

Tucson Electric Power

2018 Action Plan Update

April 30, 2018

TEP
Tucson Electric Power

Acknowledgements

Tucson Electric Power – Fuels and Resource Planning

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List of Acronyms

ACRONYMS

ACC – Arizona Corporation Commission
CO_2 – Carbon Dioxide
COD – Commercial Operation Date
DG - Distributed Generation
DLC – Direct Load Control
EE – Energy Efficiency
EV – Electric Vehicles
FERC – Federal Energy Regulatory Commission
ITC – Investment Tax Credit
kW – Kilowatt
kWh – Kilowatt-Hour
kWyr – Kilowatt-Year
LCOE – Levelized Cost of Electricity
MMBtu – Million British Thermal Units, also shown as MBtu
MBtu – Million British Thermal Units, also shown as MMBtu
MW – Megawatt
MWh – Megawatt-Hour
NGCC – Natural Gas Combined Cycle
NGS – Navajo Generating Station
NO_X – Nitrogen Oxide(s)
NPV – Net Present Value
NPVRR – Net Present Value Revenue Requirement
O&M – Operations and Maintenance
PPA - Purchased Power Agreement
PTC – Production Tax Credit
REST – Renewable Energy Standard
RICE – Reciprocating Internal Combustion Engine
RFP – Request for Proposal
SAT – Single-Axis Tracking
SCR – Selective Catalytic Reduction
SJGS – San Juan Generating Station
SRP – Salt River Project
TEP – Tucson Electric Power Company
TOUA - Tohono O'odham Utility Authority
TRICO – Trico Electric Cooperative
WECC - Western Electricity Coordinating Council

EXECUTIVE SUMMARY

ACTION PLAN UPDATE

Tucson Electric Power Company (TEP or "Company") has updated its a five-year action plan in response to system needs and changing market conditions. Under this action plan, additional detailed study work will be conducted to validate technical and financial assumptions prior to any final implementation decisions. TEP's updated action plan includes the following:

Gila River Unit 2

- TEP's near-term portfolio diversification strategy involves reducing its coal resource capacity by 508 MW over the next five years. In anticipation of these coal capacity reductions, the Company worked with the Salt River Project (SRP) to acquire rights to 550 megawatts (MW) of natural gas combined cycle capacity at the Gila River Power Station (Gila River). In October 2017, TEP entered into a 20-year tolling agreement with SRP to purchase all the capacity, energy, and ancillary services from Gila River Unit 2. Under the agreement with SRP, TEP has the option to purchase the unit within three years. TEP intends to exercise this purchase option prior to its expiration.
- As part of TEP's strategy for acquiring Gila River Unit 2, the Company entered into a ten-year natural gas hedge that guarantees savings of approximately $546 million for TEP customers over the next decade.[1] On an equivalent energy basis, Gila River Unit 2 will save TEP's customers approximately $75 million a year in fuel and non-fuel expenses in comparison to energy sourced from the Navajo Generating Station and the San Juan Generating Station.[2]

Renewable Resources

- TEP plans to continue with its community-scale build out of renewable energy to achieve a diverse portfolio that targets serving 30% of its retail load from renewable generation by 2030. In order to take advantage of expiring tax incentives, the Company plans to install 200 MW of new wind and solar resources in 2020, and is evaluating an additional 150 MW of wind to be in service by 2021. .
- Furthermore, with the retirement of the Navajo Generating Station in 2019, the Company is committed to exploring opportunities to develop future renewable energy projects on the Navajo Nation.
- Finally, the Company's 2019 REST Implementation Plan will include a proposal to developing forest biomass projects within Arizona. The Company plans to conduct a Request for Information (RFI) this year to evaluate options on forest biomass projects.

[1] In this updated analysis, the acquisition of Gila River Unit 2 for $300/kW will save TEP's customers an additional net present value savings of approximately $380 million related to the retirement of TEP's ownership interest in Navajo at the end of 2019 and the retirement of TEP's ownership interest in San Juan Unit 1 at the end of June 2022. Furthermore, TEP avoided approximately $165 million in pollution controls with its commitment to retire San Juan Unit 2 at the end of 2017.

[2] This cost analysis is detailed on Page 23 of this report.

Renewable Integration

- As part of TEP's commitment to expand its renewable resource portfolio, TEP is implementing a Generation Modernization Plan at the Sundt Generating Station located in Tucson, Arizona. This modernization plan will result in the retirement of 162 MW of capacity from Sundt Units 1 and 2 (1950's natural gas steam generation technology), to be replaced with 182 MW of new, more efficient natural gas Reciprocating Internal Combustion Engine (RICE) technology. In addition to balancing renewable energy intermittency, the project will reduce air emissions and water consumption. The retirement of Sundt Units 1 and 2 and the commercial operation of the RICE units will commence in the third quarter of 2019.

Energy Efficiency

- TEP will continue to implement cost-effective Energy Efficiency (EE) programs based on the Arizona EE Standard. The Company is also committed to working with the ACC and other stakeholders in the development of new rules relating to EE under the Energy Modernization Plan.

Energy Storage

- TEP's near term energy storage plans include the addition of a 30 MW, four-hour battery energy storage system to be co-located with a 100 MW solar project by the end of 2020. This project will increase TEP's investments in battery storage to 52 MW and 125 MWh.
- Furthermore, TEP is evaluating participation in the proposed Big Chino Valley pumped storage hydroelectric project.
- Finally, TEP plans to monitor advancements of battery storage technologies to serve as potential solutions within our distribution, transmission and generation portfolios on a longer term basis.

Natural Gas Storage

- TEP in efforts with other Arizona utilities continues to evaluate the viability of large scale underground natural gas storage as a means to improve system reliability and resiliency as efforts are made to accelerate the reliance on higher levels of renewable resources.

As with any planning analysis, this Action Plan Update represents a snapshot in time based on known and reasonable planning assumptions. TEP plans to communicate any major change in its anticipated resource plan with the ACC as part of its ongoing planning activities.

CHAPTER 1

INTRODUCTION

In April 2017, TEP submitted an Integrated Resource Plan ("TEP 2017 IRP") in accordance with the Arizona Corporation Commission (ACC) Resource Planning and Procurement rules[3]. The TEP 2017 IRP presented loads and resources based on anticipated energy and capacity needs for a 15-year planning horizon. The TEP 2017 IRP also identified potential changes facing the industry and TEP, as well as our plans to meet our customers' energy needs in light of these changes.

The major theme of the TEP 2017 IRP was the continuing diversification of our resource portfolio by reducing our reliance on coal-fired generation and expanding the use of renewable energy and efficient natural gas resources. Planning for a more diverse resource portfolio resulted in re-defining the role that certain generators play in meeting energy needs and heightened focus on the challenges of integrating a higher penetration of intermittent renewable resources within TEP's system. The TEP 2017 IRP presented a Reference Case Plan as a reasonable path forward in terms of reliability, affordability, environmental performance and risk, including a Five-Year Action Plan highlighting projects that the Company is actively pursuing for near-term implementation.

Due to changing conditions and new opportunities, TEP has made adjustments to several of the projects addressed in the Five-Year Action Plan. In October 2017, we entered into a tolling agreement with SRP for Unit 2 at Gila River, with a three-year option to purchase the unit. In the ACC's March 2018 Decision No. 76632[4], TEP was ordered to file an update to its Action Plan[5] to reflect the Company's intentions regarding Gila River Unit 2.

This Action Plan update documents TEP's strategy regarding Gila River Unit 2 as well as other changes to the Five-Year Action Plan included in the TEP 2017 IRP, such as changes in the pricing and timing for the installation of RICEs, and the pricing and timing of large solar and wind Purchased Power Agreements (PPAs). The Action Plan Update describes these changes and presents the impact to the Net Present Value Revenue Requirement relative to the Reference Case Plan included in the TEP 2017 IRP.

Finally, TEP supports the principals and objectives outlined in the proposed Energy Modernization Plan[6], and we recognize that many of the actions contemplated in our integrated resource planning will be guided by the outcome of that process. Arizona needs a coordinated, integrated energy policy established and overseen by the ACC, and we embrace the development of a more comprehensive resource planning process that incorporates resiliency, affordability, reliability, innovation, economic development and resource diversity.

[3] Arizona Administrative Code (AAC) R14-2-703

[4] Final Order to "Resource Planning and Procurement in 2015 and 2016", Docket No E-00000V-15-0094, dated March 29, 2018

[5] The Order requires TEP to "file an update to its Three-Year Action Plan". TEP has elected to extend its near-term action plan to five years to capture significant resource changes anticipated to occur through 2022.

[6] Review, Modernization, and Expansion of the Arizona Energy Standard and Tariff Rules and Associated Rules, Docket No. E-00000Q-16-0289

TEP looks forward to working with the ACC to create fair and balanced energy policies that reflect our shared commitment to building a more sustainable energy future.

CHAPTER 2

REFERENCE CASE PLAN UPDATE

The TEP 2017 IRP presented "A New Integration Approach to Resource Planning"[7] whereby the resources available to meet future energy needs were re-categorized based on the role those resources will play in the overall diversification strategy. These four "new" categories are:

- Load Modifying Resources
- Renewable Load Serving Resources
- Conventional Load Serving Resources
- Grid Balancing and Load Leveling Resources

The paragraphs below describe the changes in the Five-Year Action Plan relative to the TEP 2017 IRP Reference Case Plan according to these four categories, as applicable.

Load Modifying Resources

Energy Efficiency

TEP continues to develop and deploy cost effective Energy Efficiency (EE) programs designed to meet the state EE standard[8] to reduce customers energy use 22% by 2020. Following sunset of the standard, TEP intends to evaluate energy efficiency measures within the context of the IRP process and is eager to participate in workshops called for in Decision 76632. TEP is also committed to working with the ACC and other stakeholders in the development of any rules relating to energy efficiency that may result from the Energy Modernization Plan.

Electric Vehicles

The Company has supplemented its 2018 EE Implementation Plan with a suite of programs and incentives that encourages the deployment of Electric Vehicles (EV). Specifically, TEP's 2018 EE implementation plan proposes new EV charging infrastructure (1) in new home construction programs, (2) in existing home programs, (3) for large fleet owners, and (4) on major highways and high use areas within the Company's service territory. Finally, priority is given to EV integration plans that target day time charging from primarily solar energy resources. In the long-term EVs may provide the Company a cost effective way to help mitigate future "duck curve" issues while enabling the Company to improve its utilization of clean solar energy.

Renewable Load Serving Resources

Recent Purchased Power Agreements

The Reference Case Plan included two large renewable energy PPAs coming online in 2019. One was an 80 MW_{AC} single-axis tracking solar photovoltaic project to be installed within TEP's local service territory. The other was a 100 MW wind project to be constructed near existing TEP transmission in western-central New Mexico. Both projects required additional infrastructure to connect to the system. Therefore, the completion of

[7] TEP 2017 IRP, Chapter 4, p. 83
[8] Arizona Administrative Code (AAC) R14-2-2401 et seq.

these projects was moved to late 2020. In addition, the solar project, originally planned as an 80 MW_{AC}, was modified to 100 MW_{AC}, and the wind project, originally planned as 100 MW was modified to 99 MW. Pricing for these projects in the Reference Case Plan were estimated based on recent PPA prices seen in the industry, which were rapidly falling at the time. The Action Plan Update reflects actual pricing for these projects.

Table 1 - TEP's Planned Renewable Energy Project Changes

Planned Renewable Energy Projects	Reference Case Plan		Action Plan Update	
Solar Project	COD 2019	80 MW Capacity	COD 2020	100 MW Capacity
Wind Project	COD 2019	100 MW Capacity	COD 2020	99 MW Capacity

COD= Commercial Operation Date

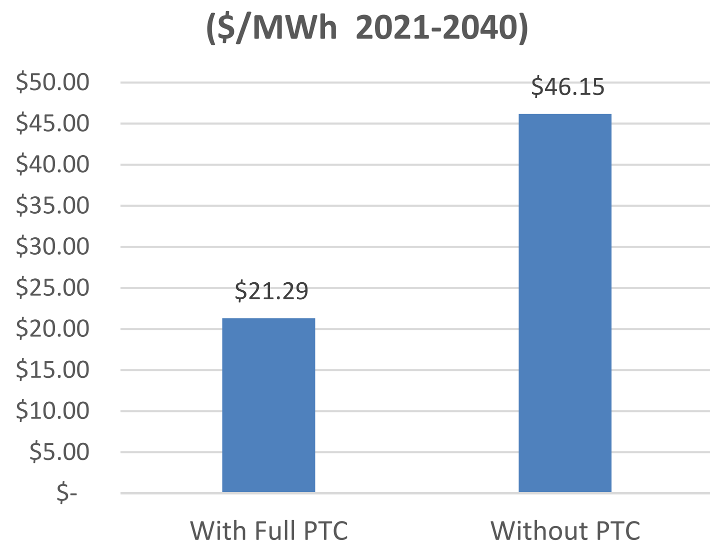
2018 Wind Request for Proposal (RFP)

The TEP 2017 IRP also discusses the need to develop a diverse mix of solar and wind resources. In January 2018, TEP issued an RFP ("Wind RFP") with the intent to capitalize on favorable renewable energy market conditions and tax incentives while complementing our current renewable energy offerings in terms of seasonal and diurnal shaping. The Wind RFP solicited 100 MW – 150 MW of wind energy with a capacity factor of 40% or greater and an hourly shape favoring non-daylight hour production. The Wind RFP asked for bids structured as PPAs and Build Own Transfer (BOT), in which case TEP would take possession just prior to commercial operation. Given TEP's anticipated tax position, a BOT option may provide a lower cost to customers than a PPA. TEP is currently evaluating responses to the January 2018 Wind RFP.

TEP anticipates that wind projects responsive to the Wind RFP will qualify for the full Production Tax Credit (PTC), which will be unavailable for projects that commence construction after 2019. Chart 1 shows the levelized cost of two otherwise identical wind projects[9] with and without the PTC.

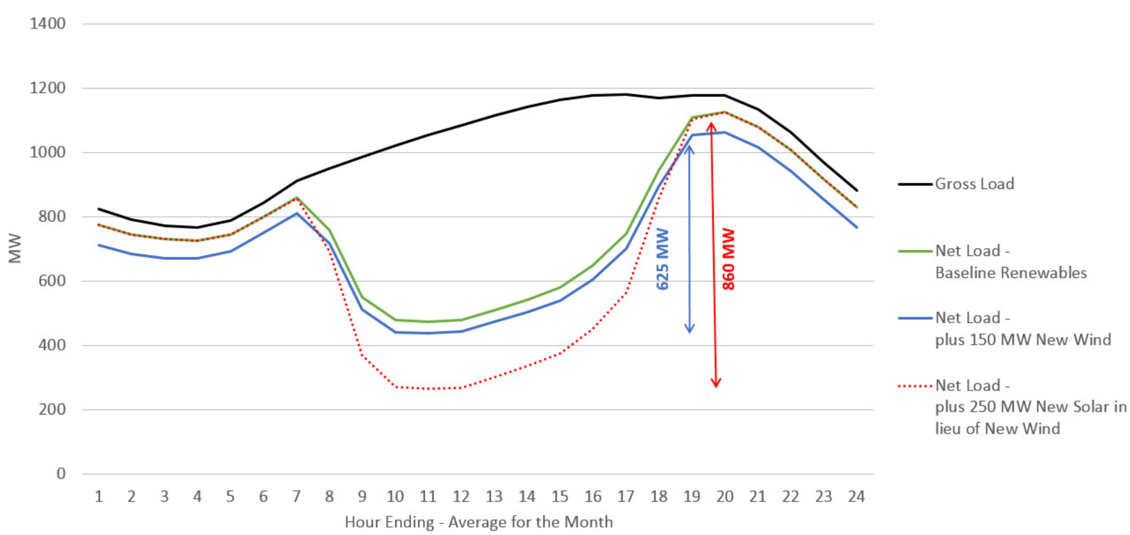
[9] The levelized cost estimate is based on 150MW at $1,400/kW, a 40% annual capacity factor, and excludes transmission costs.

Chart 1 – Levelized Cost of Energy: Wind at Busbar



High capacity factor wind energy of the nature requested in the RFP will support TEP's move toward our "30% by 2030" renewable energy target while flattening the daily renewable energy generation profile currently dominated by solar generation. Such a project would minimize the potential for over generation, often referred to as the "belly of the duck." This can be seen in Chart 2, which shows how the wind project would contribute only marginally to the belly of the duck, compared to a solar resource producing an equal amount of energy.

Chart 2 – Projected Gross and Net Loads for March 2024



Forest Biomass Energy

As part of the ACC's work on updating the Resource Planning and Procurement Rules, there has been a heightened interest in the state to generate electricity from biomass as part of a broader initiative to improve forest health. In May 2017, the ACC opened a docket[10] relating to forest bioenergy, under which a workshop was held in December 2017. APS was ordered in Decision No. 76295 to prepare a report[11] on forest bioenergy, which they submitted to the docket in November 2017. Then in March 2018, the ACC voted to direct all affected utilities to consider biomass energy as part of each utility's future Renewable Energy Standard Tariff (REST) plans.

TEP is engaged with ACC Staff in anticipation of filing a forest biomass proposal in its 2019 REST Implementation Plan, which is due July 1, 2018. As part of that process, the Company intends to issue a Request for Information (RFI) in order to gather technical and cost data on such projects. In addition, TEP will coordinate with other Arizona utilities, as appropriate, to investigate potential joint efforts on developing a forest biomass energy project within Arizona.

Navajo Nation Renewable Energy Development

TEP is aware of efforts to develop renewable energy on Navajo Nation land. Following TEP's exit from the Navajo Generating Station at the end of 2019, TEP will retain transmission capacity between the plant site and the TEP load center. Transmission can be significant hurdle for renewable energy projects. TEP is committed to exploring opportunities to develop new renewable energy projects on the Navajo Nation as part of its Five Year Action Plan.

Grid Balancing and Load Leveling Resources

Battery and RICE Implementation Updates

TEP currently has 293 MW of utility-scale renewable energy capacity on its system. As noted above, as much as 349 MW may be added by the end of 2020, a level not anticipated in the TEP 2017 IRP Reference Case Plan until 2024.

To facilitate this accelerated expansion of renewable energy, the Action Plan Update makes two changes to the grid balancing resources included in the Reference Case Plan. First, in lieu of the two 50 MW, 1-hour batteries assumed to be online in 2019 and 2021, TEP is procuring a 30 MW, 4-hour battery to be co-located with the new 100 MW solar PPA noted above. This battery system will have 20 percent more storage capacity than the two batteries assumed in 2019-2021 (120 vs 100 MWh). The cost, however, will be lower than expected in the Reference Case Plan because during its first five years of operation, it will be charged only by solar power from the project and therefore eligible for the renewable energy investment tax credit.

