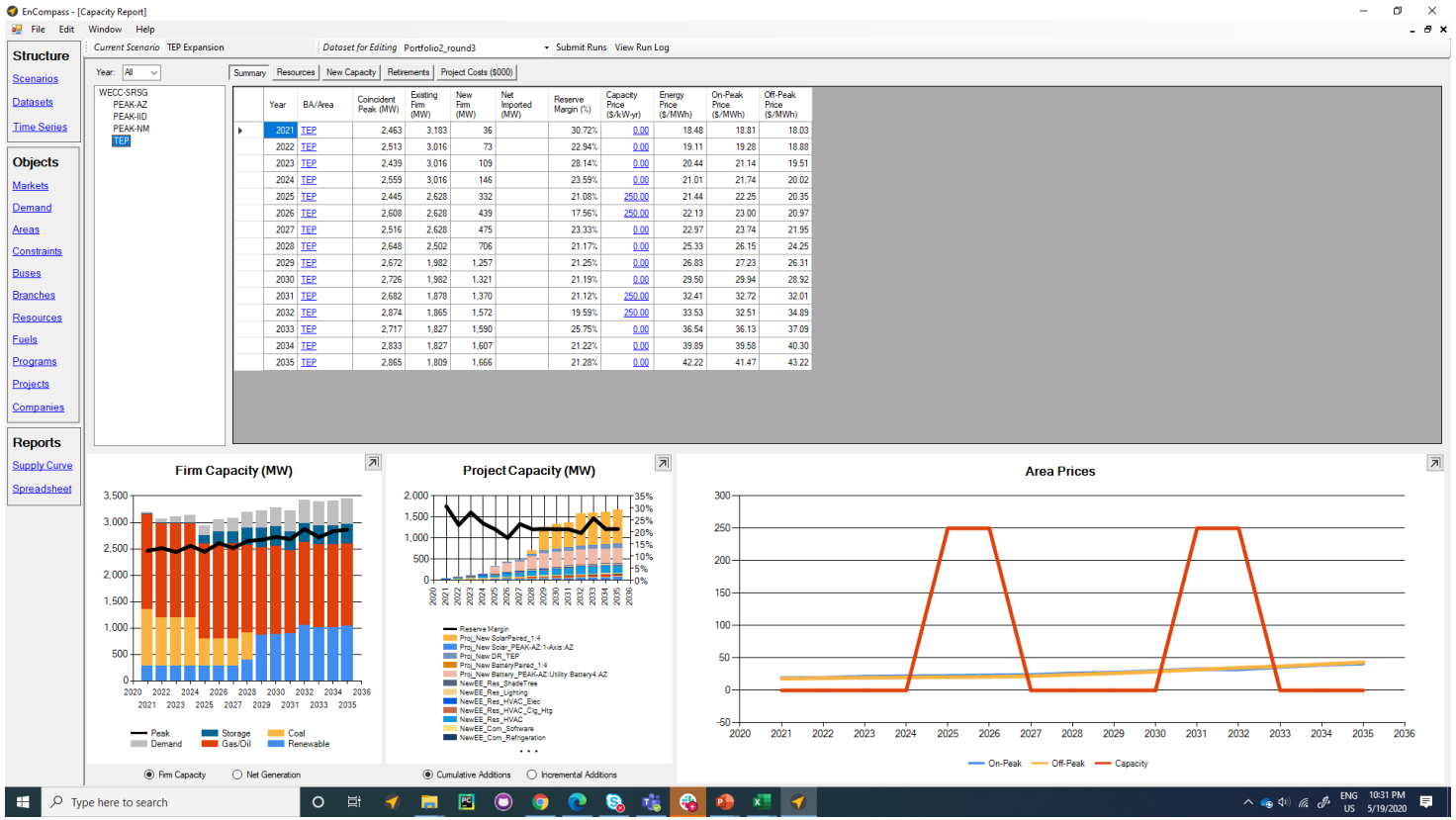
Strategen excels in stakeholder engagement, via customized small and large events.
Strategen founded Energy Storage North America (ESNA), the largest grid-connected storage conference in North America. ESNA connects over 2000 participants from 30+ countries.

# Overview

- Project Objective
- Modeling Methodology
- Portfolios
- Modeling Results
- Comparison to TEP portfolios
- Conclusions

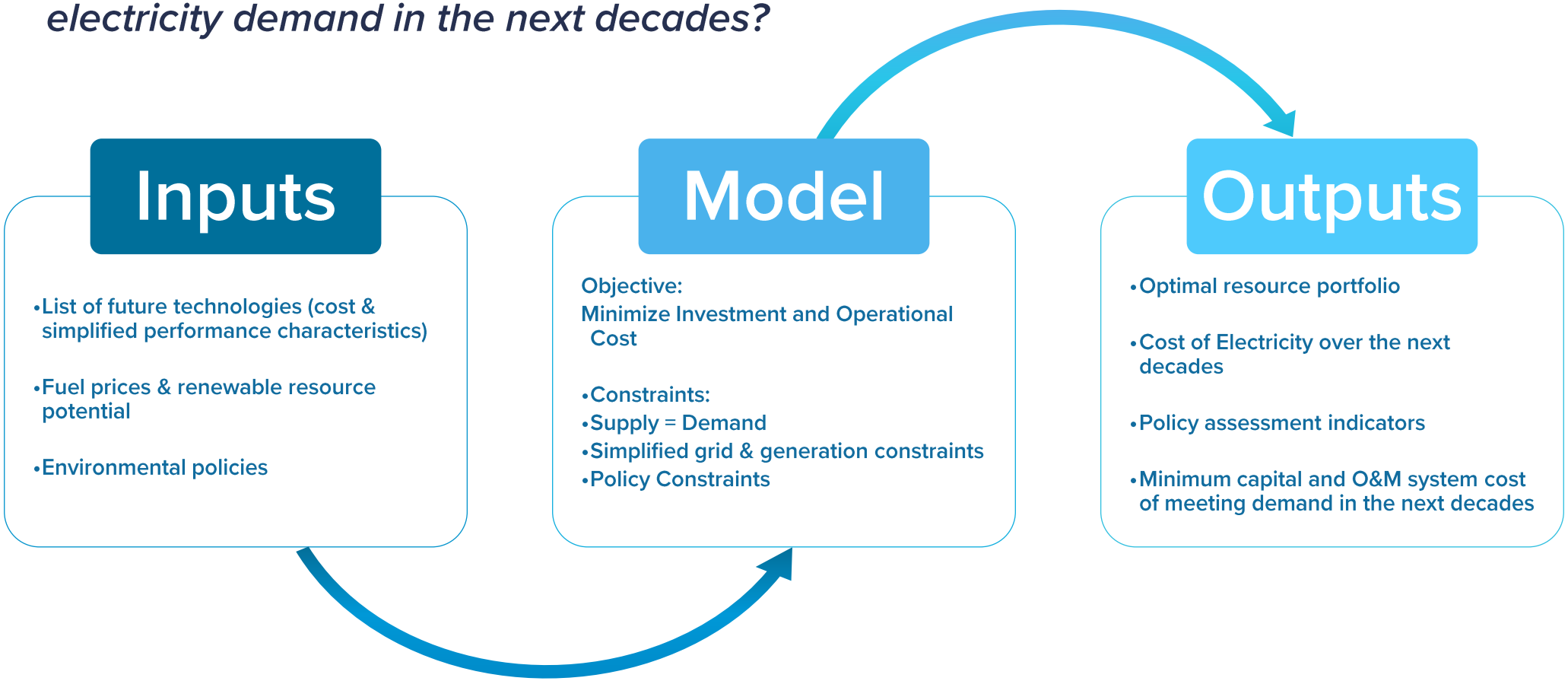
# Modeling Methodology

- TEP IRP modeling: Production Cost Modeling using *Aurora*
- SWEEP/Strategen modeling: Capacity Expansion Modeling using *EnCompass*



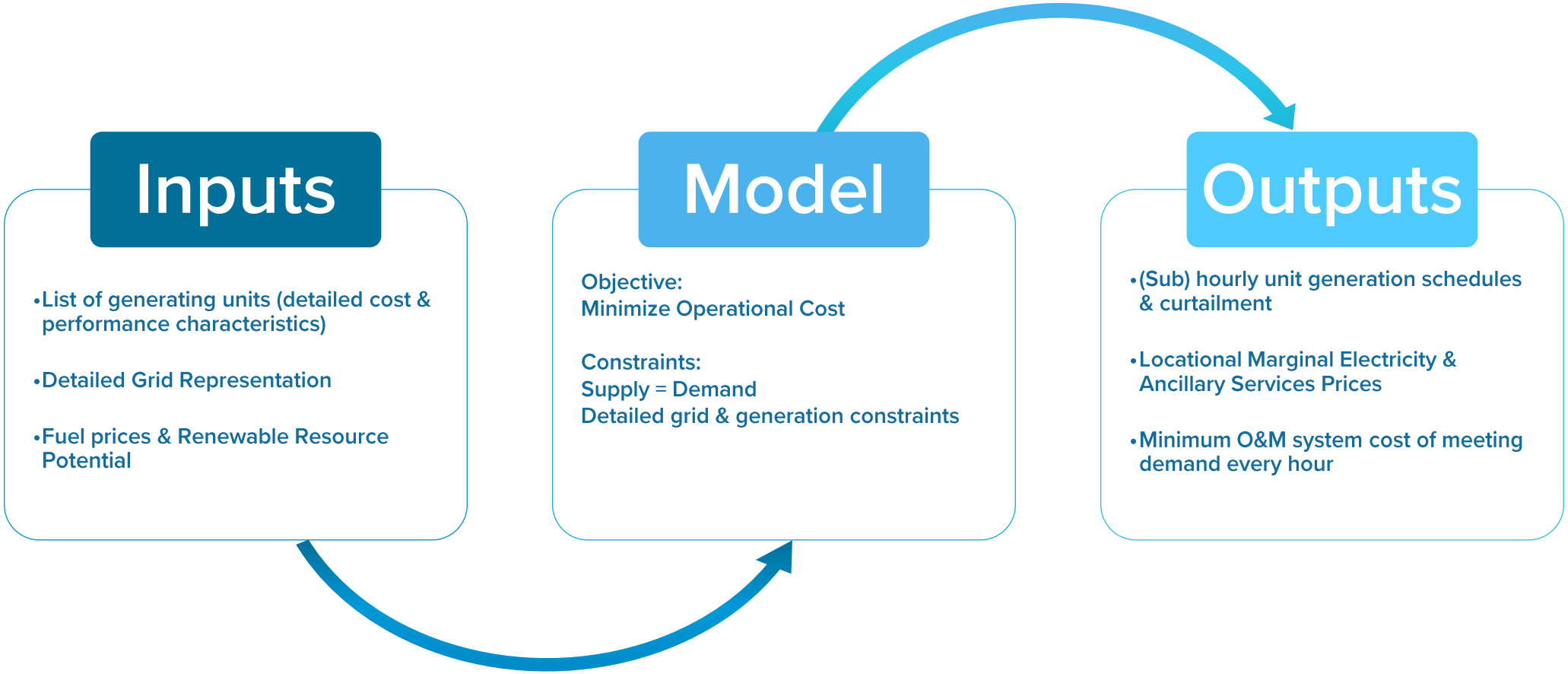
# Capacity Expansion Modeling (CEM)

*What is the least cost portfolio of resources that should be built to reliably meet electricity demand in the next decades?*



# Production Cost Modeling (PCM)

*What is the least cost dispatch of a given system of generators to reliably meet load in every hour of the day at every location?*



# Questions driving SWEEP/Strategen modeling

Optimal Resource Mix

- *What is the least cost mix of resources for TEP's system?*

Coal Resources

- *When should coal units be retired based on economic considerations (if given the option)?*
- *What are the environmental impacts from early retirement?*
- *How should coal units be dispatched if operated economically? (i.e. absent "must-run" constraints)*

Energy Efficiency & Demand Side Management

- *How much Energy Efficiency is economic when modeled as a resource option (vs. fixed load-modifying assumption)?*
- *How does the selection of EE measures impact TEP's energy and capacity needs?*
- *How selection of EE measures vary based on cost, hourly shape, coincident peak, and savings?*

# Coal Operations

- Historically, coal units have been designated as “must run”.
- Must-run units remain online and generate electricity regardless of system economics.
- Although there were reasons behind this practice, the market’s changing economics call for a different approach: economic cycling.
- SWEEP/Strategen examined the relaxation of those constraints as a transition to a cleaner system for TEP.

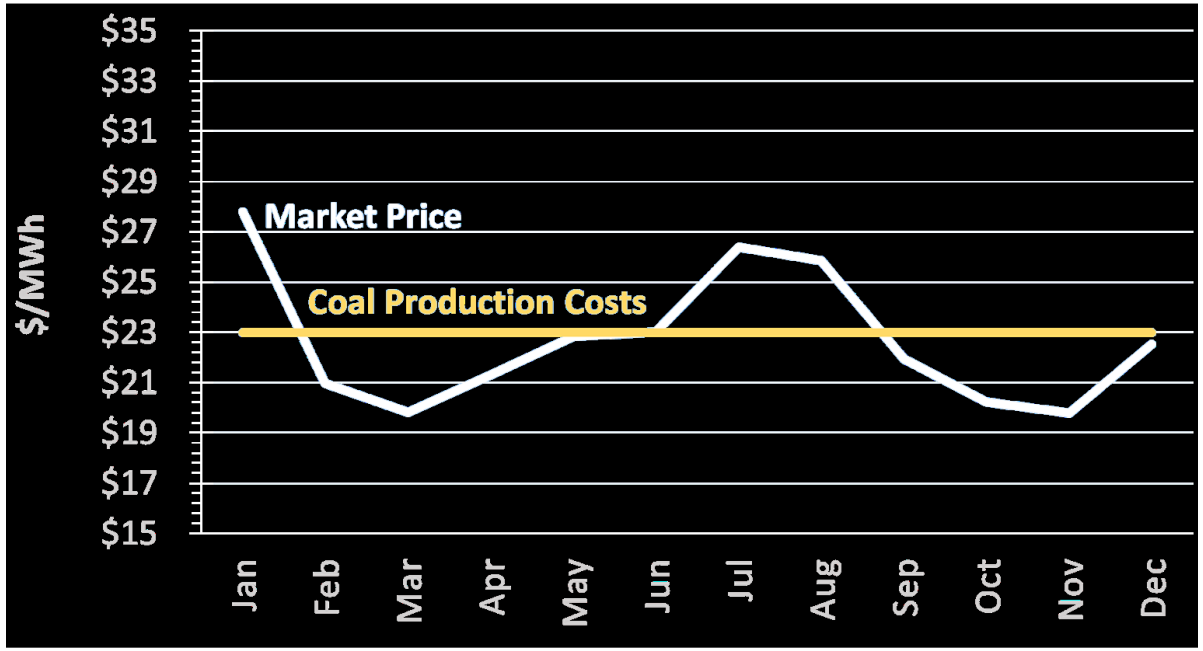



Image source: UCS

# Portfolio Assumptions – Coal Portfolios

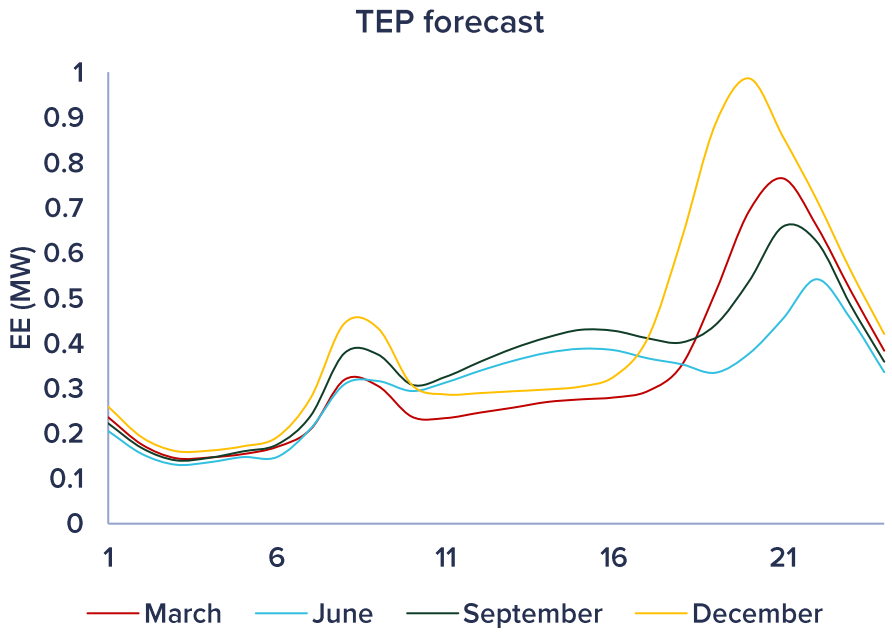
| | Coal Units | | Energy Efficiency |
|---|---|---|---|
| Portfolio 1 | Fixed Retirement<br>Four Corners – 2031<br>Springerville – after 2035 | Must Run | Model can select EE measures based on their cost competitiveness |
| Portfolio 2 | Economic Retirement (Earliest Retirement 12/31/2023) | Summer Must Run | Model can select EE measures based on their cost competitiveness |
| Portfolio 3b | Economic Retirement (Earliest Retirement 12/31/2023) | Economic Cycling | Base EE (similar to TEP base assumption) |

# Results – Coal Operations

- Coal units are uneconomic with marginal costs higher than the rest of TEP's portfolio - even more so when fixed O&M costs and capital expenses are accounted for.
- Incremental savings can be achieved with the relaxation of must run constraints on coal units. Moving from portfolio 1 (must run) to portfolio 3b (economic cycling) can reduce the revenue requirement approximately $250M).