[10] Inquiry in to the Role of Forest Bioenergy in Arizona, Docket No. E-00000Q-17-0138
[11] APS Forest Bioenergy Report, November 2017

Picture 1 - Wärtsilä 18V50SG engines to be installed at the Sundt Generating Station

Second, in lieu of the two banks of 96 MW of RICEs assumed to be online in 2020 and 2022 (for a total of 192 MW), TEP is procuring 182 MW of RICEs to be online in 2019.[12] As with the battery system, TEP's competitive procurement process resulted in a cost for these RICEs that is significantly less than the cost assumed in the Reference Case Plan. Moreover, their earlier implementation date will support an earlier retirement of Sundt Steam Units 1 and 2. Because the RICEs are more efficient and can operate at lower capacities than Sundt Steam Units 1 and 2, which were built in the late 1950s, the net cost of installing and operating the RICEs is expected to be no greater than continuing to operate Sundt Steam Units 1 and 2, but with substantially greater operational benefits, reduced air emission, and less water use.

Table 2 – Action Plan Update to Grid Balancing Resources

Planned Renewable Energy Projects	Reference Case Plan		Action Plan Update	
2019 Storage Project	COD 2019	50 MW / 50 MWh	COD 2020	30 MW / 120 MWh
2021 Storage Project	COD 2021	50 MW / 50 MWh		
2020 RICE Project	COD 2020	96 MW	COD 2019	182 MW
2022 RICE Project	COD 2022	96 MW		

COD = Commercial Operation Date

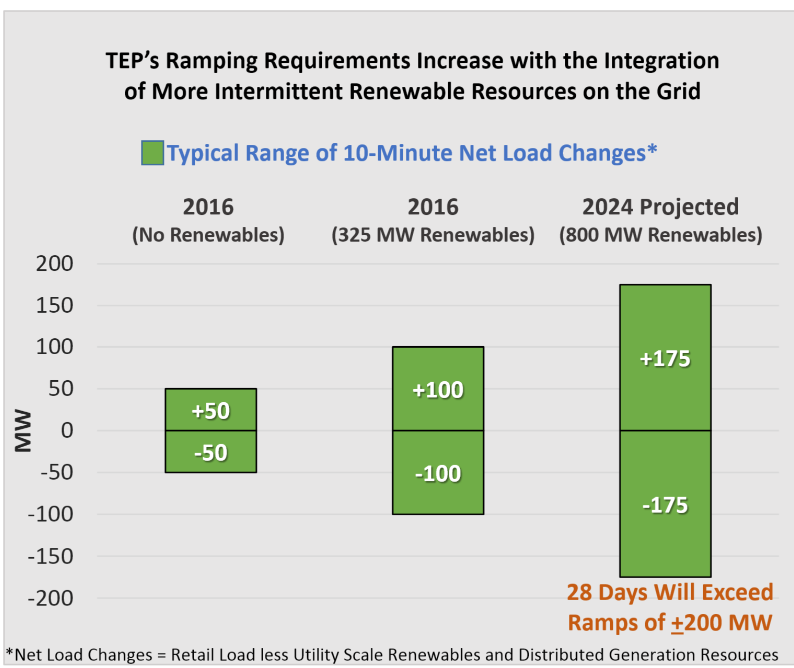
[12] On March 29, 2018, after several public stakeholder meetings and a recommendation by the Arizona Power Plant and Transmission Line Siting Committee to approve the project, the ACC granted the Company a Certificate of Environmental Compatibility ("CEC") to proceed with the project.

Figure 1 below provides a high-level comparison of operational differences between the RICE project and the exiting natural gas steam turbines. Figure 2 below summarizes the change in TEP's ramping requirements as we aggressively target 800 MW of renewable capacity by 2024.

Figure 1 – TEP's Energy Modernization Reciprocating Engine Project

	Fast Ramping Natural Gas Reciprocating Engines	Retiring Natural Gas Steam Turbines
Vintage	2019	1958, 1960
Net Capacity	182 MW (10 units @ 18.2 MW each)	162 MW (2 units @ 81 MW each)
Fuel Efficiency	8,000 Btu/kWh	11,000 Btu/kWh
<u>Superior Operating Flexibility</u>		
Operating Range	5 MW to 18.2 MW per engine (1 engine can efficiently meet minimum system must-run generation requirement of 6 MW -10 MW)	20 MW to 81 MW per unit (minimum operating level of 20 MW results in uneconomic dispatch when system must-run generation requirement is 6 MW – 10 MW)
Ramping Capability	<u>Fast Ramping</u> 1 minute: 50-182 MW if all engines on line 5 minutes: 0-182 MW (cold start)	<u>Slow Ramping</u> 10 minutes: 20-81 MW 18 hours: 0 -21 MW (cold start)
<u>Significant Reduction in Emissions & Water Usage</u>		
NOx Emissions	200 tons/year (whole plant) or 60% less	~ 520 tons/year (whole plant)
Ground Water Usage	< 230 million gallons/year or 70% less	~ 685 million gallons/year

Figure 2 – TEP Historical and Future Ramping Requirements



The need for these grid balancing resources is made clear in the TEP 2017 IRP and in the RICE Use Case Report attached to this Action Plan Update (see Appendix A). For example, Charts 2 through 4 in the Reciprocating Engine Use Case report compare the variability in customer demand with the variability of current and future renewable energy generation. Chart 3 below, which combines two of these charts, illustrates the variability in load that TEP has historically had to balance (in orange) with the much greater variability that will result by 2024 due to the addition of renewable energy on TEP's system (in blue).

Chart 3 – Historic and Projected Future Load Variability on TEP's System

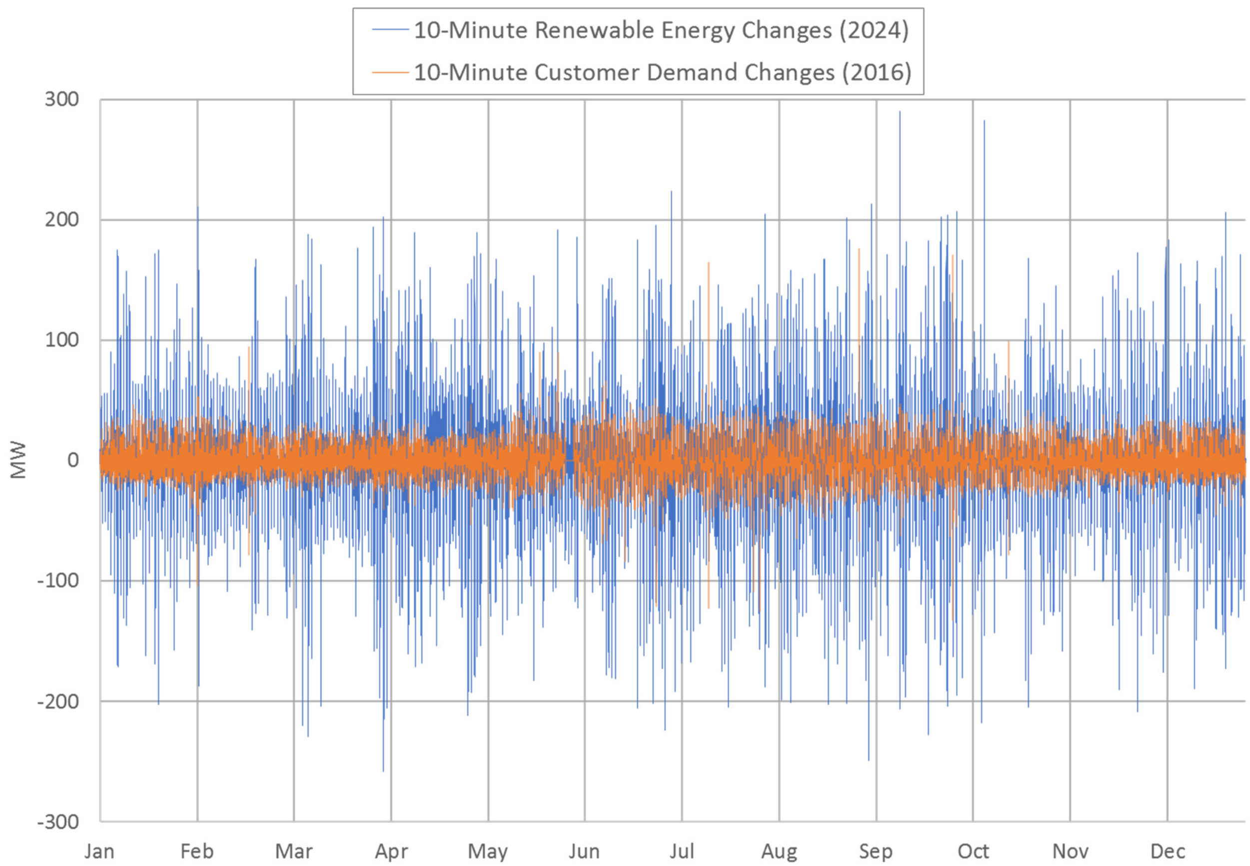
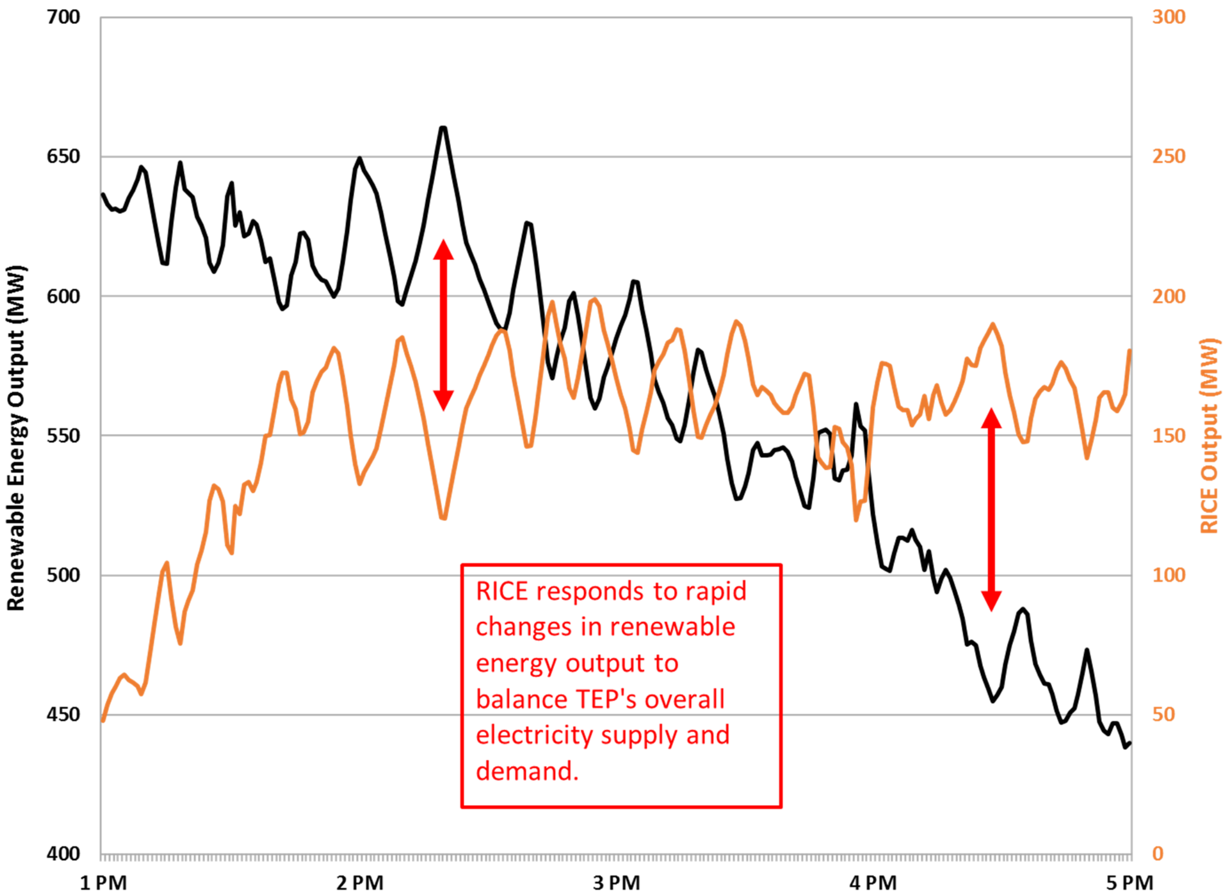


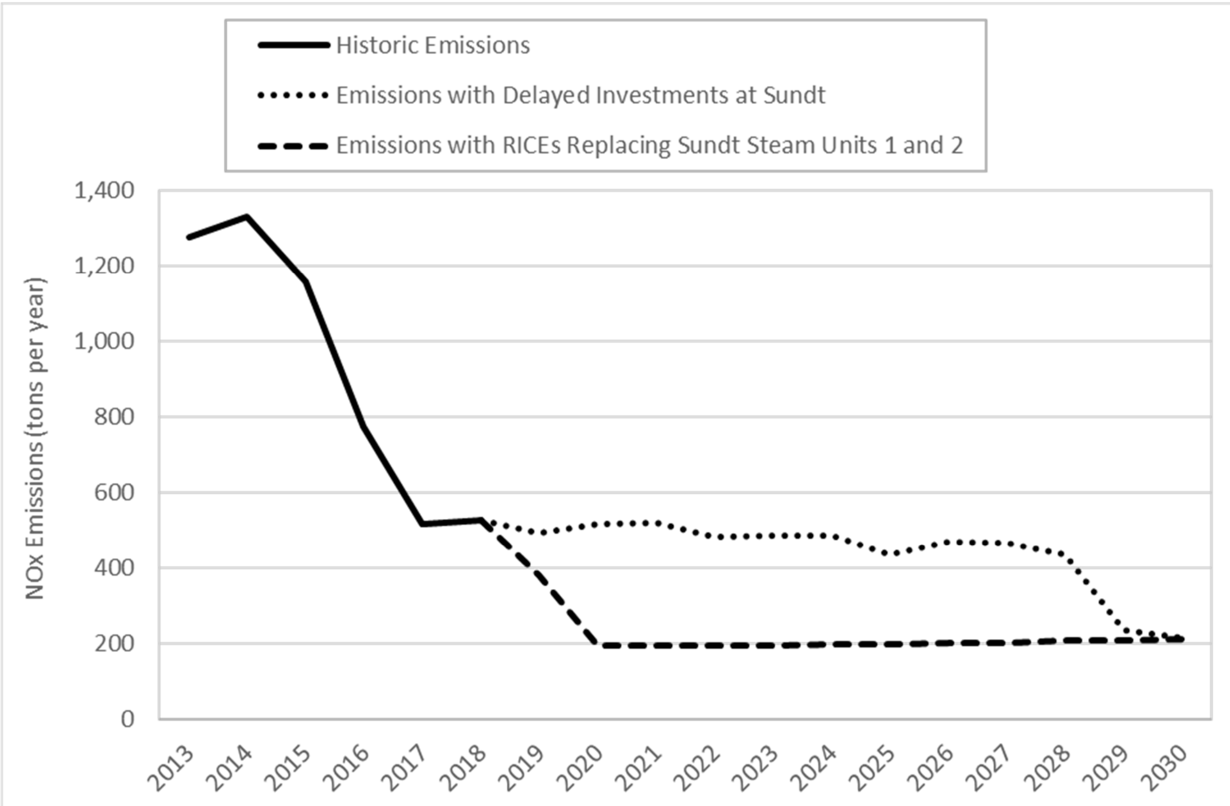
Chart 4 shows output from TEP's system dispatch modeling, which illustrates how the RICEs would be dispatched to balance the variable output of renewable energy from the Company's wind and solar resources.

Chart 4 – Modeled Renewable Energy and RICE Output on a Typical Day in July 2024



Finally, Chart 5 shows emission reductions of nitrogen oxides that result from the generation displacement of the Sundt Steam Units 1 and 2 by the RICE over the next decade.

Chart 5 – Sundt Nitrogen Oxides Emissions



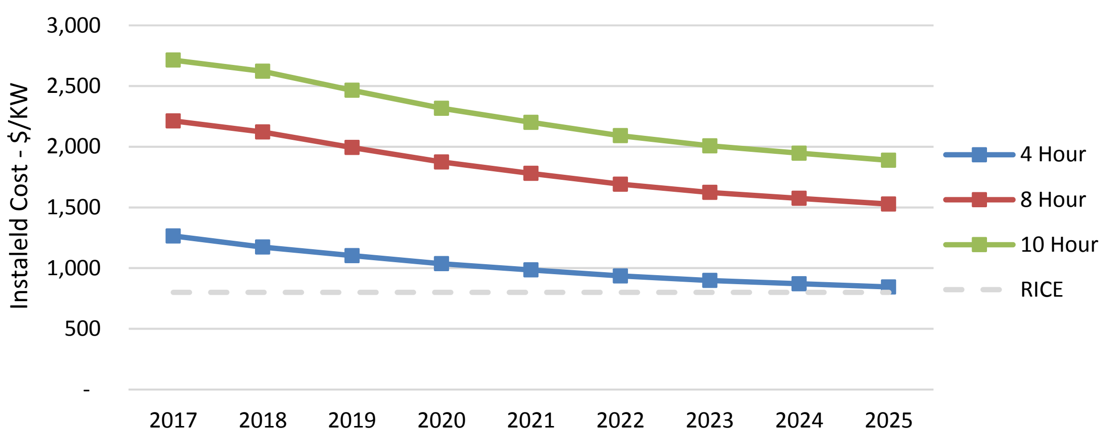
Selecting the RICE Technology

The selection of the RICE as the technology for replacing generation capacity on TEP's system was based on several months of research and technical due diligence work conducted by the Company. In December 2016, TEP hired Burns and McDonnell Engineering to conduct an in-depth technology assessment to determine the lowest cost options that would meet TEP's local area ancillary service requirements and support the integration of renewables. This study evaluated large frame natural gas turbines, aeroderivative natural gas turbines, reciprocating engines and energy storage systems (ESS). The Burns and McDonnell report concluded that RICE technology and aeroderivative combustion turbines provided the best combination of efficiency and operational flexibility. These two technologies were evaluated in the Reciprocating Engine Use Case report (Appendix A), which concluded that RICE technology was more cost effective than aeroderivative combustion turbines.

RICE Economics Compared to Energy Storage Systems

While the Company believes that energy storage systems will play a significant role in its resource portfolio in the future, the RICE technology was chosen due to its low cost and its ability to meet all of the operational requirements[13] of the Company's ancillary service support and renewable integration needs. This cost justification for the RICE technology compared to ESS was supported by the Company's 2017 RFP process[14] that received ESS proposals that were twice the cost of the RICE technology on capital cost basis. Energy Storage technology assessments such as Lazard's Levelized Cost of Storage[15] and Wood MacKenzie's Battery Storage Insight[16] projects that Lithium-ion ESS technologies will start to become cost competitive to traditional natural gas peakers within the next five to seven years.