- Economic Operations are similarly important to economic retirement and can lead to *cost and emissions* savings (emissions equivalent of shutting down a few years early) while allowing for a just transition
  - Examining economic operations is especially important due to upcoming coal contract negotiations

# Energy Efficiency in TEP Base Assumptions



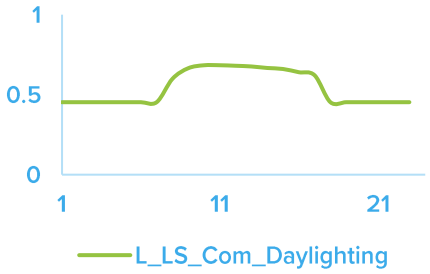

TEP Base EE portfolio consists predominantly of Residential Lighting measures.

# Energy Efficiency

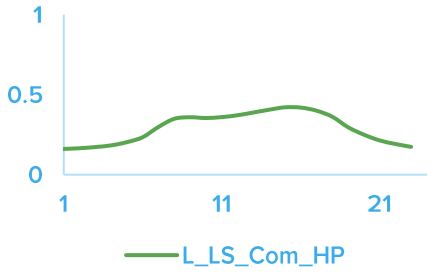
- TEP provided costs and hourly profiles of 19 EE measures:

| Measure | Maximum Annual Savings (MWh/Year) | Capacity (MW) | Lifetime (Years) | First year costs in 2020 ($/MWh) | Capacity Factor (%) | Coincident Peak* (%) |
|---|---|---|---|---|---|---|
| L_LS_Com_Daylighting | 25374 | 5.38 | 17 | 114.19 | 54% | 61% |
| L_LS_Com_HP | 8 | 0.00 | 19 | 114.19 | 29% | 63% |
| L_LS_Com_HVAC | 5239 | 3.91 | 20 | 114.19 | 15% | 60% |
| L_LS_Com_HVAC_ProgTstat | 14 | 0.02 | 11 | 114.19 | 10% | 0% |
| L_LS_Com_Lighting_Exterior | 9017 | 2.59 | 14 | 114.19 | 40% | 14% |
| L_LS_Com_Lighting_TrEx | 13 | 0.00 | 3 | 114.19 | 100% | 100% |
| L_LS_Com_Motors | 2777 | 0.58 | 15 | 114.19 | 54% | 63% |
| L_LS_Com_Refrigeration | 723 | 0.11 | 12 | 114.19 | 78% | 94% |
| L_LS_Com_Software | 1303 | 0.28 | 14 | 114.19 | 54% | 21% |
| L_LS_Res_ClothesWasher | 232 | 0.05 | 11 | 415.79 | 48% | 59% |
| L_LS_Res_HVAC | 8851 | 11.78 | 19 | 452.91 | 9% | 72% |
| L_LS_Res_HVAC_Clg_Htg | 424 | 0.41 | 30 | 452.91 | 12% | 72% |
| L_LS_Res_HVAC_Elec | 848 | 0.74 | 30 | 452.91 | 13% | 72% |
| L_LS_Res_Lighting | 42081 | 19.94 | 17 | 45.03 | 24% | 8% |
| L_LS_Res_PoolPump | 802 | 0.24 | 12 | 215.80 | 38% | 58% |
| L_LS_Res_Refrigerator | 232 | 0.03 | 15 | 415.79 | 81% | 98% |
| L_LS_Res_ShadeTree | 593 | 0.43 | 37 | 305.29 | 16% | 39% |
| L_LS_Res_Water | 191 | 0.06 | 10 | 452.91 | 39% | 27% |
| L_LS_Res_LIW | 1500 | 0.56 | 18 | 939.86 | 30% | 56% |

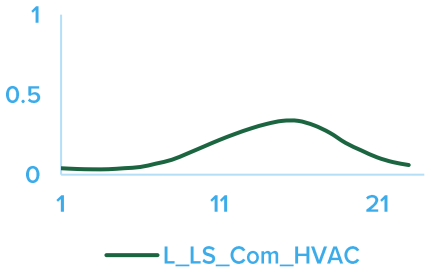
*based on load forecast provided by TEP, peak occurs in July at 17:00



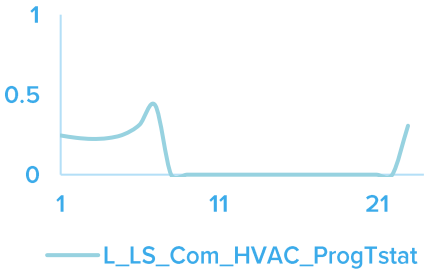
L_LS_Com_Daylighting



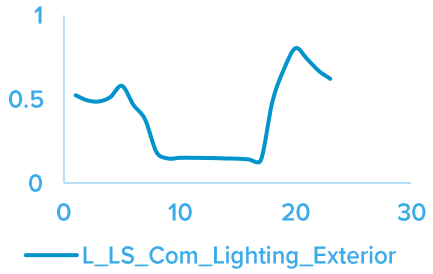
L_LS_Com_HP



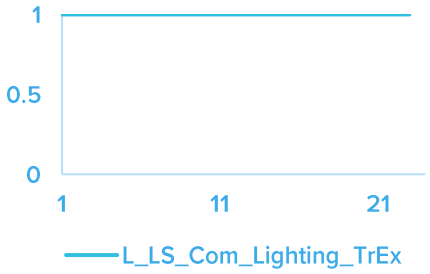
L_LS_Com_HVAC



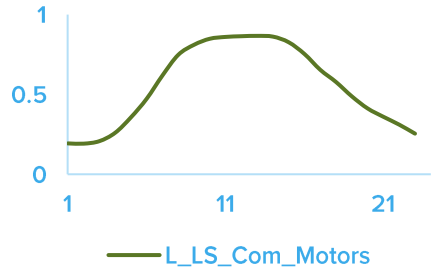
L_LS_Com_HVAC_ProgTstat



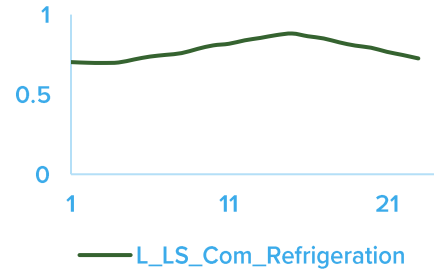
L_LS_Com_Lighting_Exterior



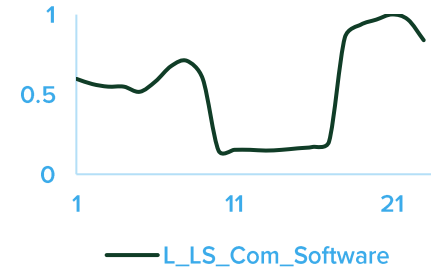
L_LS_Com_Lighting_TrEx



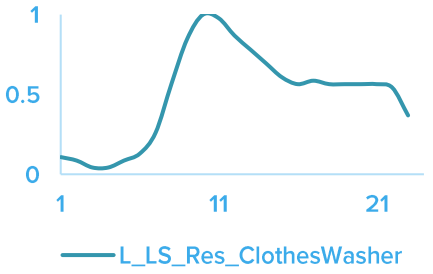
L_LS_Com_Motors



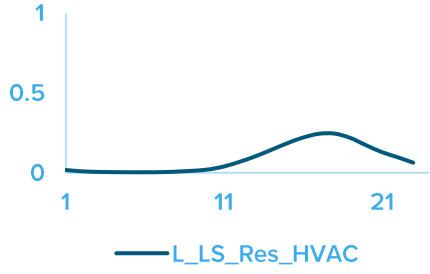
L_LS_Com_Refrigeration



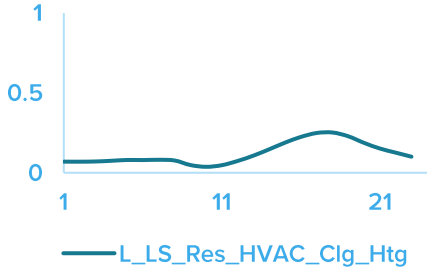
L_LS_Com_Software



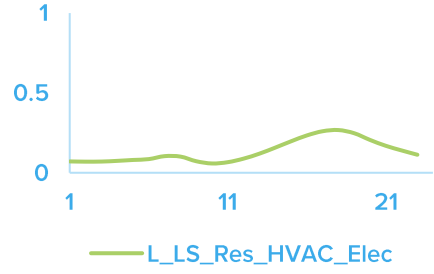
L_LS_Res_ClothesWasher



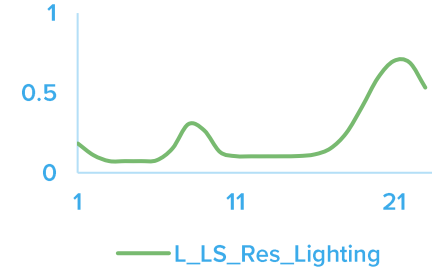
L_LS_Res_HVAC



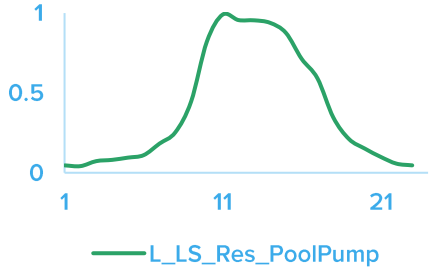
L_LS_Res_HVAC_Clg_Htg



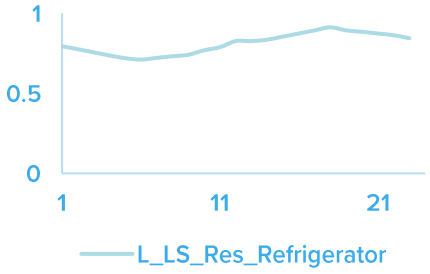
L_LS_Res_HVAC_Elec



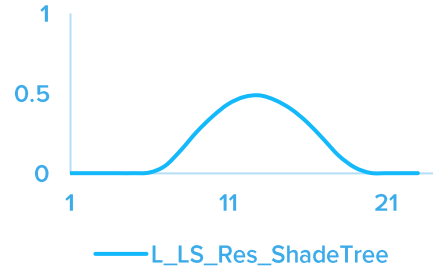
L_LS_Res_Lighting



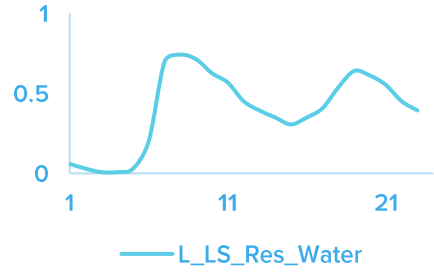
L_LS_Res_PoolPump



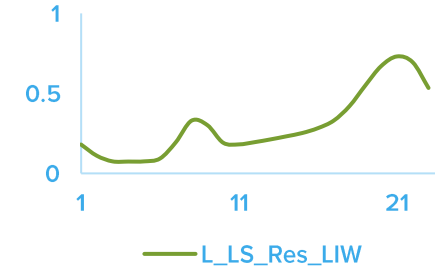
L_LS_Res_Refrigerator



L_LS_Res_ShadeTree



L_LS_Res_Water



L_LS_Res_LIW

# Portfolio Assumptions – EE Portfolios

| | Coal Units | | Energy Efficiency |
|---|---|---|---|
| Portfolio 3a | Economic Retirement (Earliest Retirement 12/31/2023) | Economic Cycling | Base EE (similar to TEP base assumption) |
| Portfolio 3b | Economic Retirement (Earliest Retirement 12/31/2023) | Economic Cycling | Model can select EE measures based on their cost competitiveness |
| Portfolio 3c | Economic Retirement (Earliest Retirement 12/31/2023) | Economic Cycling | Model can select EE measures based on their cost competitiveness (increased EE Technical Potential) |

# Economic EE measures

| Measure | Maximum Annual Savings (MWh/Year) | Capacity (MW) | Lifetime (Years) | First year costs in 2020 ($/MWh) | Capacity Factor (%) | Coincident Peak* (%) |
|---|---|---|---|---|---|---|
| Predominantly Selected in Capacity Expansion Modeling | | | | | | |
| L_LS_Com_Daylighting | 25374 | 5.38 | 17 | 114.19 | 54% | 61% |
| L_LS_Com_HP | 8 | 0.00 | 19 | 114.19 | 29% | 63% |
| L_LS_Com_HVAC | 5239 | 3.91 | 20 | 114.19 | 15% | 60% |
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| L_LS_Res_ShadeTree | 593 | 0.43 | 37 | 305.29 | 16% | 39% |
| Not Selected | | | | | | |
| L_LS_Com_Lighting_TrEx | 13 | 0.00 | 3 | 114.19 | 100% | 100% |
| L_LS_Res_ClothesWasher | 232 | 0.05 | 11 | 415.79 | 48% | 59% |
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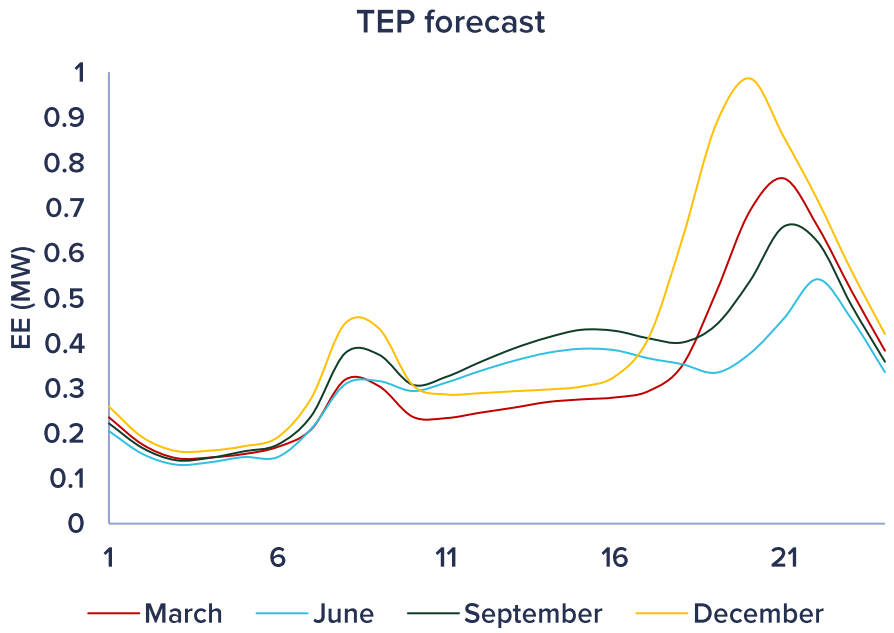
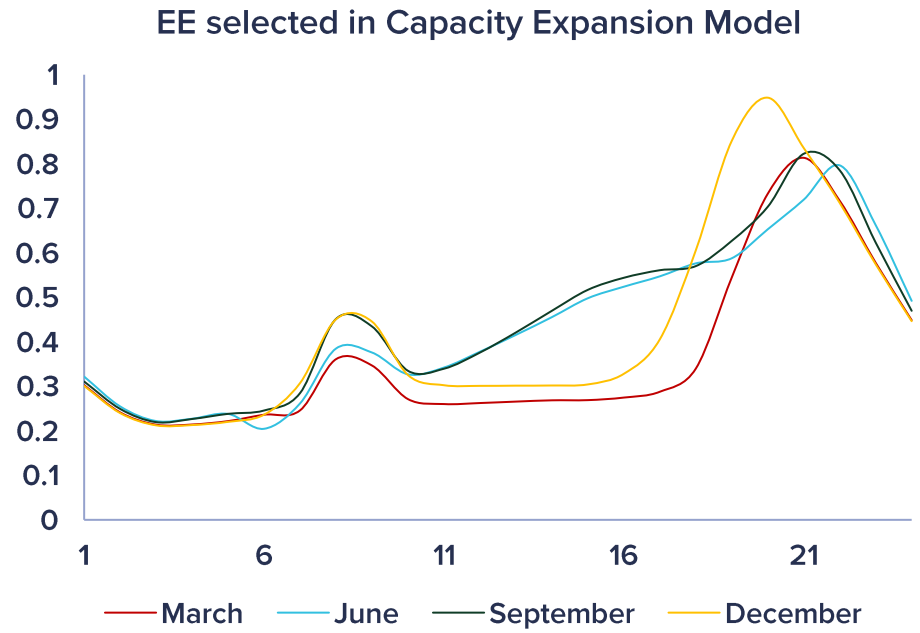
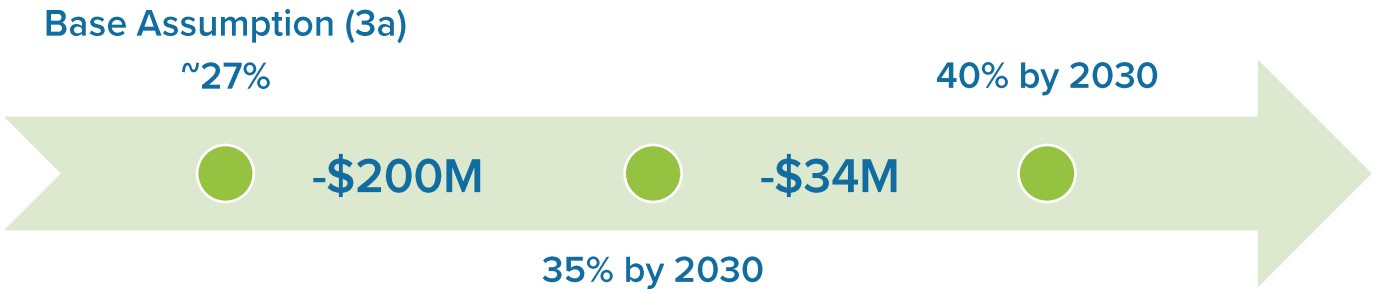
# Modeling Energy Efficiency as a Supply Resource