Chart 6 – RICE Technologies Compared to Lithium-Ion ESS



[13] The minimum operational requirements were as follows: 1.) continuous availability in order to support TEP's local area minimum must-run generation requirements, 2.) a minimum turndown or capacity of 10 MW, 3.) an initial start time of 0 to 20MW within five minutes, 4.) an initial ramp time of 10 – 20 MW in 30 seconds, 5.) a full ramp of 10 – 200 MW in five minutes, 6.) ability to have multiple starts and ramping periods each day without maintenance penalty, 7.) for natural gas resources, a maximum heat rate of 9,000 Btu/kWh is required, 8.) no operating time or capacity limits across all existing Sundt generating units due to air permitting requirements.

[14] In July 2017, the Company used Accion to issue an RFP for the Engineering, Procurement, and Construction of the RICE project. As part of this RFP, the Company received alternative technology proposals, which included battery storage technologies, interactive distributed generation systems and a hybrid natural gas turbine and battery project. These alternative technology proposals were determined to be more expensive than the RICE and in some cases, these technologies did not meet the minimum operational requirements.

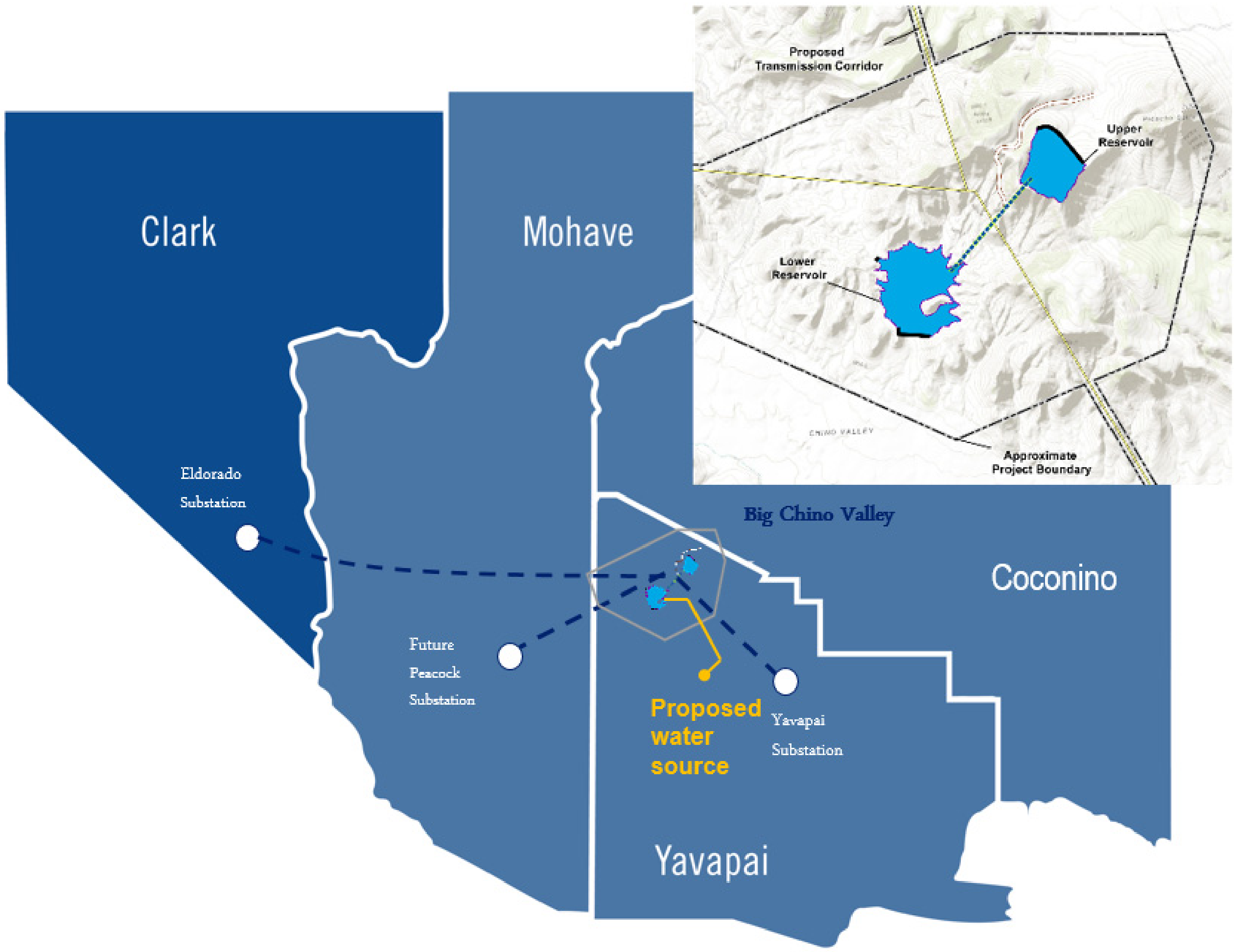
[15] https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf December 2017.

[16] Energy Storage for Peaker Plant Replacement: Economics and Opportunity in the U.S. Will Energy Storage replace Peaker plants? April 2018.

Big Chino Valley Pumped Hydroelectric Storage

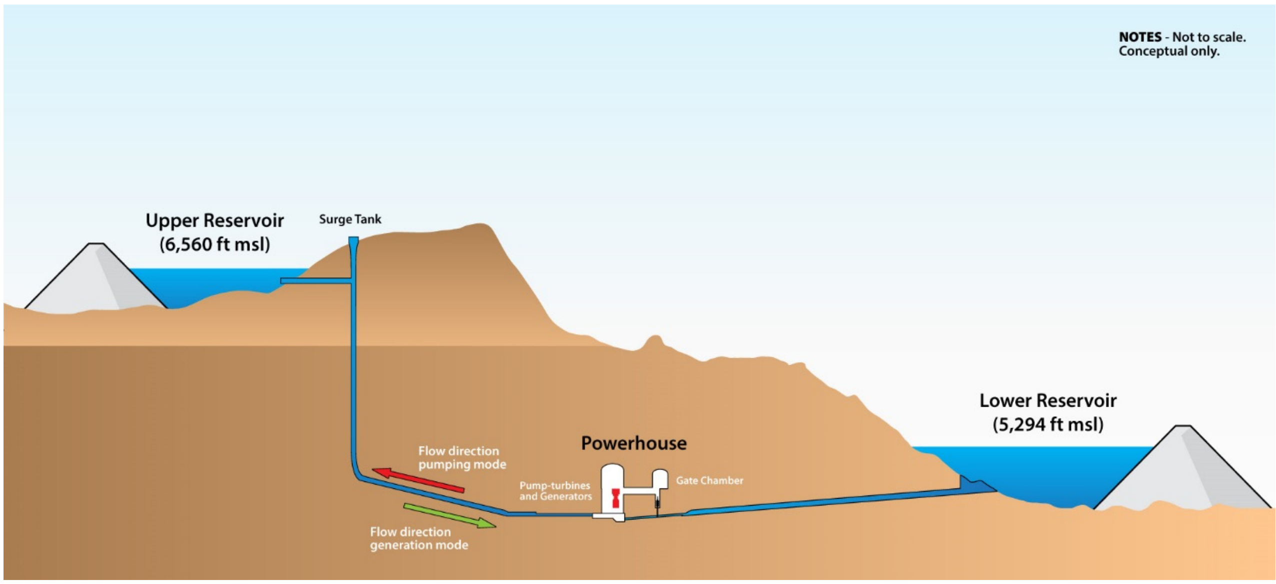
TEP is currently considering participating in the Big Chino Valley Pumped Storage Hydroelectric project ("Big Chino Valley") proposed for development by ITC Grid Development, LLC, in Yavapai, Coconino, and Mohave Counties in Arizona, and in Clark County, Nevada, Figure 3.

Figure 3 – Big Chino Valley Project Location



Pumped storage is a well-established technology with over 18GW of capacity in operation in the United States. The proposed project would involve using favorable existing topography to construct two reservoirs where water is pumped from the lower reservoir to the upper reservoir during periods of low electricity demand, then electricity is generated when needed by flowing water from the upper reservoir to the lower reservoir through hydro-electric turbine generators as shown in Figure 4.

Figure 4 – Pumped Hydroelectric Storage



Big Chino Valley would be capable of providing several grid-related services including frequency regulation, fast ramping, and load leveling for energy arbitrage as well as curtailment avoidance. The project is currently proposed to be 2,000MW and is scheduled for commercial operation between 2025 and 2028. Pumped storage projects are long-lived assets with license terms of up to 50 years[17].

In addition to evaluating Big Chino Valley and procuring new battery and RICE resources, TEP will continue monitoring the energy storage market and evaluating its system for cases in which additional energy storage may have economic or operational benefits.

[17] Hydropower Primer, A Handbook of Hydropower Basics, Federal Energy Regulatory Commission, February 2017, p.30

Conventional Load Serving Resources

Picture 2 – Gila River Power Station

Update on Gila River Unit 2

On October 10, 2017, TEP entered into a 20-year Tolling Power Purchase Agreement ("Agreement") with SRP to purchase all 550 megawatts of capacity, energy, and ancillary services from Gila River Unit 2. Under the terms of the Agreement, TEP will pay a monthly demand charge and an operating fee to compensate SRP for the non-fuel costs of operating Gila River Unit 2. In addition, TEP will be required to pay for any capital improvements needed for the continued operation of the unit, and will be responsible for the purchase of natural gas used to operate the unit. On April 17, 2018, CXA Sundevil Power[18] was granted approval by FERC under Section 203 of the Federal Power Act to sell Gila River Units 1 and 2 to SRP. Under the Agreement with SRP, TEP is obligated to toll power from Unit 2 for twenty years and has the option to purchase the unit within three-years of the SRP acquisition date. TEP's purchase option price for Gila River Unit 2 is expected to be approximately $165 million ($300/kW), subject to customary closing adjustments. TEP expects the Agreement to become effective in May 2018.

Coal Plant Retirements and the Need for Gila River Unit 2

As part of TEP's longer-term portfolio diversification strategy, the Company is reducing its significant reliance on coal to approximately 38% of retail energy deliveries by 2030. Over the next five years, TEP will reduce its coal-fired capacity through its currently planned retirements. TEP completed the shutdown of the San Juan Generating Station ("San Juan") Unit 2 at the end of 2017, and plans to exit the Navajo Generating Station ("Navajo") at the end of 2019. In addition, TEP plans to exit San Juan Unit 1 at the end of June 2022. These planned coal retirements will enable TEP to take advantage of near-term opportunities to reduce costs and rebalance its resource portfolio over the longer-term. The acquisition of Gila River Unit 2 along with the retirement of the Navajo and San Juan Generating Stations will result in cost savings of approximately $546 million[19] for TEP customers over the next decade and will result in meaningful reductions in air emissions and

[18] CXA Sundevil Power is an indirect subsidiary of Beal Financial Corporation formed as a special purpose entity to acquire and own one of the two power blocks at the Gila River Facility following a bankruptcy reorganization.
[19] In this updated analysis, the acquisition of Gila River Unit 2 for $300/kW will save TEP's customers an additional net present value savings of approximately $380 million related to the retirement of TEP's ownership interest in Navajo at the end of 2019 and the retirement of TEP's ownership interest in San Juan Unit 1 at the end of June 2022. Furthermore, TEP avoided approximately $165 million in pollution controls with its commitment to retire San Juan Unit 2 at the end of 2017.

water consumption[20]. Finally, TEP's long-term commitments to clean energy resources will help minimize the Company's long-term environmental risk while locking in lower-cost natural gas and sustainable sources of energy for decades to come.

2020-2030 Comparison between Gila Unit 2, Navajo and San Juan

Chart 7 below shows the 2020 to 2030 cost comparisons between the Gila River Unit 2 and TEP's share of the Navajo Generating Station and San Juan Unit 1. This cost comparison is based on the full cost of operations for each facility, including fuel. Based on current projections of forward natural gas prices, the equivalent energy sourced from Gila River Unit 2 will save TEP customers approximately $75 million a year in fuel and non-fuel expenses[21].

Chart 7 – 2020-2030 Comparison between Gila River Unit 2, Navajo and San Juan

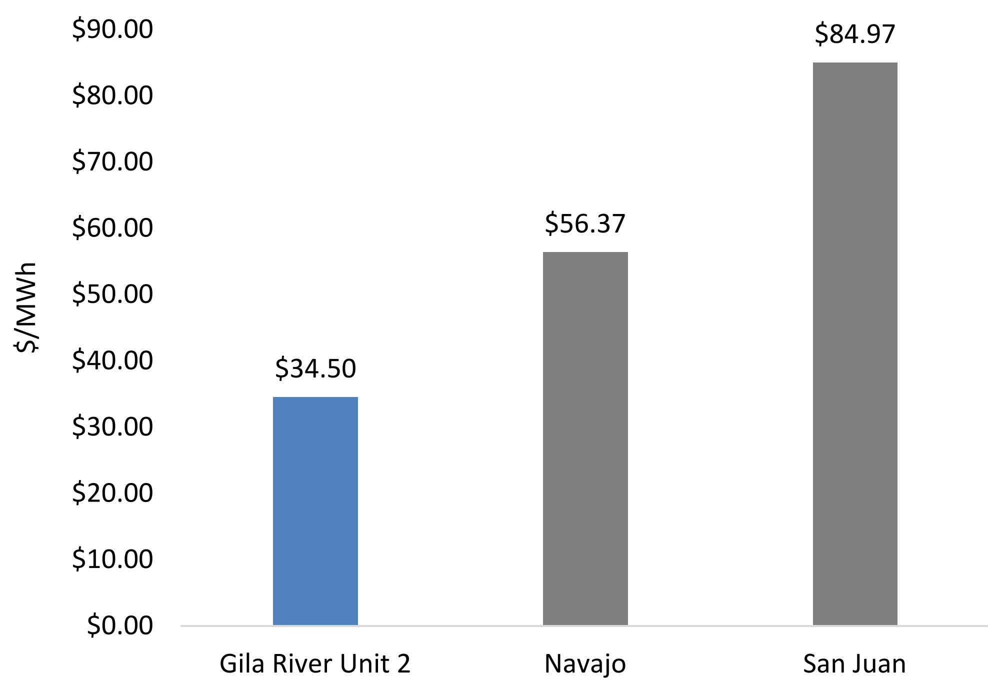


Table 3 – Cost Savings per Year based on Equivalent Energy Sourced from Gila River Unit 2

Plant	Capacity, MW	Fuel & Non-Fuel Savings, $/MWh	Annual Savings, $000
Navajo Generating Station	168	$21.87	$22,530
San Juan, Unit 1	170	$50.47	$52,612
Total	338	$36.25	$75,142

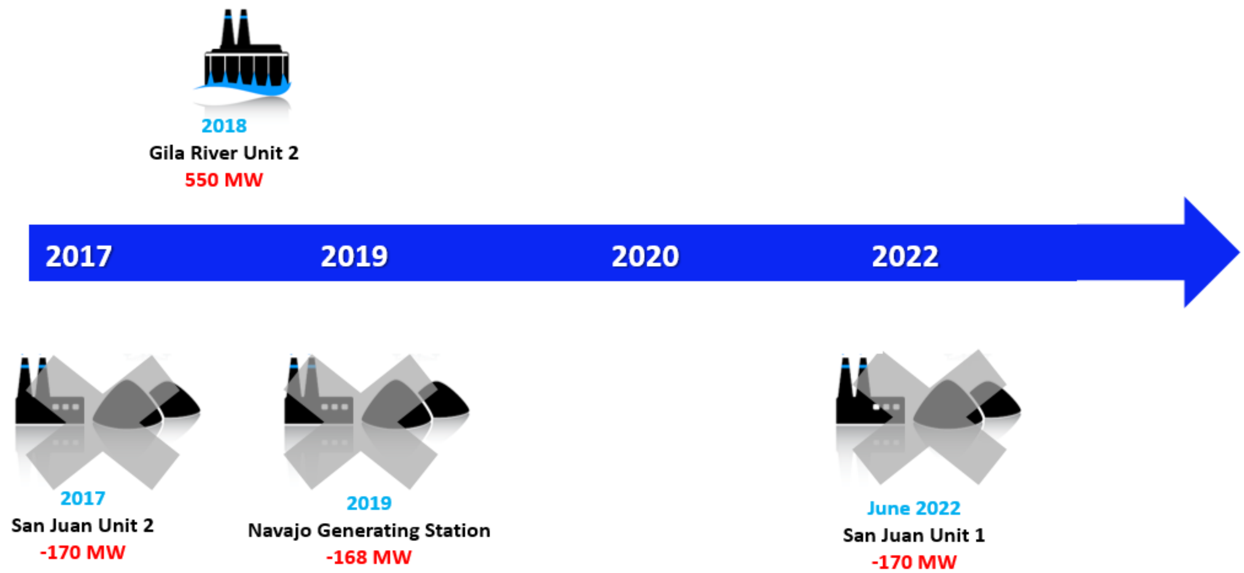
[20] The retirement of both Navajo and San Juan Units 1 and 2 results in reductions in TEP's total system emissions of 15.8% for carbon dioxide (CO_2), 29.8% for nitrogen oxides (NOx), and 9.8% for sulfur dioxide (SO_2). In addition, the retirement of the Navajo and San Juan units show water consumption is reduced by approximately 2,599 acre feet per year, an overall savings of 16.18%.

[21] This estimate assumes that both NGS and SJGS Unit 1 are displaced by equivalent energy from Gila River Unit 2. For purposes of this analysis an 70% annual capacity factor was used for the comparison.

Timing of Gila River Unit 2 and Planned Coal Retirements

The timeline in Figure 5 below shows how the addition[22] of Gila River Unit 2 (550 MW) will replace the planned coal unit retirements of 508 MW.

Figure 5 – Timing of Gila River Unit 2 and Planned Coal Retirements

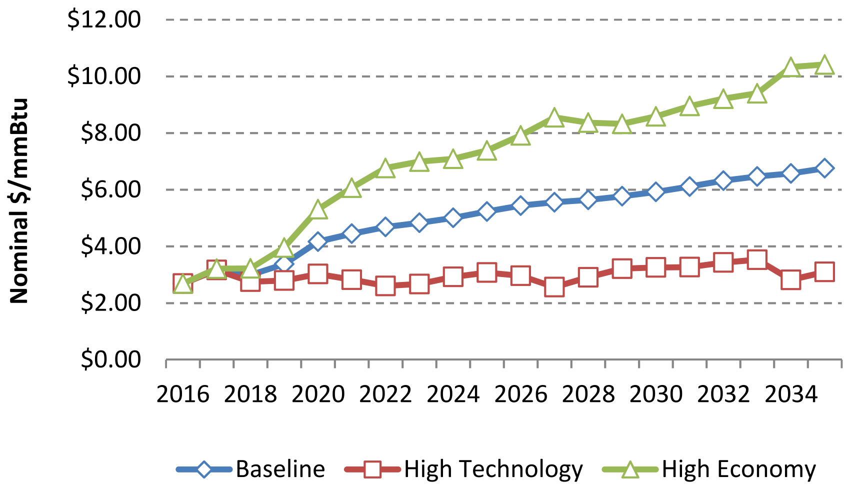


[22] TEP's toll of Gila River Unit 2 will commence in 2018. TEP intends to take ownership of the unit during the three-year purchase option period.