# Results – Energy Efficiency

- Modelling energy efficiency as a non-dispatchable resource (based on the hourly profiles and costs provided by TEP) indicates that EE is cost effective at a level much higher than what currently included in the TEP base assumptions

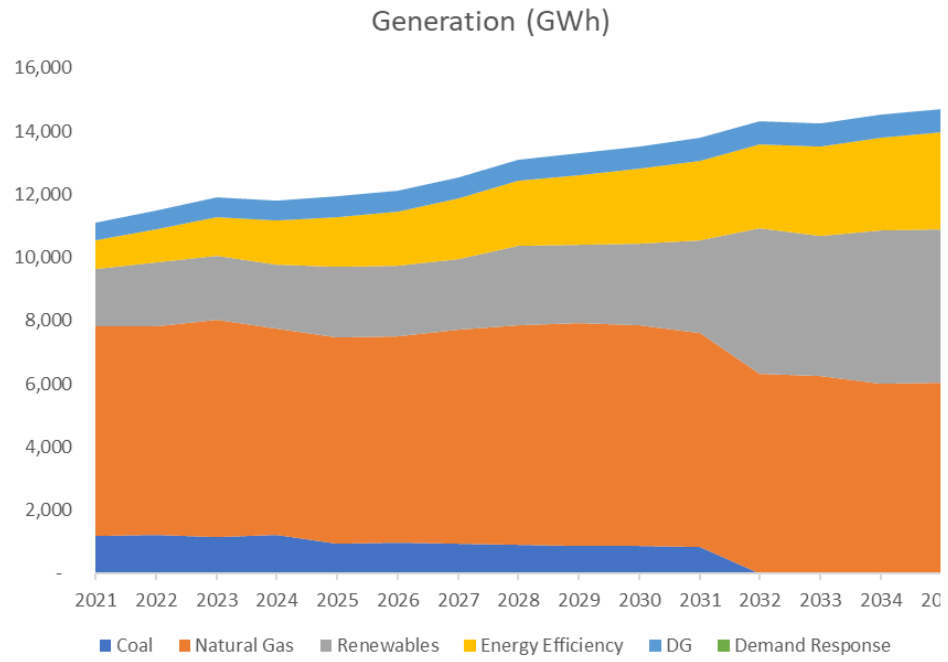


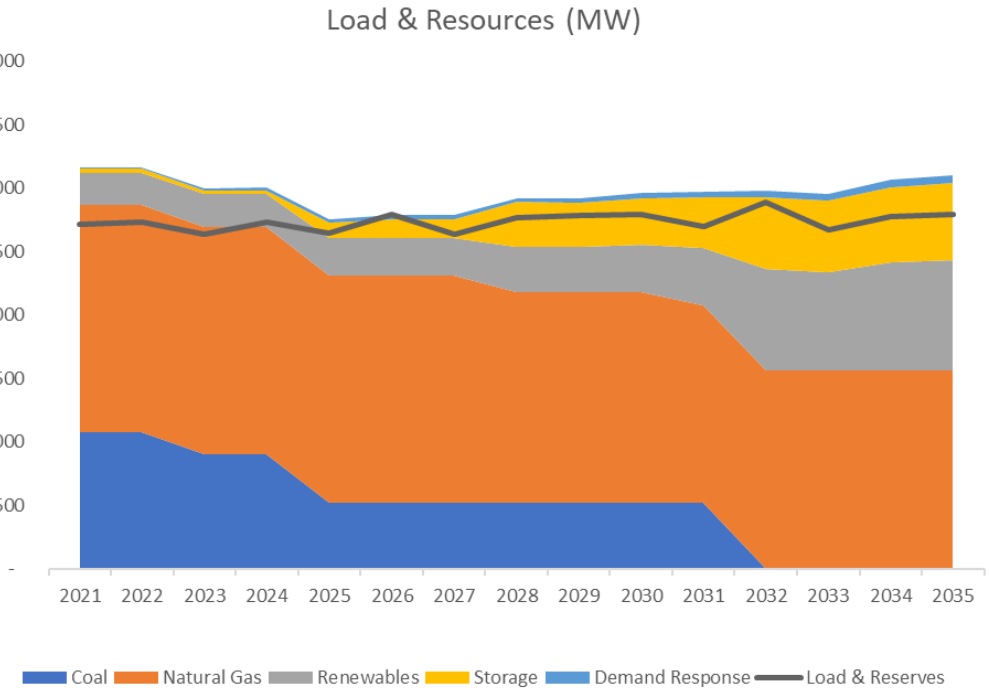

- Currently, the amount of EE in the model was mainly limited by the EE measures available (i.e. assumed technical potential) and not their cost-competitiveness.

Savings are not additive to the coal operations results

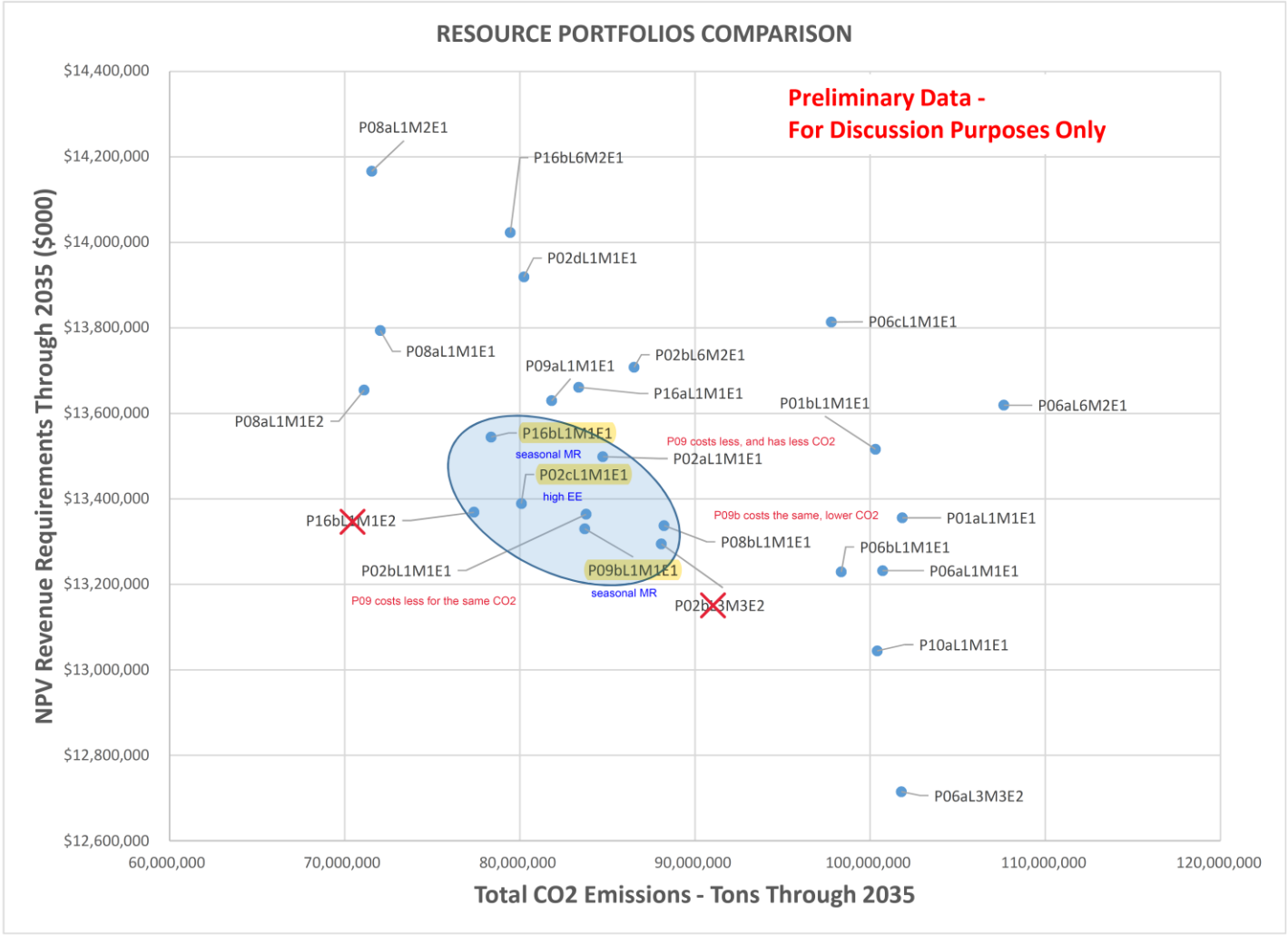
# Portfolio 3c (includes economic cycling & 40% EE by 2030)