Range of Forward Natural Gas Prices

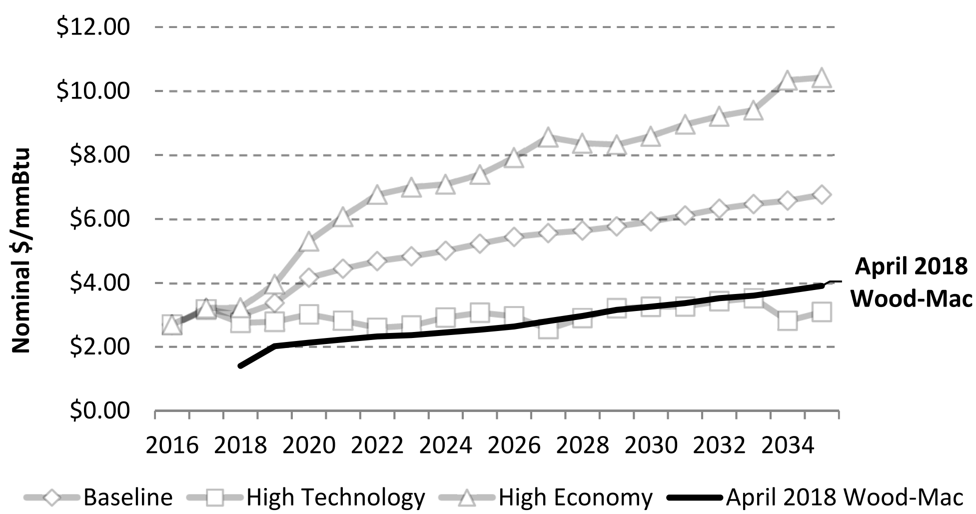
Chart 8 below shows the range of Permian natural gas price assumptions that were used as scenarios in the decision to acquire Gila River Unit 2 and retire 508 MW of coal-fired generation at Navajo and San Juan. Based on these scenarios natural gas prices ranged from a low of $2.56/MMBtu to a high of $10.42/MMBtu.

Chart 8 – PACE Global Forward Permian Natural Gas Prices ($/MMBtu)[23]



In addition to these three scenarios, Chart 9 below shows a current forward price projection from Wood MacKenzie based on an April 2018 forecast. The price projection was also modeled to show the cost savings associated with Gila River Unit 2.

Chart 9 – Forward Permian Natural Gas Prices ($/MMBtu)[24]



[23] These forward natural price projections were developed by PACE Global and each scenario made assumptions about "Future States of the World". A complete description of these scenarios can be found in Appendix A of the TEP 2017 IRP.
[24] Long-term forecast projection based on Wood-Mackenzie (Wood-Mac), North America Gas, Power and Coal Markets. April 2018.

Gila River Unit 2 Locks in Long-Term Value for TEP's Retail Customers

As part of TEP's strategy for acquiring Gila River Unit 2, TEP entered into a ten-year natural gas hedge to lock in long-term savings for TEP's retail customers. As shown in Table 4 below, the ten year hedge guarantees long-term savings for TEP's customers ranging from $405 million under a future scenario where natural gas prices average $7.61/MMBtu (as shown in Chart 8 as the PACE Global High Economy Case) to $546 million under a future scenario where natural gas prices average $2.80/MMBtu (as shown in Chart 9 as the Wood-Mac, April 2018 Case).

Table 4 – Gila River Unit 2 Long-Term Savings by Natural Gas Scenario

NPV Savings ($000)	PACE Global High Technology	PACE Global Base Case	PACE Global High Economy	Wood Mac April 2018
Fuel Savings	$33,568	-$129,212	-$316,938	$135,549
Non-Fuel Savings	$243,291	$243,291	$243,291	$243,291
Natural Gas Hedge Savings	$34,736	$174,206	$313,632	$1,812
NPV Revenue Requirement Savings	**$311,595**	**$288,285**	**$239,984**	**$380,652**
Avoided SCR Upgrades at San Juan	$165,000	$165,000	$165,000	$165,000
Total Cost Savings	**$476,595**	**$453,285**	**$404,984**	**$545,652**

Loads and Resource Assessment

Chart 10 and Chart 11 show the change in the Loads and Resources Assessment between the Reference Case Plan and the Action Plan Update. The increase in capacity due to the earlier incorporation of Gila River Unit 2 into the portfolio, relative to the planned 2022 NGCC assumed in the Reference Case Plan, is largely offset by a 475MW tolling agreement that TEP has entered with a third party through 2020. The 475MW toll will primarily be served by Gila River Unit 2.

Chart 10 – TEP's 2017 IRP Reference Case Plan Loads and Resource Assessment

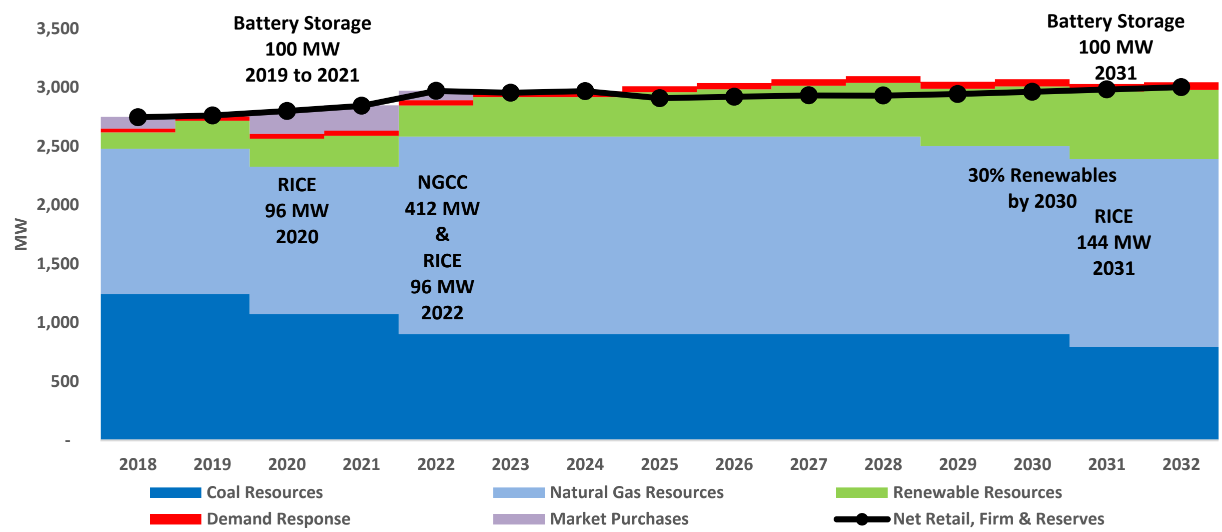
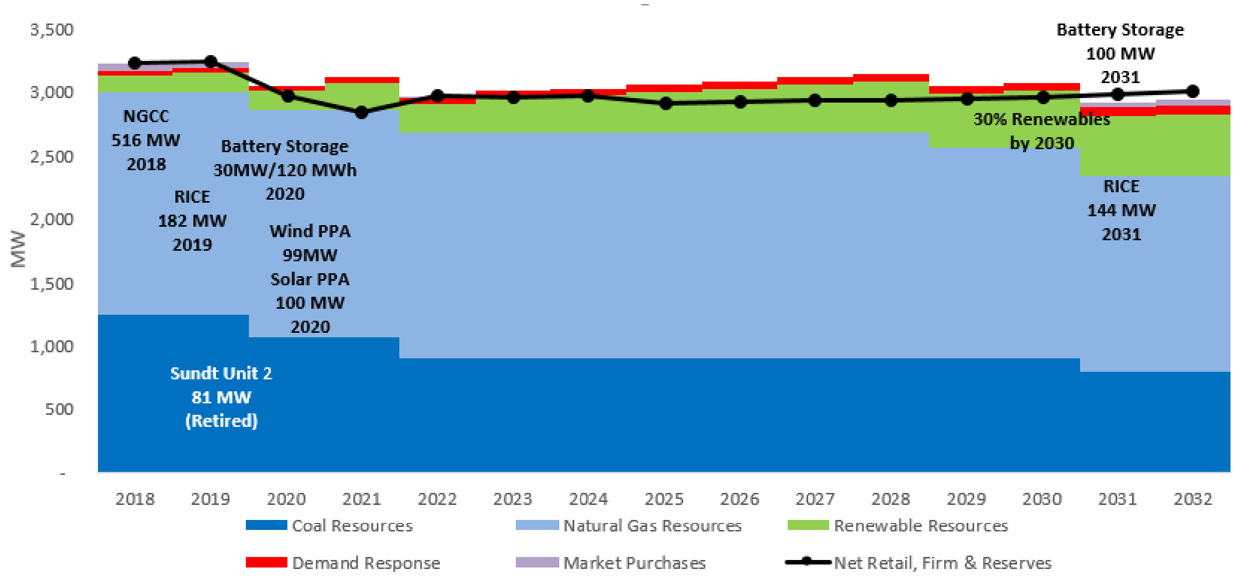


Chart 11 – TEP's Action Plan Update Loads and Resource Assessment



Updated Reference Case Plan Timeline

Figure 6 details the changes between the Reference Case Plan and the Action Plan Update. Figure 7 presents a full timeline of the Company's overall plan to achieve 30% renewables by 2030 incorporating the changes described in the Action Plan Update.

Figure 6 – Action Plan Update Timeline Changes

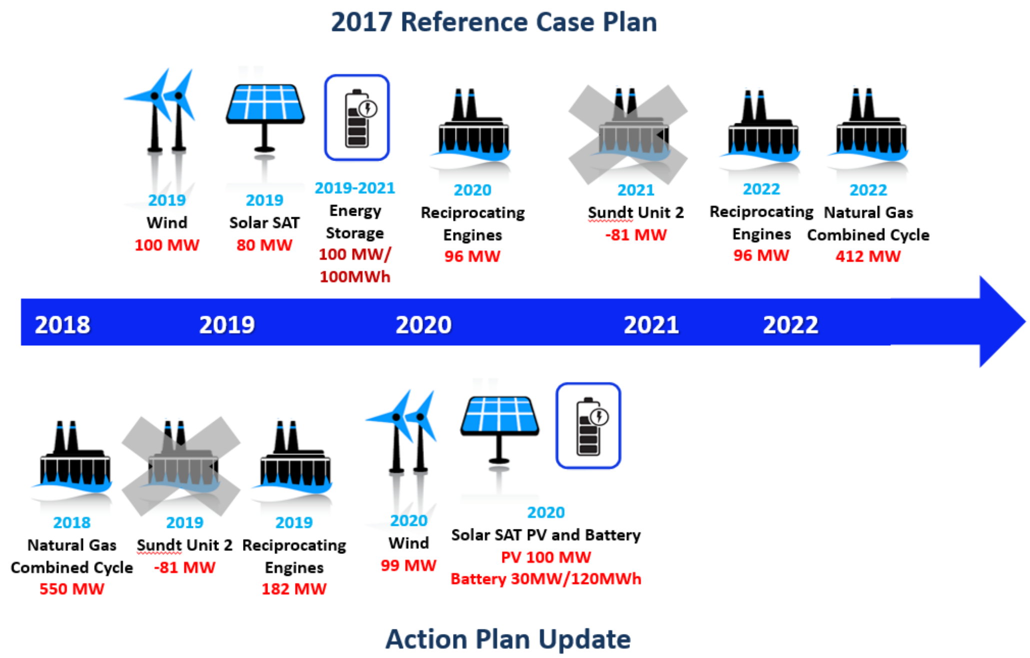
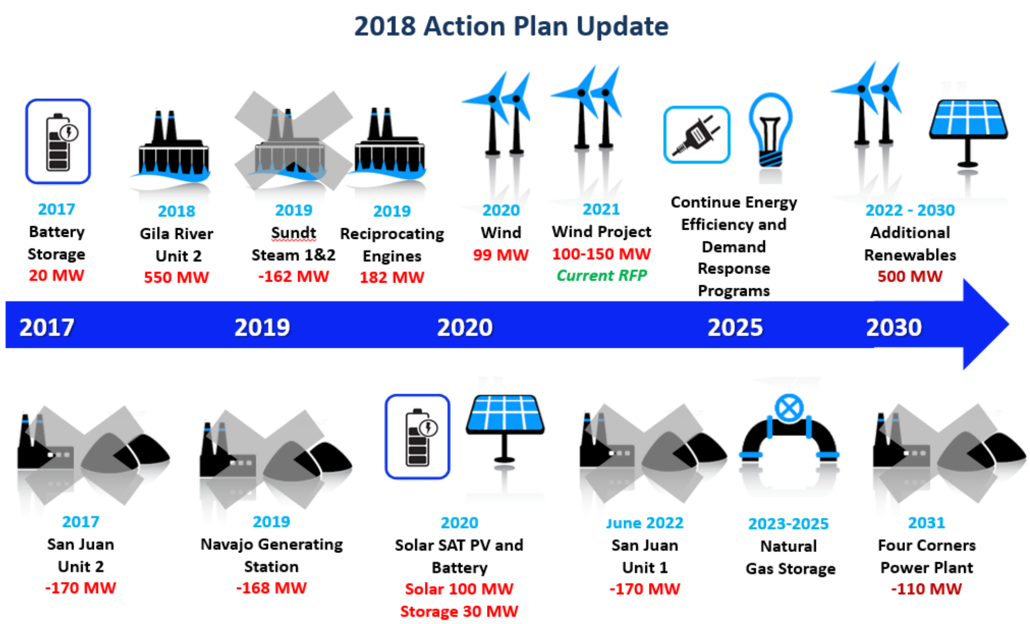


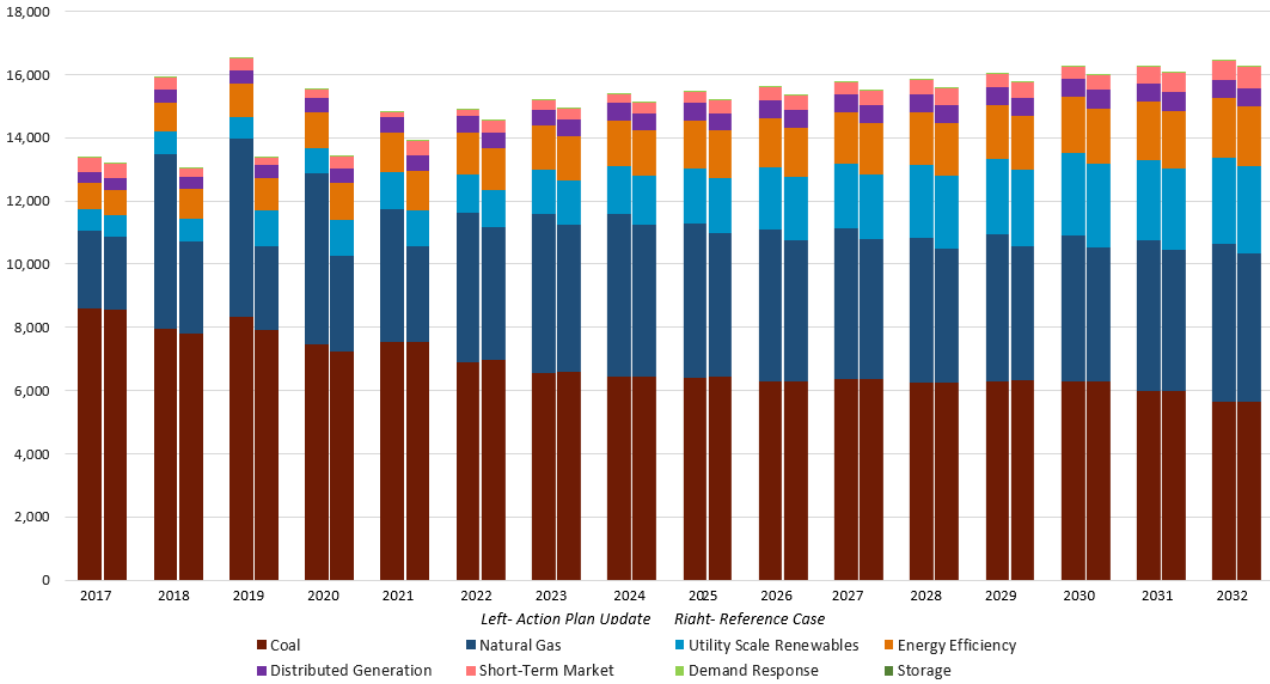
Figure 7 – Updated Reference Case Plan Resource Timeline



Updated Reference Case Plan Generation Profile

Chart 12 shows the change in the annual generation profile between the Reference Case Plan and the Action Plan Update.

Chart 12 – Updated Annual Energy by Resource (MWh)



Summary of NPV Revenue Requirement

Chart 13 below summarizes the net present value revenue requirements (NPVRR) for TEP's portfolio as revised by the changes in the Action Plan Update relative to the TEP 2017 IRP Reference Case Plan. The changes in the Action plan update result in $273 million in savings relative to the Reference Case Plan. Chart 14 shows the contribution of individual projects to the overall NPVRR savings and Table 5 presents the savings by fuel-related and non-fuel related categories.

Chart 13 – Updated NPV Revenue Requirement ($000)

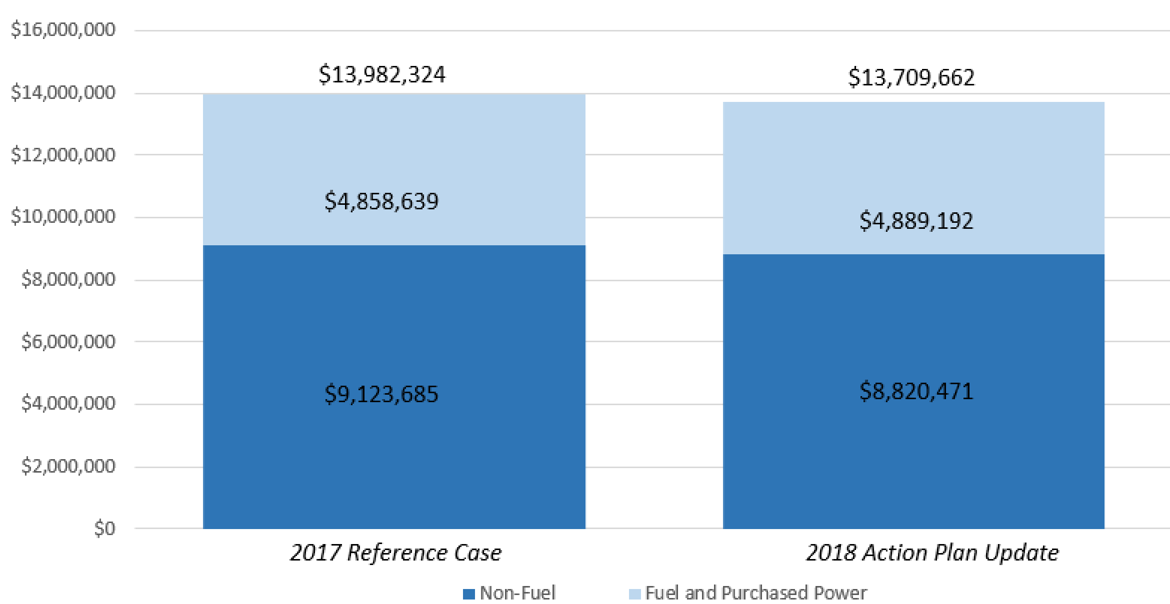


Chart 14 – Updated NPV Revenue Requirement by Project ($000)

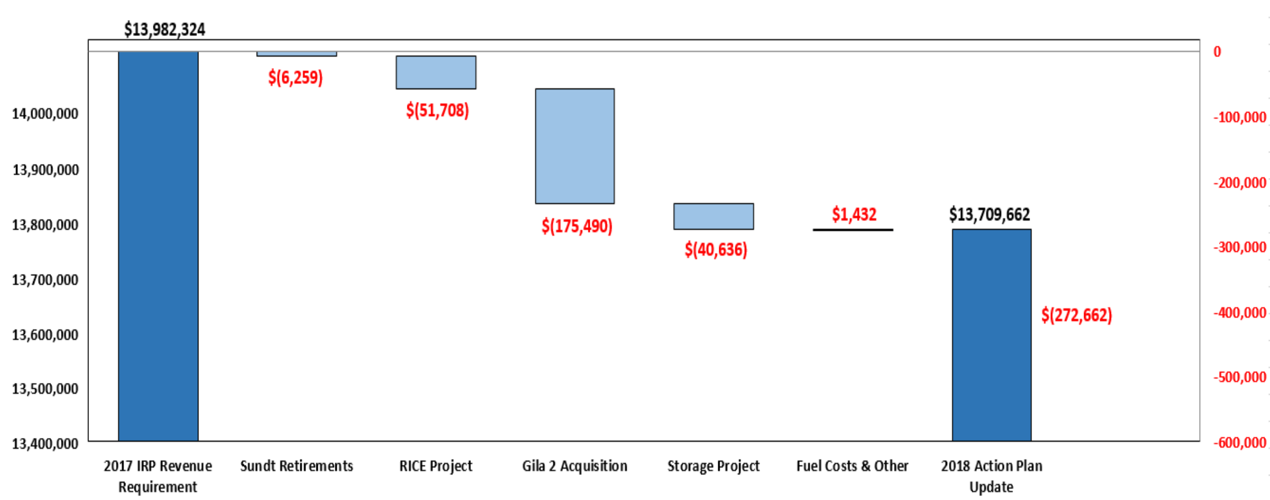


Table 5 – NPV Revenue Requirements Comparison ($000)

Non Fuel Revenue Requirements, $000	Reference	Action Plan Update
Existing T&D Resources	$4,061,825	$4,061,825
Existing Generation Resources	$3,909,337	$3,905,229
New Generation Resources	$695,575	$468,376
Storage Resources	$140,203	$68,295
New Renewable Resources	$79,736	$79,736
Existing Transmission Expenses	$237,009	$237,009
Total Non-Fuel Revenue Requirements	$9,123,685	$8,820,471

Fuel & Purchase Power, $000	Reference	Action Plan Update
Total PPFAC Costs	$4,133,336	$4,177,088

Energy Efficiency and Renewables, $000	Reference	Action Plan Update
Energy Efficiency	$285,450	$285,450
Demand Response	$39,714	$39,594
Total Energy Efficiency	$325,164	$325,045

Total Renewables	$400,139	$387,059

Total Energy Efficiency and Renewables	$725,303	$712,103

Total System Revenue Requirements	**$13,982,324**	**$13,709,662**

NPV Difference from Reference Case Plan		**$272,662**

CHAPTER 3

FIVE-YEAR ACTION PLAN

TEP has updated its five-year action plan in response to system needs and changing market conditions. Under this action plan, additional detailed study work will be conducted to validate technical and financial assumptions prior to any final implementation decisions. TEP's action plan includes the following:

- TEP plans to continue with its community-scale build out of renewable energy to achieve a diverse portfolio that targets 30% of retail load from renewable generation by 2030. As a result, TEP has entered into PPAs for 99 MW of wind energy and 100 MW of solar energy. Both projects are scheduled for commercial operation in late 2020. In addition, TEP released a Wind RFP for 100-150 MW in January 2018 targeting high capacity factor wind projects that will be in service no later than 2021. In addition, as part of the Company's 2019 REST Implementation Plan, TEP will include a plan to conduct an RFI on forest biomass projects within Arizona. Finally, the Company is committed to exploring opportunities to develop future renewable energy projects on the Navajo Nation.

- As part of TEP's portfolio diversification strategy, the Company is reducing its coal resource capacity by 508 MW over the next five years, which represents 36% of TEP's current coal capacity. These planned coal retirements will enable TEP to take advantage of near-term opportunities to reduce costs and rebalance its resource portfolio over the longer-term. This reduction in coal resources will result in significant costs saving for TEP customers and will result in meaningful reductions in air emissions and water consumption.

- In order to accommodate increased renewable energy resources, and to allow for the retirement of older natural gas steam units at the Sundt Generating Station, TEP is implementing a generating resource modernization plan at Sundt. As part of this modernization plan, TEP will retire Sundt Steam Units 1 and 2, and install 182 MW of RICEs to achieve commercial operation beginning in the third quarter of 2019.

- TEP will continue to implement cost-effective EE programs based on the Arizona EE Standard. The Company will participate in workshops and other forums for stakeholder engagement to develop EE as a resource in the IRP and as part of broader objectives at the state level. TEP will closely monitor its EE program implementation and adjust its near-term capacity plans accordingly. TEP will continue to monitor closely and implement demand response programs that are mutually beneficial to the Company and its customers.

- TEP is optimistic about the potential of energy storage systems as an economically viable solution to provide grid balancing services relating to renewable intermittency mitigation. The Action Plan Update includes the addition of a 30 MW, four-hour battery energy storage system to be co-located with the 2020 solar PPA. Furthermore, TEP is evaluating participation in the proposed Big Chino Valley pumped storage hydroelectric project and TEP plans to monitor advancements of battery storage technologies to serve as potential solutions within our distribution, transmission and generation portfolios.

- In October 2017, TEP entered into a 20-year tolling PPA with SRP to purchase all 550 megawatts of capacity, energy, and ancillary services from Gila River Unit 2. Under the agreement with SRP, TEP has the option to purchase the unit within three years. TEP intends to exercise this purchase option.

- TEP and other Arizona utilities continue to evaluate the viability of large scale underground natural gas storage. Natural gas storage within the state would improve the reliability of natural gas fired generation to respond to changing loads as well as the intermittency caused by renewable resources. Moreover, due to the distance between Arizona's largest load pockets of Phoenix and Tucson from the San Juan and Permian natural gas production basins, a state sourced natural gas storage facility would boost system resiliency by supplying natural gas during periods of shortfalls and storing excess natural gas during periods when the natural gas mainlines experience operational limitations.

As with any planning analysis, the TEP 2017 IRP, including this Action Plan Update, represents a snapshot in time based on known and reasonable planning assumptions. TEP plans to communicate any major change in its anticipated resource plan with the ACC as part of its ongoing planning activities.

APPENDIX A

RECIPROCATING ENGINE USE CASE

Tucson Electric Power

H. Wilson Sundt Generating Station Reciprocating Engine Use Case

Final Report

Final Update – December 2017

ACKNOWLEDGEMENTS

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Chapter 1

EXECUTIVE SUMMARY

Tucson Electric Power Company's (TEP's) 2017 Integrated Resource Plan (IRP)[1] identifies the need for flexible, natural gas-fired resources to support future reliability requirements associated with the planned expansion of renewable energy resources. Specifically, the IRP's Five-Year Action Plan calls for a resource modernization plan at the H. Wilson Sundt Generating Station ("Sundt"), which would add new, fast-start, fast-ramping resources while retiring older, less efficient steam generating units.[2] This report builds on the IRP with additional analyses relating to the need for fast-ramping, thermal resources and minimum must-run generation requirements at Sundt.

This study uses AuroraXMP[3], the Company's long-term modeling platform, to evaluate the two thermal generation technologies best suited to meet TEP's future system needs:

- Reciprocating Internal Combustion Engines (RICE), and
- Simple Cycle Gas Turbines (SCGT).

Portfolios incorporating these technologies are compared to one in which the Company's investment in new, fast-ramping generation is delayed until the useful life of the existing steam generating units is reached. This "delayed investment" portfolio provides a baseline for comparing alternative portfolios. However, the baseline case is not consistent with the IRP and would not be compatible with TEP's plans for expanding its renewable generation.

Study Results

The results of this analysis support the use of RICE technology for the Sundt resource modernization project. The RICE portfolio results in significant cost savings for TEP's customers relative to the SCGT portfolio. Under the current assumptions, TEP's customers would realize a net present value savings of approximately $135 million relative to the portfolio incorporating SCGT technology.

Replacement of the older steam generating units with modern, efficient RICE technology also results in meaningful reductions in local air emissions and water consumption. Incorporating RICE technology results in reductions in local area nitrogen oxides ("NO_X") emissions of approximately 60%, beginning as early as 2019. These reductions are meaningful given that NOx is a precursor for ground-level ozone and the Tucson area is very close to non-attainment status for the ozone ambient air quality standard. In addition, the incorporation of

[1] https://www.tep.com/wp-content/uploads/2017/04/TEP-2017-Integrated-Resource.pdf

[2] As part of TEP's 2015 Rate Case, the Company committed to study the future need of its local area must-run generation resources in the 2017 Integrated Resource Plan. As a result, Sundt Units 1 and 2, which were expected to retire in 2020 and 2018, had their service lives extended by ten years to 2030 and 2028, respectively.

[3] AURORAxmp is a stochastic based dispatch simulation model used for resource planning production cost modeling. Additional information about AURORAxmp can be found at http://epis.com/

RICE technology shows reductions in wastewater generation, with sewer fee savings of approximately $3.6 million.[4]

Finally, as part of TEP's portfolio diversification strategy, replacing Sundt Units 1 and 2, which were commissioned in 1958 and 1960, with modern, flexible, natural gas-fired generation will significantly enhance TEP's ramping capabilities, thus supporting the Company's efforts to serve 30% of retail load with renewable energy resources by 2030. Taking advantage of low-cost, utility-scale renewable energy is a key component of TEP's efforts to rebalance its resource portfolio over the long-term. This resource diversification will reduce long-term carbon dioxide risks while locking in low-cost, sustainable sources of energy for decades to come. The increased ramping capability afforded by investing in RICE is key to addressing the reliability issues associated with higher penetrations of renewable resources.

[4] This cost savings estimate is based on a comparison of the RICE technology versus Units 1 and 2 at the H. Wilson Sundt Generating Station.

Chapter 2

BACKGROUND

Study Overview

This study presents a Use Case for the installation of new, fast-ramping thermal generation resources at Sundt and analyzes portfolios incorporating the two thermal generation technologies that are the best suited for the intended use. The portfolio analysis incorporates technology assumptions developed by Burns and McDonnell as part of a 2017 Flexible Generation Technology Assessment performed for TEP.

All other assumptions are consistent with those used in TEP's 2017 IRP, most notably the assumptions developed by PACE Global ("PACE") regarding future fuel and wholesale power market prices. As in the IRP, this study assumes a "base case" forecast, as well as two alternative forecasts representing higher and lower growth rates in these prices relative to the base case, thereby providing a range of plausible outcomes. All PACE forecasts, which account for the interdependency of fuel and power prices, are summarized in Chapter 3 and explained in detail in Appendix A found within TEP's 2017 IRP report.[5]

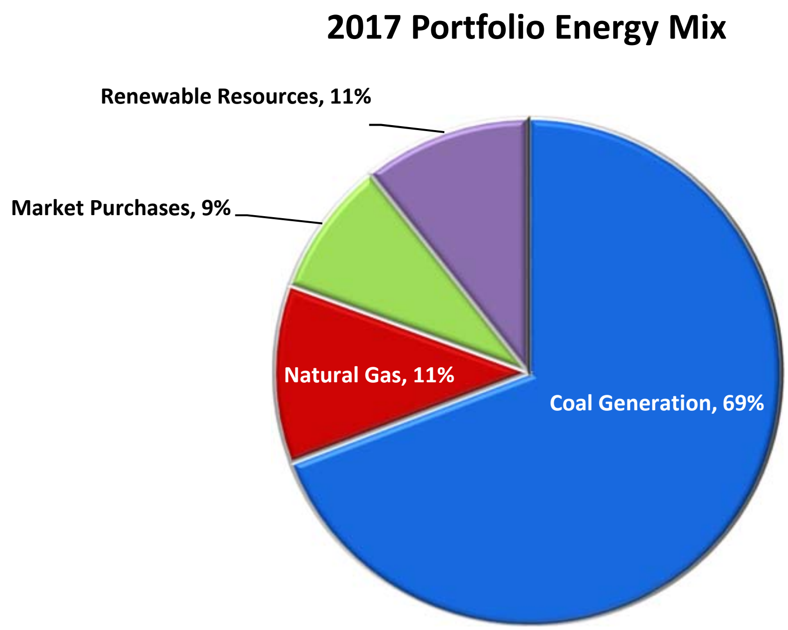
TEP summarizes the relative difference between the financial impacts associated with each of the technology alternatives in the context of the Company's resource portfolio.

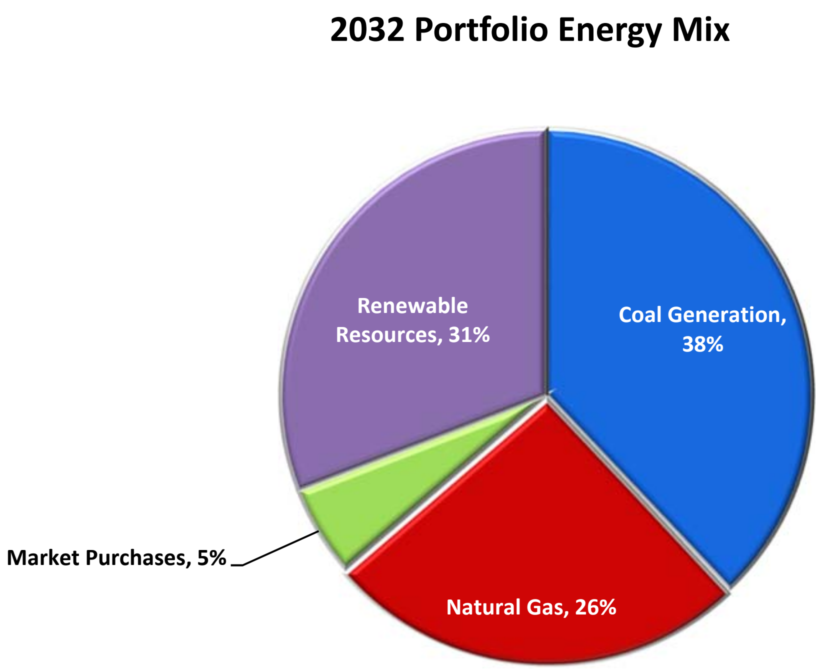
TEP Integrated Resource Plan

TEP's 2017 IRP describes the Company's long-term strategy to diversify its generation portfolio and serve 30% of its retail energy sales with renewable resources. This will be accomplished by retiring over 500 MW of aging coal-fired capacity and replacing it with a mix of efficient natural gas-fired capacity and renewable energy resources. Between now and 2030 TEP expects to add approximately 800 MW of utility-scale solar and wind projects. The anticipated change in TEP's energy mix is shown in Chart 1.

[5] https://www.tep.com/wp-content/uploads/2017/04/TEP-2017-Integrated-Resource.pdf

Chart 1 – Changes in TEP's Portfolio Energy Mix





The portfolio energy charts shown above represent the energy resource mix to serve TEP's retail customers. Wholesale market sales are excluded from these results. By 2030, 30% of TEP's retail demand will be served by renewable energy. This is based on a combination of utility-scale and distributed generation resources.

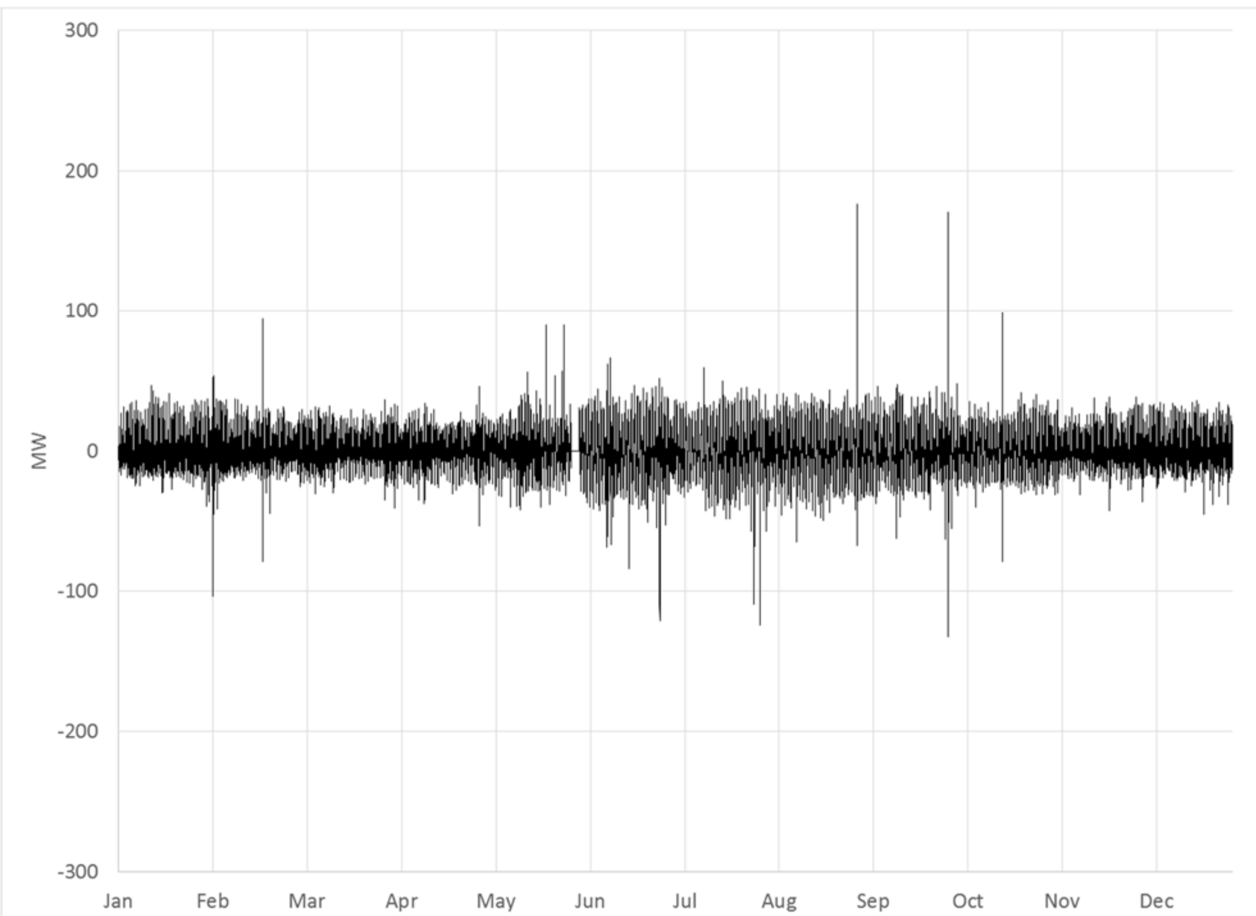
Ramping Needs Analysis

One of TEP's most critical responsibilities is to maintain – within certain, narrow limits – a continuous balance between the output of its generating resources and the energy used by its customers. Because customer energy use varies continuously, TEP must maintain adequate ramping capacity within its generation fleet to respond to changes in energy use. Maintaining a balance between generation and use, however, is becoming increasingly difficult as a greater portion of the generation fleet itself is becoming variable due to the penetration of intermittent solar and wind resources. This places a greater burden on the remaining, dispatchable resources to balance the variability of both energy use and intermittent generation.