- Includes: 1) economic cycling for coal & 2) 40% EE by 2030
- Results: $234 million reduction in NPV cost by 2030 (versus base portfolio)



# Observations on TEP's Modeled Portfolios



# Key Takeaways

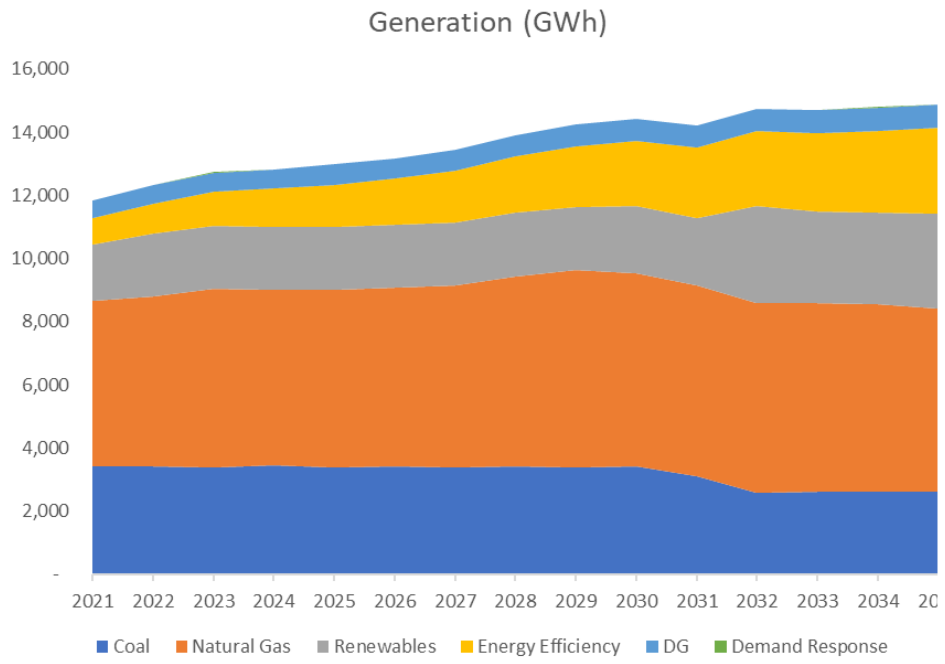
- Allowing economic retirement and/or economic cycling of coal units yields significant portfolio level savings (e.g. ~$250M reduced revenue requirement when both are included)
- EE is selected as a cost-effective resource above TEP base case assumptions when given the option.
- Applying EE load shapes can better tailor the EE portfolio to the most cost-effective measures (i.e. optimizing among factors such as cost, lifetime savings, and peak-coincidence)
- The least cost portfolio in Strategen's analysis included *both* economic cycling and high EE (i.e. 40% by 2030). This yielded NPV RR that was $286M less than the base case (Scenario 1 versus Scenario 3c).

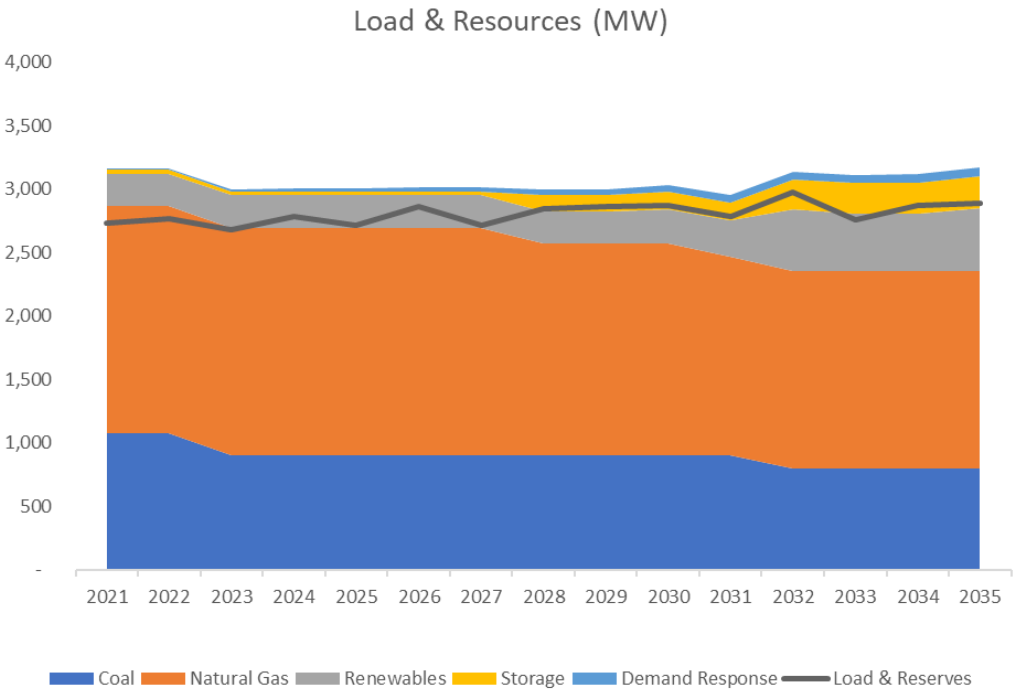
# Appendix

# Energy Modeling

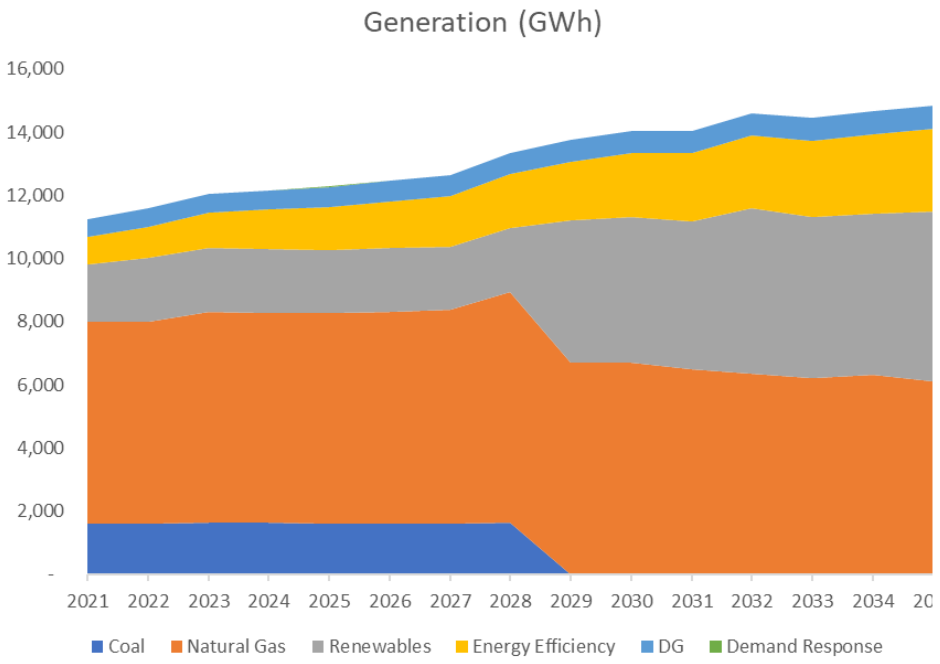
| | Capacity Expansion Model | Production Cost Model |
|---|---|---|
| Planning horizon | Decades | Weeks |
| Optimization Step / Temporal Resolution | (1-5) Years | (Sub) hourly |
| Spatial Resolution | Detailed network | Simplified network |
| Objective (least cost) | Investment & Operations | Operations |
| Input | • Set of future technologies<br>• Fuel prices & renewable resource potential<br>• Policies | • Existing grid & generation Infrastructure<br>• Fuel prices & renewable resource potential |
| Output | Optimal Grid & Generation Infrastructure | (Sub) hourly unit generation schedules & prices |
| Economic Dispatch | Yes | Yes |
| Set of hours | Use of representative hours | Modeling every hour in chronological order |
| Operational Constraints | Simplified | Detailed |
| Endogenous investment & retirement | Yes | No |