To illustrate the effect this is having, TEP isolated the short-term variability attributable to retail demand from that attributable to intermittent renewable generation over the course of 2016. The 10-minute changes solely attributable to retail demand typically fall within a range of ±25 MW and rarely exceed ±50 MW, as shown in Chart 2 below. Prior to the introduction of intermittent renewable energy resources to the system, TEP's existing generation fleet was able to accommodate this magnitude and frequency of retail load swings.

Historical Load Volatility

Chart 2 – 10-Minute Changes Attributable to TEP Retail Demand in 2016

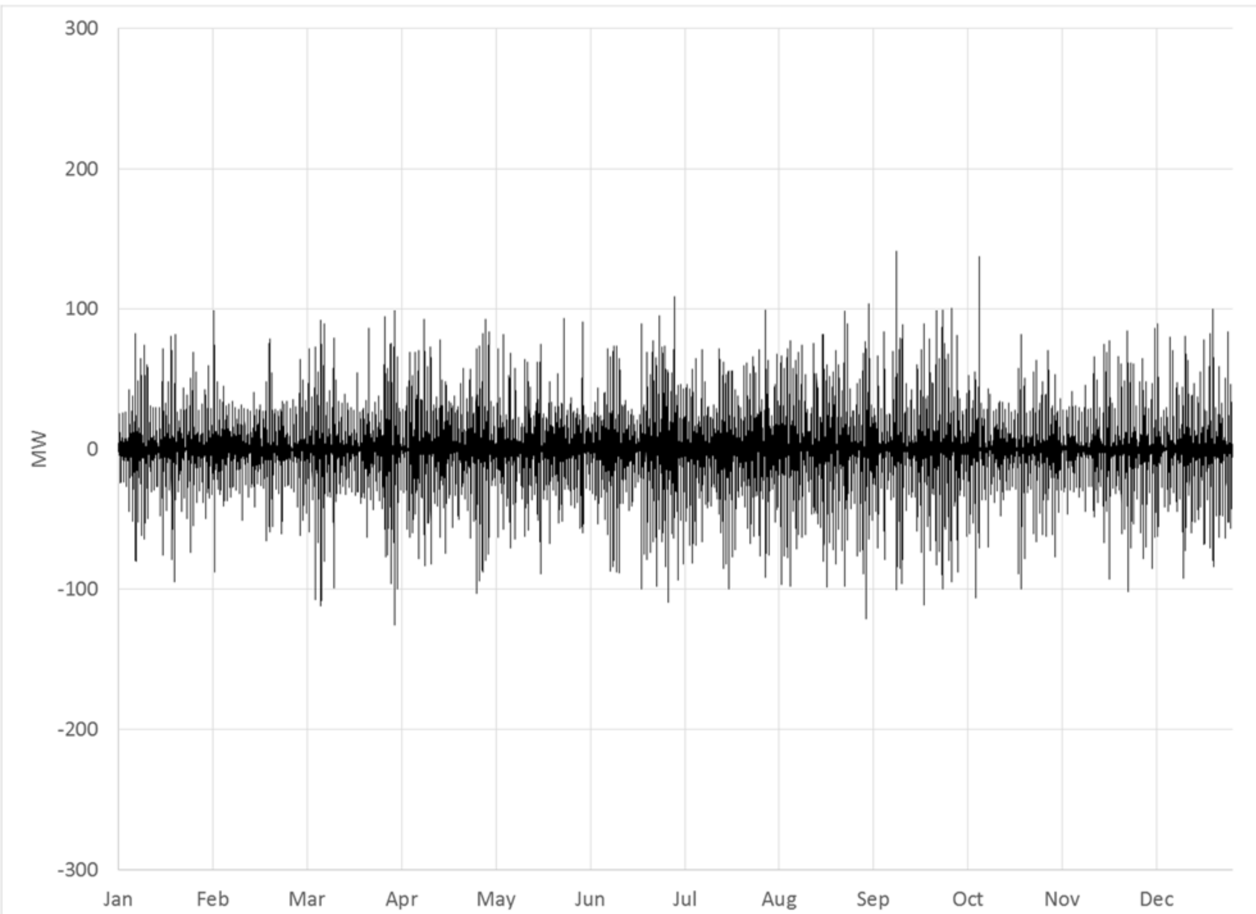


The chart above represents the change in retail load on a 10-minute basis (52,560 intervals) over the course of a year.

In 2016, renewable energy generation served almost 11 percent of TEP's retail load. As shown in Chart 3 below, the variability solely attributable to this level of intermittent generation is routinely greater than ±25 MW and often reaches or exceeds ±100 MW in certain 10-minute timeframes. Retail load variability is already being exceeded by the variability in TEP's renewable energy generation. TEP has adjusted to this higher variability by carrying higher levels of spinning reserves on the system. In addition, TEP added 20 MW of battery energy storage in 2017 and continues to explore cost-effective enhancements to improve the ramping capabilities of other, existing resources.

Current Renewable Intermittency

Chart 3 – 10-Minute Changes Attributable to TEP Renewable Energy Generation in 2016

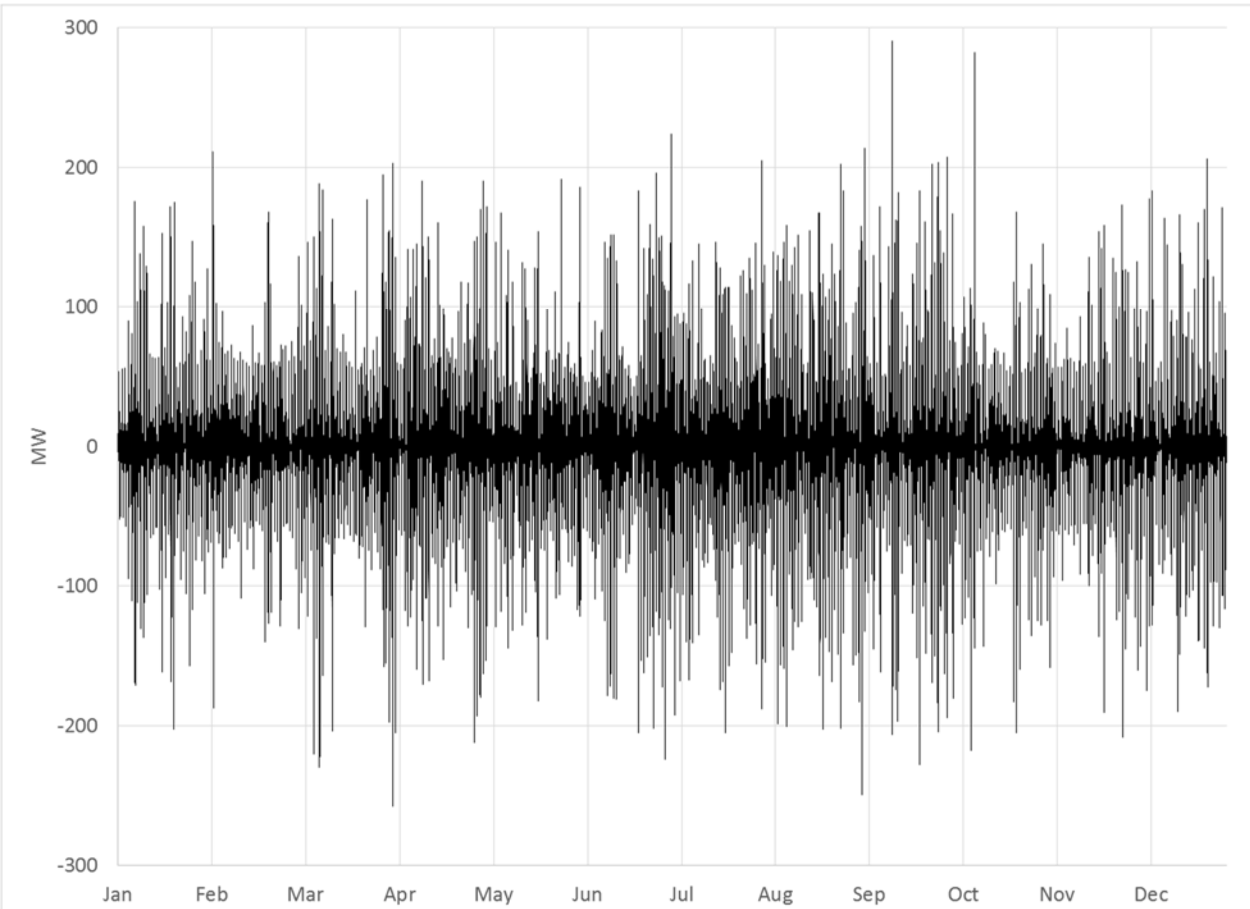


The chart above represents the change in renewable output on a 10-minute basis (52,560 intervals) over the course of a year.

However, by 2024, TEP expects to double its capacity in renewable energy resources to over 20% of retail load, which will dramatically increase its ramping requirements, as shown in Chart 4 below. The need for new ramping resources will be three times our historical load ramping requirements and double our 2016 renewable ramping requirements. Given this magnitude of change, TEP will not be able to rely on its existing generation fleet to meet the reliability obligations associated with this level of variability.[6] New, fast ramping resources will be required.

Future Renewable Intermittency

Chart 4 – 10-Minute Changes Attributable to TEP Renewable Energy Generation (2024 Forecast)



The chart above represents the change in renewable output on a 10-minute basis (52,560 intervals) over the course of a year.

[6] Over the next five years, TEP will reduce its coal-fired capacity by 508 MW through planned retirements. TEP plans to exit San Juan Generating Station ("San Juan") Unit 2 by the end of 2017, exit the Navajo Generating Station ("Navajo") by the end of 2019, and exit San Juan Unit 1 by the end of June 2022.

TEP's Future Ramping Capacity Needs

Precisely how much ramping capacity will be needed in the future depends in large part on where future renewable energy resources are located. In Chart 4 above, TEP assumed that future solar and wind resources are located at or near a number of existing renewable energy facilities in the Tucson metropolitan area. In addition to this "base case," which resulted in a maximum renewable energy change of 255 MW over 10 minutes, TEP also estimated the ramping requirement if future renewable energy resources are sited more dispersedly across southern Arizona (geographically dispersed case) and if they are sited at a fewer number of locations (geographically concentrated case). As shown in Chart 5 below, depending on where future renewable energy resources are located, TEP's ramping requirement in 2024 could range from 224 MW to 328 MW over 10 minutes, and the number of days with ramps exceeding 200 MW in 2024 could range from 3 to 118.

Chart 5 – TEP Ramping Requirements Under Alternative Siting Scenarios for Future Renewable Energy and Their Comparison to TEP Ramping Resources Under Optimal Conditions (2024)

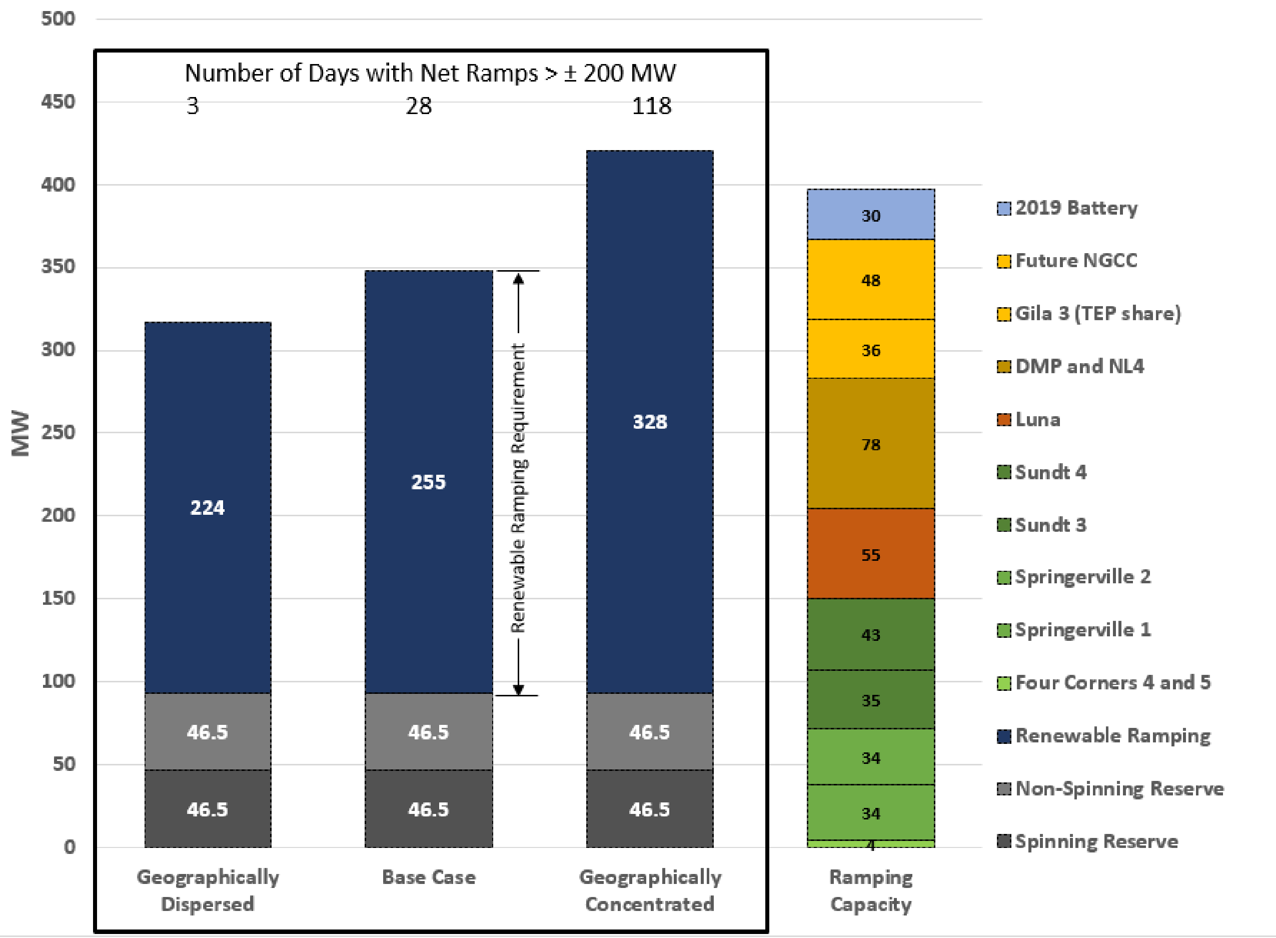


Chart 5 above also compares these potential ramping requirements to future ramping capacities. The comparison includes 10-minute ramping requirements associated with spinning and non-spinning reserves, since these are also required for reliability purposes and would be served by the same set of resources. Future ramping resources include existing resources that will continue to be in service in 2024 plus the addition of a new combined cycle natural gas plant similar to what TEP currently owns at Gila River Generating Station, plus a 30 MW battery system to be deployed with the 100 MW_{DC} solar plant under development by NextEra. The comparison in Chart 5 shows that 2024 ramping requirements could be met in two of the three cases, but only if all future ramping resources are fully available. Since it can be somewhat common for one or more resources to be unavailable, or to have less than their maximum ramping capacity available, it is clear that TEP will require additional ramping resources to reliably balance renewable energy intermittency across a range of plausible future scenarios in 2024. Moreover, ramping requirements will increase after 2024 as more renewable energy is brought on line to achieve the Company's goal of serving 30% of retail load with renewable resources.

Burns and McDonnell Study Scope

Given this future need for additional fast-ramping capacity, the Company hired Burns and McDonnell to conduct an in-depth analysis to determine the least-cost technology that would best support TEP's long-term renewable energy goal.

The Burns and Mac Report identified candidate technologies to be evaluated in terms of their ability to support TEP's system by providing quick-start and fast-ramping (i.e., flexible) generation in anticipation of increasing levels of renewable energy in the system. The candidate technologies are listed below.

Aeroderivative Simple Cycle Gas Turbines (SCGT):

- 6 x 45 MW (based on GE LM6000 PF / GE LM6000 PF+)
- 4 x 45 MW (based on LM6000 Hybrid EGT)
- 4 x 65 MW (based on GE LM9000)
- 2 x 100 MW (based on GE LMS100 PB+)

Frame SCGT:

- 1x 220 MW F-class (based on GE 7FA.05)

Reciprocating Engines:

- 20x 10 MW (based on MAN 20V35/44G)
- 10x 20 MW (based on MAN 18V51/60G)

Combined Cycle Gas Turbines (CCGT):

- 200 MW 3 x 1 Configuration based on Siemens SGT-800 featuring:
    - Air Cooled Condenser (ACC)
    - Duct firing
    - Evaporative inlet cooling

Solar Photovoltaics (PV):

- 100 MW block (with incremental "next unit" option) featuring:
    - Polycrystalline silicon modules
    - Single axis tracking system

Wind Generation:

- 67x 3 MW of on-shore turbines operating at a 40 percent capacity factor

Battery Storage:

- 50 MW / 200 MWh lithium ion (with incremental "next unit" option)

Burns and McDonnell Study Results

The Burns and Mac Report concluded that aeroderivative SCGT and RICE technologies provide the best combination of flexibility and efficiency (i.e., heat rate) of the thermal generation options. The PV option is not sufficient because it can only meet minimum must-run generation requirements during the day, and even then, the requirements are sometimes well in excess of 100 MW. Pairing energy storage with a solar plant would help with some of the peak requirements and some of the night hours, but to provide complete sufficiency for reliability purposes, such a system would have to be grossly (and expensively) overbuilt. Likewise, a wind plant is not sufficient because it has some of the same reliability and dispatch limitations as solar, plus the 67 wind turbines could not be located in or near the Tucson metropolitan area and provide the local area voltage support noted above.

TEP's System Reliability Requirements for Future Ramping Technologies

Subsequent to the Burns and McDonnell study, the Company developed a list of resource operational requirements that would support TEP's long-term system reliability requirements for accommodating high levels of variable generation and minimum must-run generation. These operational requirements were developed based on feedback from TEP's renewable integration teams. These operational requirements were used to help make the final determination between SGCTs and RICE technologies. These operational requirements are listed below:

- Continuous operation (8,760 hours) at no greater than 10 MW, at a heat rate of no greater than 9,000 Btu/kWh.
- Initial start time of 0 – 20 MW in five minutes
- Initial ramp time of 10 – 20 MW in 30 seconds
- Full ramp of 10 – 200 MW in five minutes
- Multiple starts and ramping periods each day without maintenance penalty
- Support minimum local area generation requirements at the H. Wilson Sundt Generating Station

H. Wilson Sundt Generating Station Overview

Sundt consists of a four unit, peaking and intermediate-load, steam electric generating station and two SCGTs located in Tucson, Arizona. Steam Units 1 and 2 and the SCGTs are gas- or oil-burning generating units. Steam Unit 3 fires natural gas and Unit 4 fires natural gas and landfill gas.[7] Unit capacities and service lives are presented in Table 1 below.

Table 1 - Sundt Unit Capacity and Service Life

Units	Capacity (MW)	Entered Service	Planned Retirement
Steam Unit 1	81	1958	2030[8]
Steam Unit 2	81	1960	2028
Steam Unit 3	104	1962	2030
Steam Unit 4	156	1967	Not Planned
SCGT Unit 1	25	1972	Not Planned
SCGT Unit 2	25	1973	Not Planned

[7] Unit 4 was capable of operating with either coal or natural gas as the primary fuel since a coal conversion project was completed in the late 1980s. In 2015, coal was permanently eliminated as a fuel source for Unit 4 as part of a federal plan to implement requirements relating to regional haze.
[8] As part of the TEP 2015 Rate Case, the service lives for Sundt Units 1 and 2 were adjusted to be through 2030 and 2028, respectively. These dates serve as the base case useful life for these units.

The primary fuel at Sundt Generating Station is natural gas. The station is supplied by gas purchased on the spot market and through gas hedging agreements that are consistent with TEP's hedging policy. Natural gas is delivered through the Kinder Morgan natural gas pipeline which is located adjacent to the Sundt property. The SCGTs at Sundt are black-start capable and are designated as the first generation on line in the case of a state-wide outage.

Steam Units 1-4 utilize cooling towers for the cooling portion of the steam cycle. Cooling tower blowdown water is discharged to the sanitary sewer (a certain amount of cooling tower blowdown has been held in evaporation ponds prior to discharge to the sewer) under an industrial wastewater discharge permit issued by the Pima County Wastewater Department. Wastewater discharges are subject to a fee. A summary of cooling tower wastewater discharge volumes and fees for the period 2014 through 2016 is presented in Table 2.

Table 2 - Cooling Tower Wastewater Discharge Volumes and Fees (2014-2016)

	2014	2015	2016
Annual Discharge Volume (000 gal)	95,720	113,127	142,607
Annual Fee ($000)	$451	$533	$672

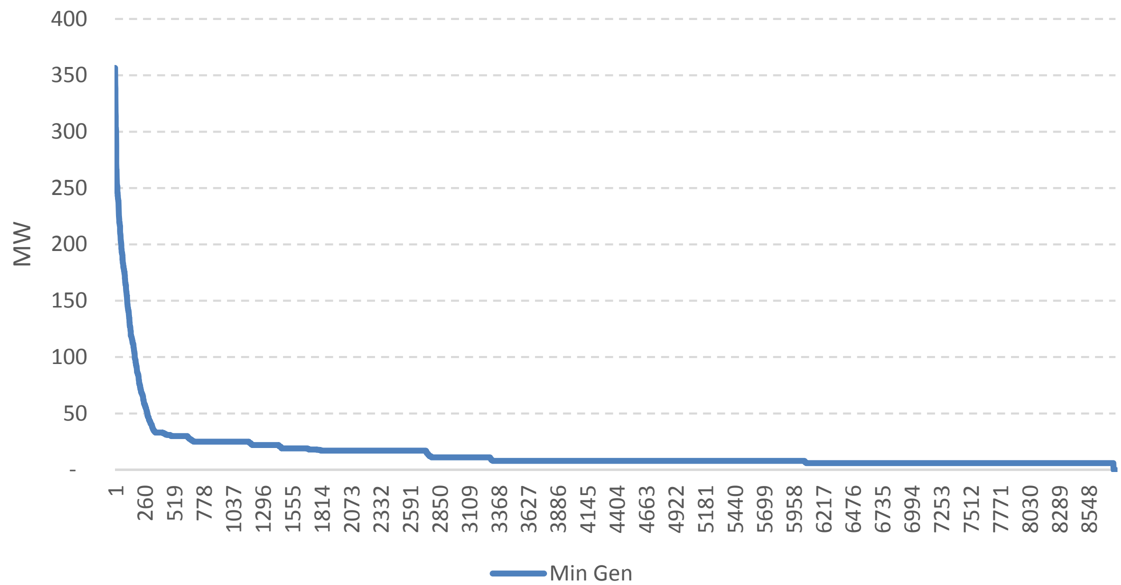
The addition of new, efficient thermal generation resources at Sundt is expected to result in decreased utilization of the steam units and a corresponding decrease in sewer discharges and fees.

Minimum Generation Requirements

TEP's balancing authority area includes a concentrated load center in and around the Tucson metropolitan area served by generating resources located both locally and remotely from the load center. Local resources include the Sundt station described above as well as two, peaking SCGT stations: DeMoss Petrie Generating Station ("DeMoss Petrie"), consisting of a single 75 MW SCGT, and North Loop Generating Station ("North Loop"), consisting of four smaller SCGTs, each with a net capacity below 25 MW.

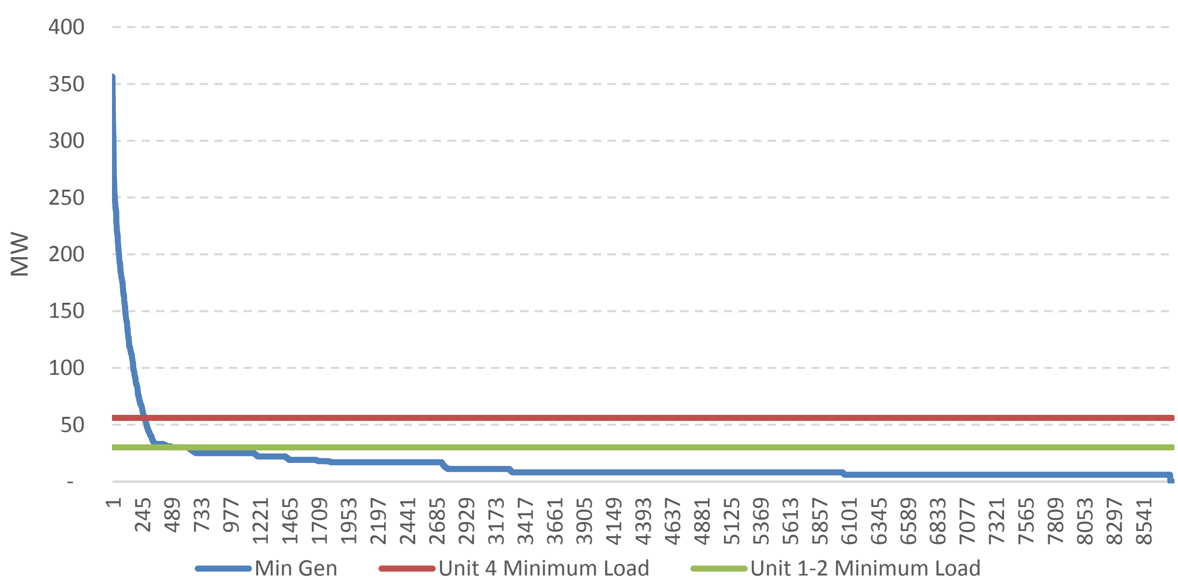
The vast majority of TEP's retail energy load is met by energy imported from TEP's remote generating stations. In order to maintain this import capability and to ensure the system has sufficient voltage support in the case of a loss of power or transmission from one of the remote generating units, system reliability engineers specify a level of minimum must-run generation that must be carried by one of the local area resources at all times. The hourly minimum must-run generation requirement for 2016 is presented in Chart 6 below in the form of a load duration curve. For 2016, the minimum must-run generation requirement was less than or equal to 25 MW for 92 percent of the year and less than or equal to 10 MW for 63 percent of the year.

Chart 6 - TEP Local Minimum Generation Requirement (2016)



Historically, Sundt Steam Unit 4 operated as a base-load resource (when operating on coal) and was therefore used to satisfy the minimum must-run generation requirement. One of the advantages of eliminating the use of coal at Sundt Steam Unit 4 is that it now has the flexibility to operate more like the other steam units, as a peaking resource. These steam units, however, are limited in their turndown capability, which, as shown on Chart 7 below, results in an uneconomical over-dispatch of these resources relative to what is necessary to meet minimum must-run generation requirements for significant portions of the year.

Chart 7 – Steam Unit Minimum Load versus Minimum Generation Requirement



In comparison, RICEs are capable of operating at low output without significant heat rate degradation. In addition, their modular capacity (i.e., multiple engines) would allow TEP to dedicate one or two engines (at any given time with multiple back-up units) to serve the minimum must-run generation requirements, thereby eliminating uneconomical unit dispatch. As a result, the RICE technology provides the best combination of operating flexibility and cost effectiveness. A single 20 MW unit operating between 6 and 10 MW will efficiently meet the minimum must-run generation requirements while having capacity for an additional 10-14 MW ramp in under a minute. Furthermore, there is an inherent operation and maintenance cost benefit in limiting the total number of units.

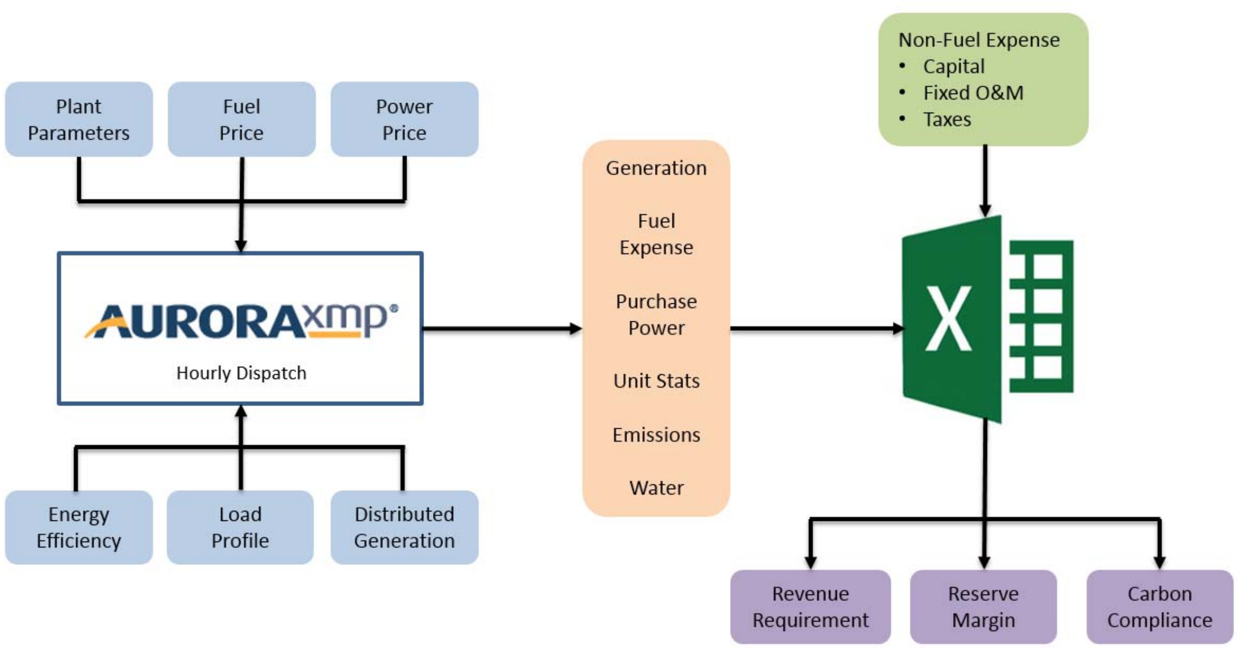
Chapter 3

STUDY METHODOLOGY AND ASSUMPTIONS

Modeling Methodology

TEP has a comprehensive database of its current resources, along with future portfolio expansion alternatives. These resource characteristics, along with future projections of customer load populate TEP's production cost model, AuroraXMP®, developed by EPIS. This analysis modeled unit-level thermal resource operating characteristics to reflect unit capacity, unit heat rate, unit ramp rate, and unit minimums. Renewable resources were also modeled to reflect their hourly intermittent delivery of energy by season, along with their coincident contribution to peak resource capacity for resource adequacy purposes.

Figure 1 – Production Cost Model Overview



The primary outputs of AURORAxmp are variable operating costs, including fuel costs, contract costs, and market transaction costs. (Fixed O&M and capital costs are included in the Components of Revenue Requirement modeling.) The model also reports plant-specific capacity factors and environmental compliance costs, along with a distribution of wholesale power prices.

Financial Modeling

The financial modeling is based on a projection of revenue requirements over the 2017 - 2036 study horizon. To determine this projection, TEP uses long-term planning models to derive a total revenue requirement. In addition to the use of AURORAxmp described above, this includes transmission costs (new and existing), power plant balances (new and existing), depreciation schedules, tax treatment (including treatment of deferred taxes), fixed O&M expenses, and cost of capital.

Components of Revenue Requirement

It should be noted that the total revenue requirement captures all the costs associated with generation and transmission resources within each portfolio.

The major elements of TEP's revenue requirement calculation include the following costs:

Variable Costs

- ***Fuel Costs:*** The fuel costs are a function of plant dispatch and are based on AURORAxmp dispatch projections for the study period and fuel price inputs.
- ***Variable Operating and Maintenance (VOM) Expenses:*** The VOM expenses are a function of plant dispatch and are based on AURORAxmp dispatch projections for the study period.
- ***Purchased Power Costs:*** Purchased Power Costs are modeled as a function of projected wholesale power prices from the AURORAxmp model. Costs associated with existing short-term purchased power agreements (PPAs) and long-term renewable PPAs are based on existing contracts in place at TEP. For new renewable resources additions, resource and/or PPA costs are based on PACE Global's resource cost estimates.
- ***Market Purchases (net of Market Sales):*** Any wholesale market purchases (net of wholesale market sales) are included in the variable costs. Market purchases and sales are calculated dynamically in the portfolio simulation based on TEP's hourly load profile and the performance of TEP's individual units versus regional wholesale market prices during each hour.

Fixed Costs

- ***Fixed Operating and Maintenance (FOM) Expenses:*** Plant-specific FOM expenses are based on TEP's projections and are included in the revenue requirement.
- ***Carrying Costs:*** Fixed carrying costs include book depreciation, income taxes, property taxes, and return on rate base.
    - **Book Depreciation:** Plant-specific book depreciation expenses are based on TEP's projections and are included in the revenue requirement.
    - **Income Taxes and Property Taxes:** Plant-specific income taxes and property taxes are based on TEP's projections and are included in the revenue requirement.
    - **Return on Rate Base:** The rate base is based on outstanding generation, transmission, and distribution plant property balance at the end of each year and TEP's weighted average cost of capital (WACC) of 7.04%.
- ***Stranded Costs:*** These costs are associated with the retirement of existing generation facilities. For purposes of this analysis, any net plant balance that was remaining on the books after the year the unit was retired was assumed to be amortized on a straight line basis over a 10-year recovery period.

Results of Revenue Requirement

The revenue requirement results are presented in nominal dollars using the following metric over the study horizon of 2017-2036.

- **Net Present Value (NPV) of the Revenue Requirements:** The NPV of the revenue requirements is discounted at TEP's WACC of 7.04% and takes into account the variable costs of the generation, as well as the fixed costs of both the transmission and generation over the study period.

Scenario Analysis

In this evaluation, the Company performed a scenario analysis on each of the portfolios to be studied based on a range of forecast assumptions about future conditions such as economic growth, fuel and wholesale power markets, regulatory conditions (e.g., emission prices), and the pace of technological development. Due to the inherent uncertainty about these future assumptions, it is necessary to test the performance of each resource portfolio against a range of future conditions to better assess whether a portfolio is robust under varying conditions. Alternative future scenarios must be identified that capture a range of future conditions that are plausible and that account for the interdependency of certain market conditions.

Fuel and Market Prices

As part of TEP's 2017 IRP planning cycle, the Company selected PACE Global as the third-party source for developing its natural gas and wholesale power price forecasts.[9] PACE Global developed three forecast scenarios capturing a wide range of uncertain forward market conditions. These three forecast scenarios are also used in this analysis and are defined as:

- PACE Global Base Case Scenario
- PACE Global High Technology Scenario
- PACE Global High Economy Scenario

Table 3 – Forecast Scenario Assumption Summary

Forecast Source	Scenario	Natural Gas, Average $/MMBtu	7x24 Palo Verde, Average $/MWh
PACE Global	Base Case	$5.20	$44.52
PACE Global	High Tech	$2.94	$30.49
PACE Global	High Econ	$7.47	$60.84

PACE Global Base Case Scenario

In the short-term, the PACE Global Base Case assumes a business-as-usual perspective for all market drivers, consistent with current forward market conditions. Gas prices increase somewhat from current low levels beginning around 2018 as demand catches up to shale supply. Power prices move up with natural gas in 2022. In the long term, natural gas and power prices tend to level out in real terms. Power market participants are able to adapt and adjust in a timely manner to changing market forces.

PACE Global High Technology Scenario

Under the PACE Global High Technology Scenario, significant advances in solar, wind, and energy storage technology result in greater renewable energy deployment along with some improvement in high efficiency gas-fired generation and natural gas extraction productivity. Overall, there are higher levels of distributed energy resources (DERs) and energy efficiency, which help mitigate future load growth that might otherwise be expected in a High Technology scenario with robust economic growth, including the adoption of electric vehicles. Innovations in storage technologies in the mid-term result in greater levels of renewable development without the need for back-up natural gas generation, reducing the effective cost of utility-scale renewables and

[9] Based on an independent analysis from PACE Global; "PACE Global Future States of the World", 2016. See Appendix A in TEP's 2017 IRP report.

DERs. These conditions tend to subdue fuel prices, power prices, and capital costs, and put pressure on coal plant economics, resulting in additional retirements.