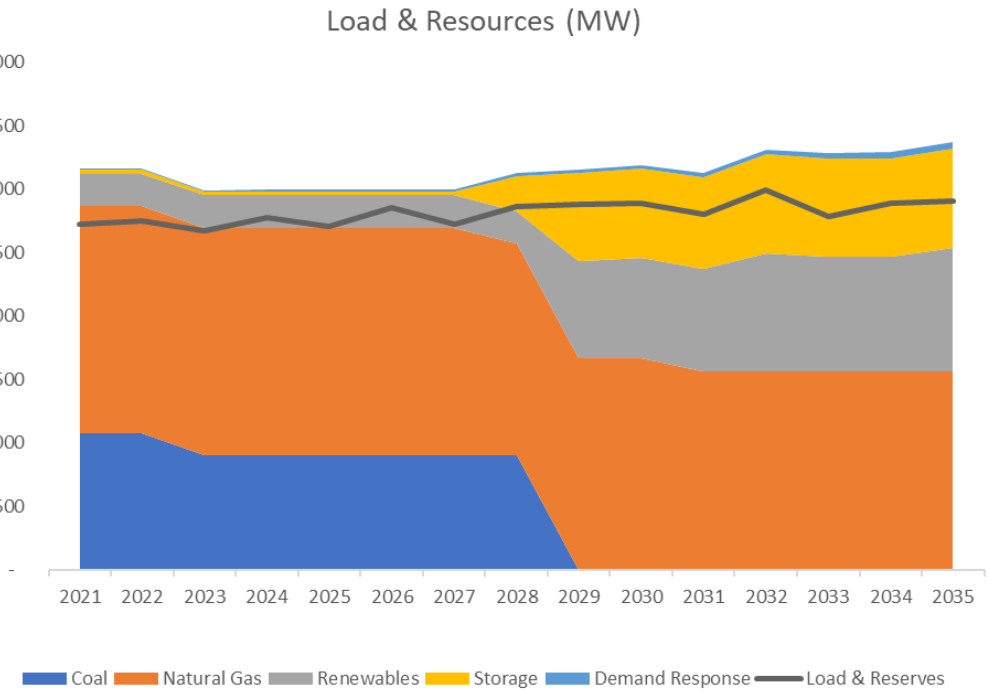
# Portfolio 1


Generation (GWh)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 20
Coal
Natural Gas
Renewables
Energy Efficiency
DG
Demand Response

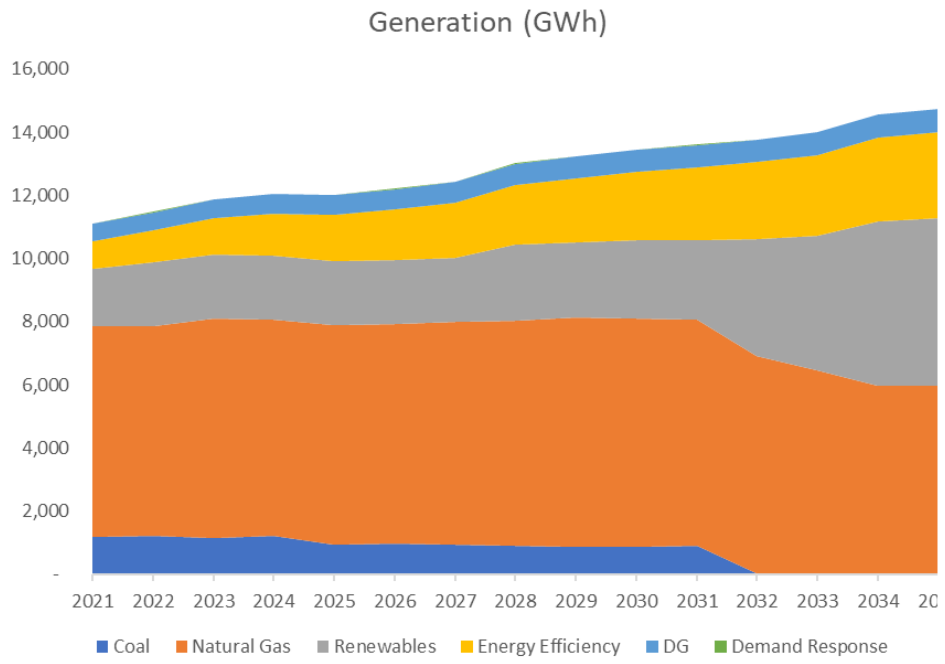

Load & Resources (MW)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
Coal
Natural Gas
Renewables
Storage
Demand Response
Load & Reserves

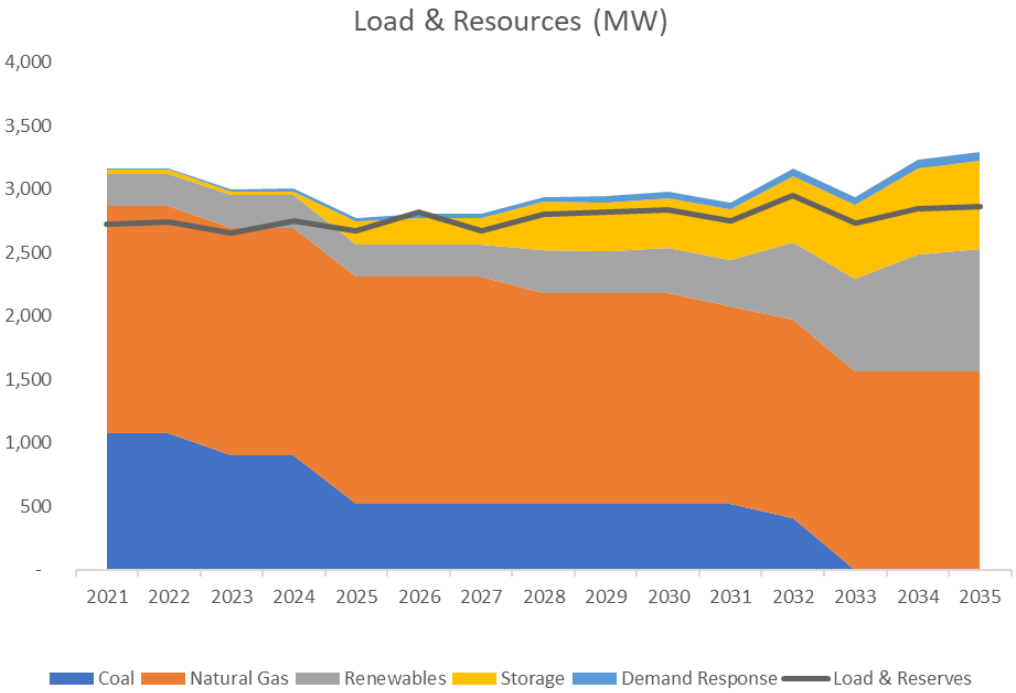
# Portfolio 2


Generation (GWh)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 20
Coal
Natural Gas
Renewables
Energy Efficiency
DG
Demand Response

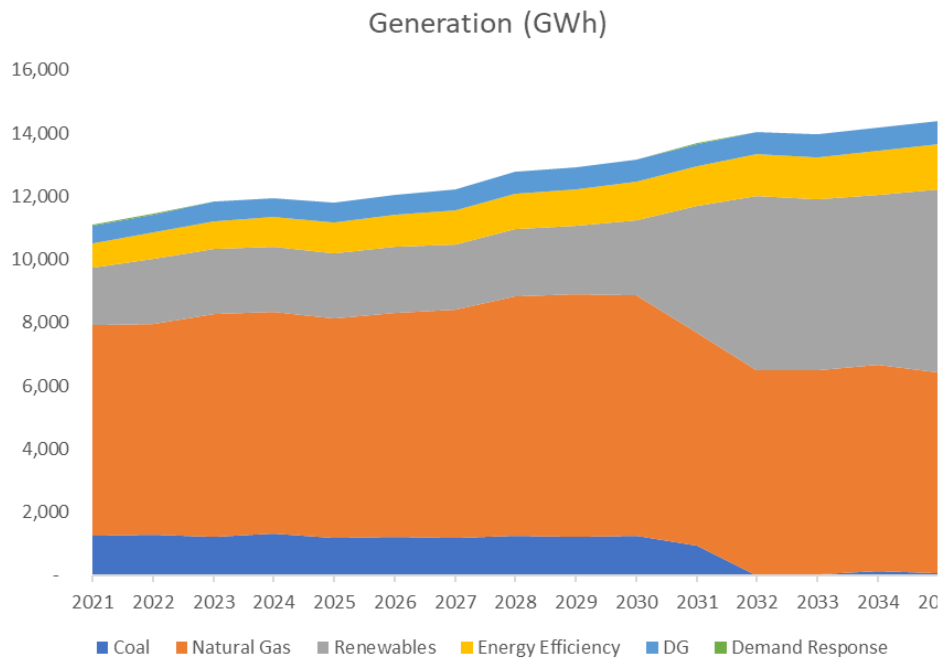

Load & Resources (MW)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
Coal
Natural Gas
Renewables
Storage
Demand Response
Load & Reserves

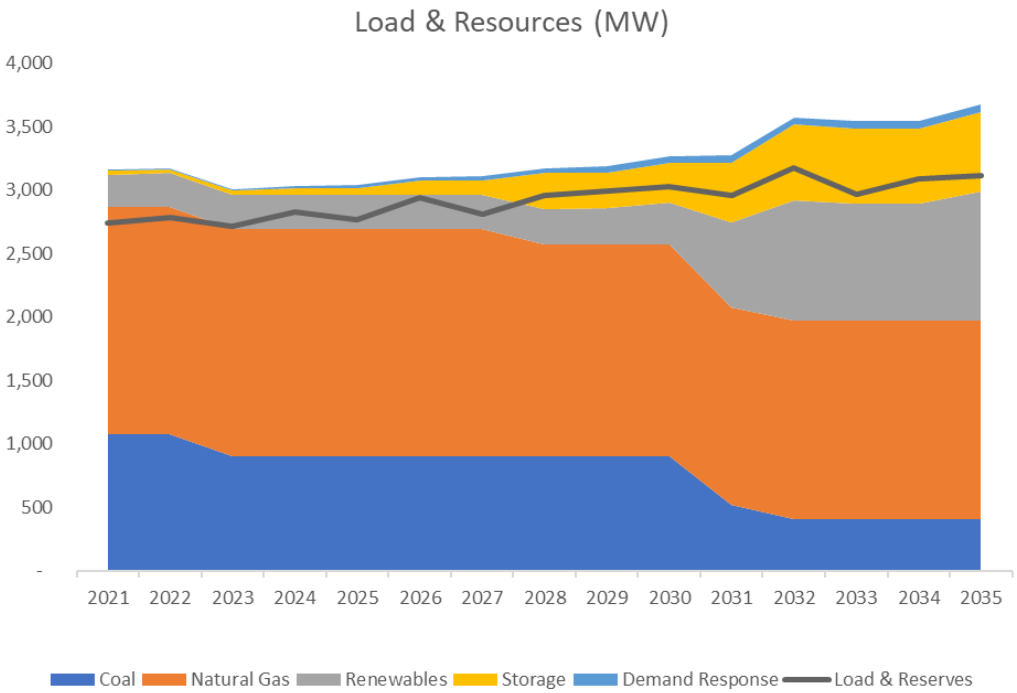
# Portfolio 3b



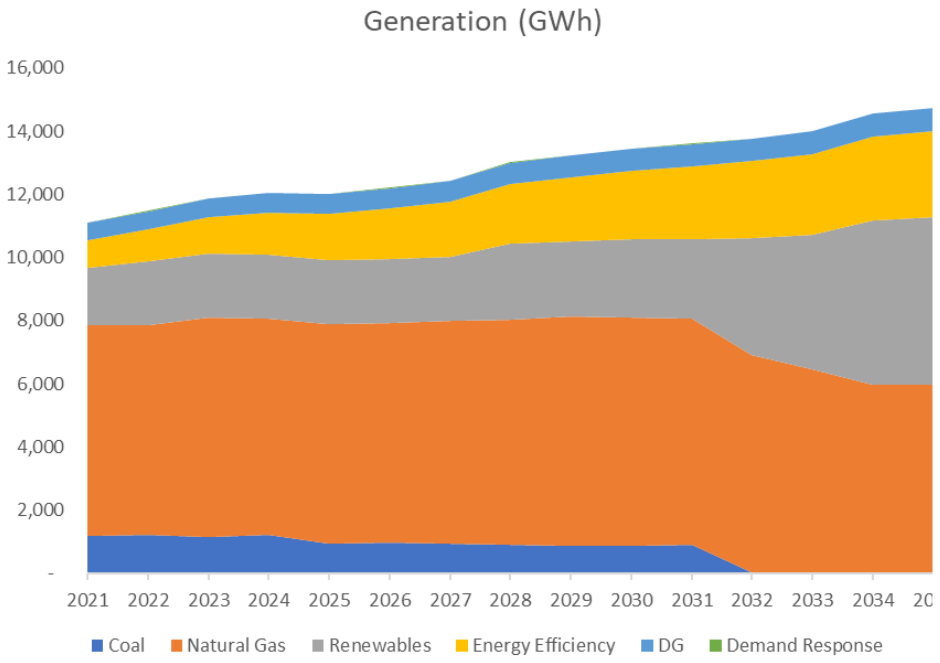



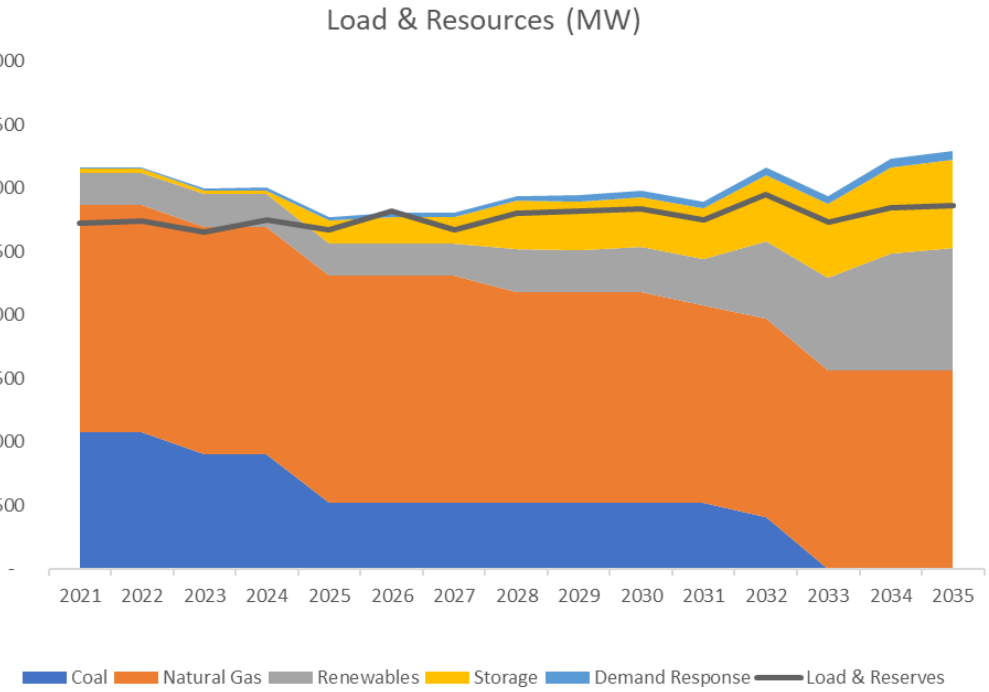
# Portfolio 3a



# Portfolio 3b



# Observations on TEP's Modeled Portfolios