PACE Global High Economy Scenario

Under the PACE Global High Economy Scenario, a robust and growing U.S. economy keeps upward pressure on all of the major market fundamentals, including load growth, fuel costs, power prices, and capital costs. This growth is also in the absence of major technological breakthroughs. Existing generation resources are needed to maintain this economic expansion, limiting the number of coal retirements while accelerating the number of capacity additions, which favors natural gas in the near and mid-term, although renewables outpace natural gas over the long term. While this scenario shares many of the attributes of the previous "High Technology" scenario, the pace of technological innovation is not as dynamic and therefore not beneficial to keeping wholesale power and natural gas prices in check. Regulations are similar to those in the Base Case.

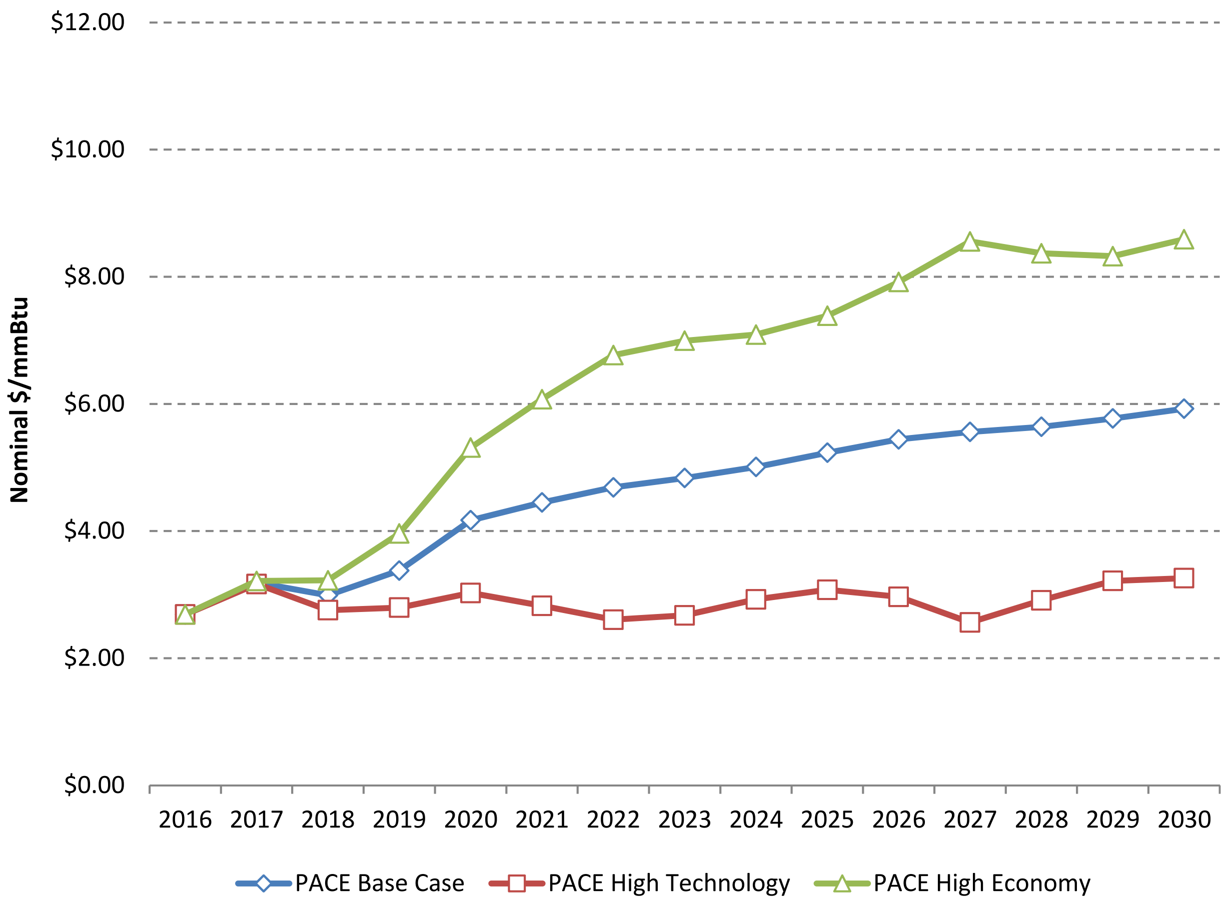
These scenario price forecast assumptions are provided in more detail below:

- Permian Basin Natural Gas Price Assumptions
- Palo Verde (7x24) Wholesale Market Price Assumptions

Forward Natural Gas Prices

Chart 8 shows the Permian Basin natural gas price assumptions for the PACE Global scenarios.

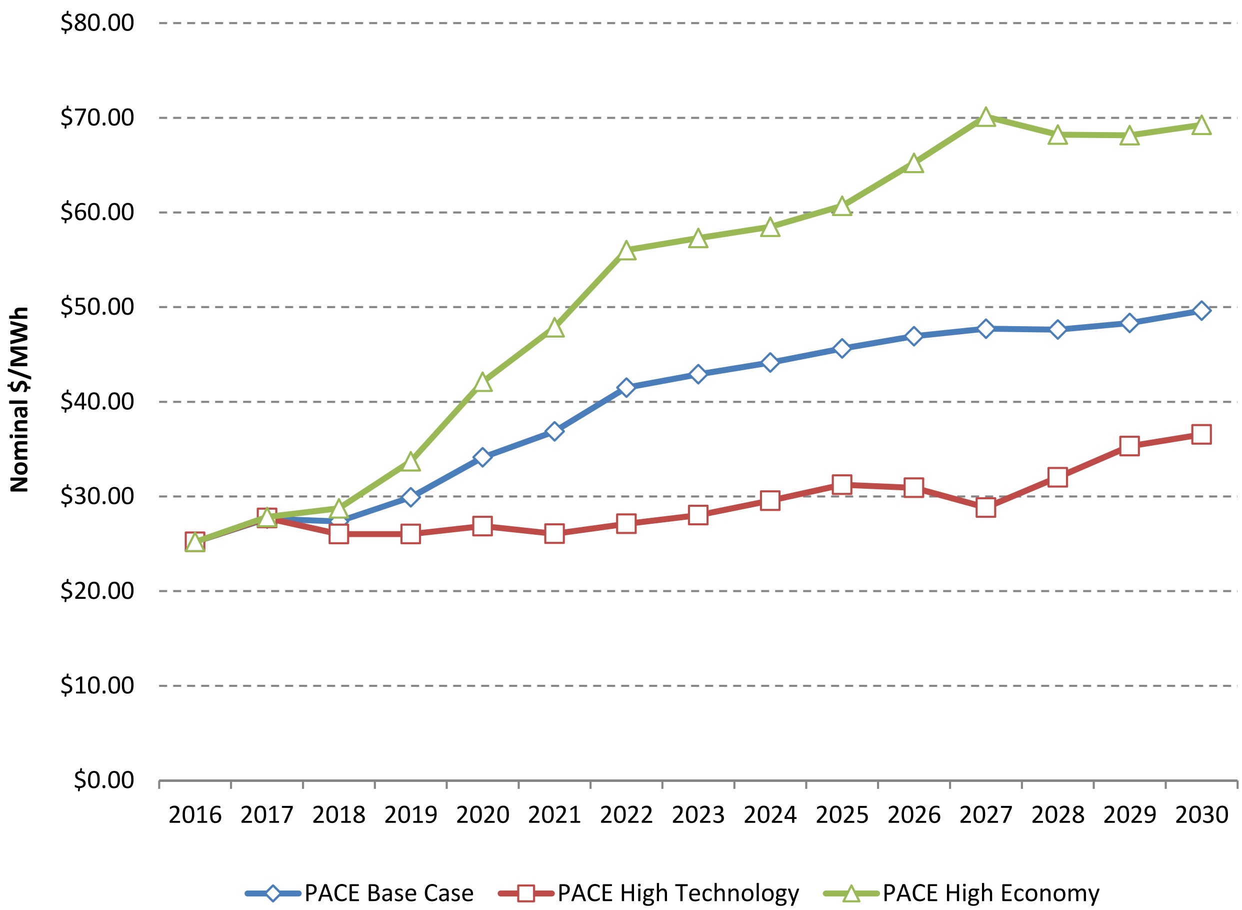
Chart 8 – Permian Basin Natural Gas Price Assumptions ($/mmBtu)



Forward Wholesale Power Prices

Chart 9 shows the Palo Verde (7x24) wholesale power price assumptions for the PACE Global scenarios.

Chart 9 – Palo Verde (7x24) Market Price Assumptions ($/MWh)



Portfolio Analysis

TEP's 2017 IRP identified the need for flexible thermal generation within the next five years in order to provide grid balancing for the planned expansion of renewable generation on the TEP system. The addition of local, thermal generation would also allow for the early retirement of the older and less-efficient Sundt steam generating Units 1 and 2. As stated previously, RICE and aeroderivative SCGT technologies were determined to be best suited to provide these grid balancing services. Portfolios incorporating these technologies will require large, near-term capital investments. Therefore, in addition to comparing the RICE and an aeroderivative SCGT portfolios to each other, a "delayed investment" portfolio is also presented in which Sundt Units 1 and 2 operate through their useful life, and are then retired and replaced with new thermal generation. The "delayed investment" portfolio's elimination of near-term, flexible, thermal generation would likely necessitate scaling back TEP's planned renewable energy expansion in order to maintain grid reliability. However; for purposes of this assessment, the amount of renewable energy is identical in all three portfolios, which allows us to isolate cost differences between the thermal generation technologies. Descriptions of the three portfolios are presented below.

RICE Portfolio

Under the RICE Portfolio, Sundt Units 1 and 2 retire at the end of 2018 and are replaced by ten (10) 19 MW RICE generators, half of which are operational by June 2019 and half by October 2019.

SCGT Portfolio

Under the SCGT Portfolio, Sundt Units 1 and 2 retire at the end of 2018 and are replaced by four (4) 45 MW SCGT generators (similar to GE LM6000), half of which are operational by June 2019 and half by October 2019.

Delayed Investment Portfolio

Under the Delayed Investment Portfolio, Sundt Unit 2 retires at the end of its depreciable life in 2028 and is replaced by five (5) 20 MW RICE generators. Then at the end of 2030, Sundt Unit 1 becomes fully depreciated and is replaced by a second set of five (5) 20 MW RICE generators.

Treatment of Reliability Minimum Must-Run Generation

As described above, the minimum must-run generation requirement at Sundt for the vast majority of the year is 25 MW or less. But during some hours, particularly in the summer and fall, the minimum generation requirements can be much higher. Thus, it has generally been assumed in TEP's production cost modeling that Sundt Steam Unit 4 is operated continuously throughout the year, at least at its minimum generation capacity, and that Sundt Steam Units 1 and 2 operate continuously for a few months of the year, at least at their minimum generation capacity. These assumptions are consistent with actual unit output during 2016. The result is that the Sundt steam units are modeled to produce a minimum amount of power that ranges from 56 to 88 MW over the course of each year until such time that the first RICEs or SCGTs become available, which is May 2019 in the RICE and SCGT Portfolio and January 2029 in the Delayed Investment Portfolio.

With the installation of resources at Sundt that can operate at low outputs and start and ramp quickly, it is possible to lower the total output of the plant to be closer to the minimum generation requirements while maintaining the ability to quickly meet those requirements should they change on short notice. In TEP's production cost modeling, this is simulated by designating two RICE units (or a single SCGT) to operate continuously throughout the year, at least at their minimum capacity, and another two RICE units (or another SCGT) to operate continuously for six months, at least at their minimum capacity. This approach to utilizing the new resources at Sundt would forego the need to operate the steam units for purposes of meeting minimum must-run generation requirements, except for Steam Unit 4, which might be needed during the mid-afternoon hours in the summer and fall, when minimum generation requirements exceed 100 megawatts and when the unit is also needed for capacity purposes anyway. Thus, TEP assumes in its modeling that Steam Unit 4 will run continuously, at least at its minimum capacity, for seven hours a day for six months a year. The result is that Sundt's plant-wide minimum output ranges from 10 to 76 MW over the course of the year if RICEs are assumed to be installed and 13 to 81 MW if SCGTs are assumed to be installed.

Chapter 4

STUDY RESULTS

Net Present Value Revenue Requirement

The results below are based on the Company's projection of total revenue requirements, as described in detail in Chapter 3. As shown in Chart 10, the net present value of the Company's revenue requirement over the 2017-2036 study period (NPVRR) is minimally affected by replacing Sundt Steam Units 1 and 2 with more modern, flexible generation technologies, particularly RICE technology. This is because the capital costs of the new technologies are largely offset by the fuel savings associated with their lower heat rates and more flexible operating capabilities, including lower minimum generation limits.

Chart 10 – NPVRR for Each Portfolio and Scenario ($000)

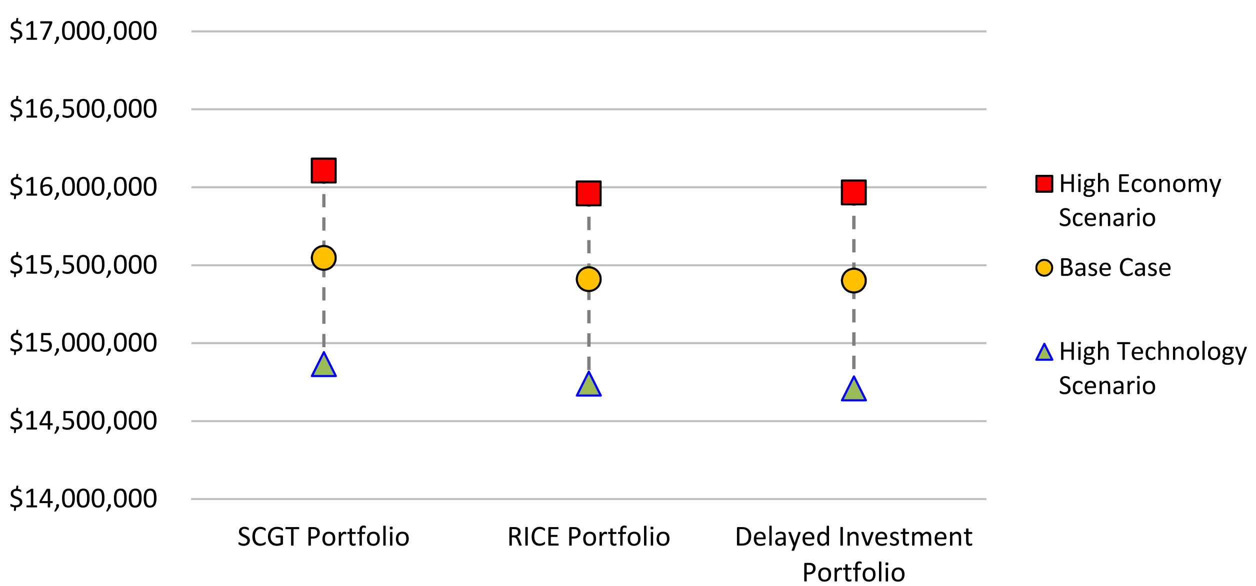


Chart 11 compares the costs of the SCGT and RICE Portfolios relative to the cost of the Delayed Investment Portfolio. In all three scenarios, the NPVRR associated with replacing Sundt Steam Units 1 and 2 is less for the RICE Portfolio than for the SCGT Portfolio. This is because RICEs have a lower capital cost at the capacities required for this project, as well as more operational flexibility and lower heat rates, particularly at higher ambient temperatures and under low-load conditions. Table 4 breaks down the NPVRR associated with the SCGT and RICE Portfolios by operating and fixed costs.

Chart 11 – NPVRR Relative to the Delayed Investment Portfolio ($000)

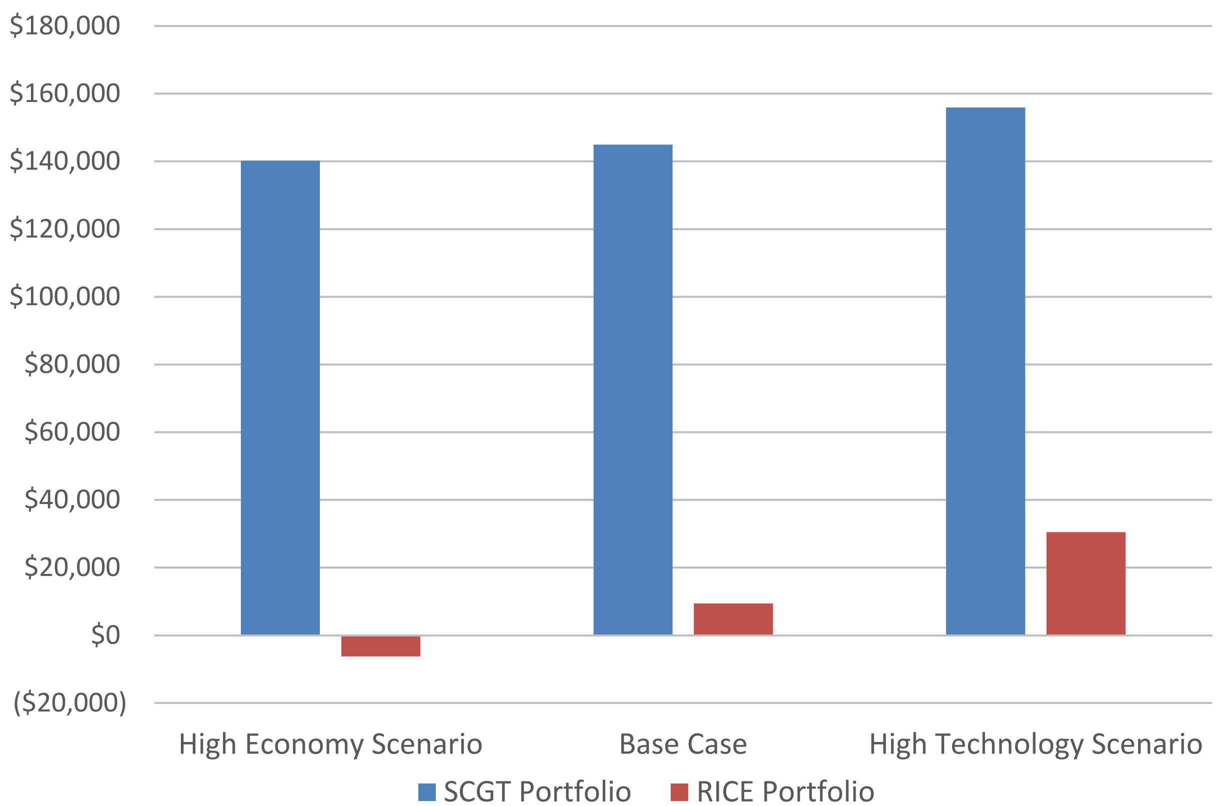


Table 4 – NPVRR Relative to the Delayed Investment Portfolio Operating and Capital ($000)

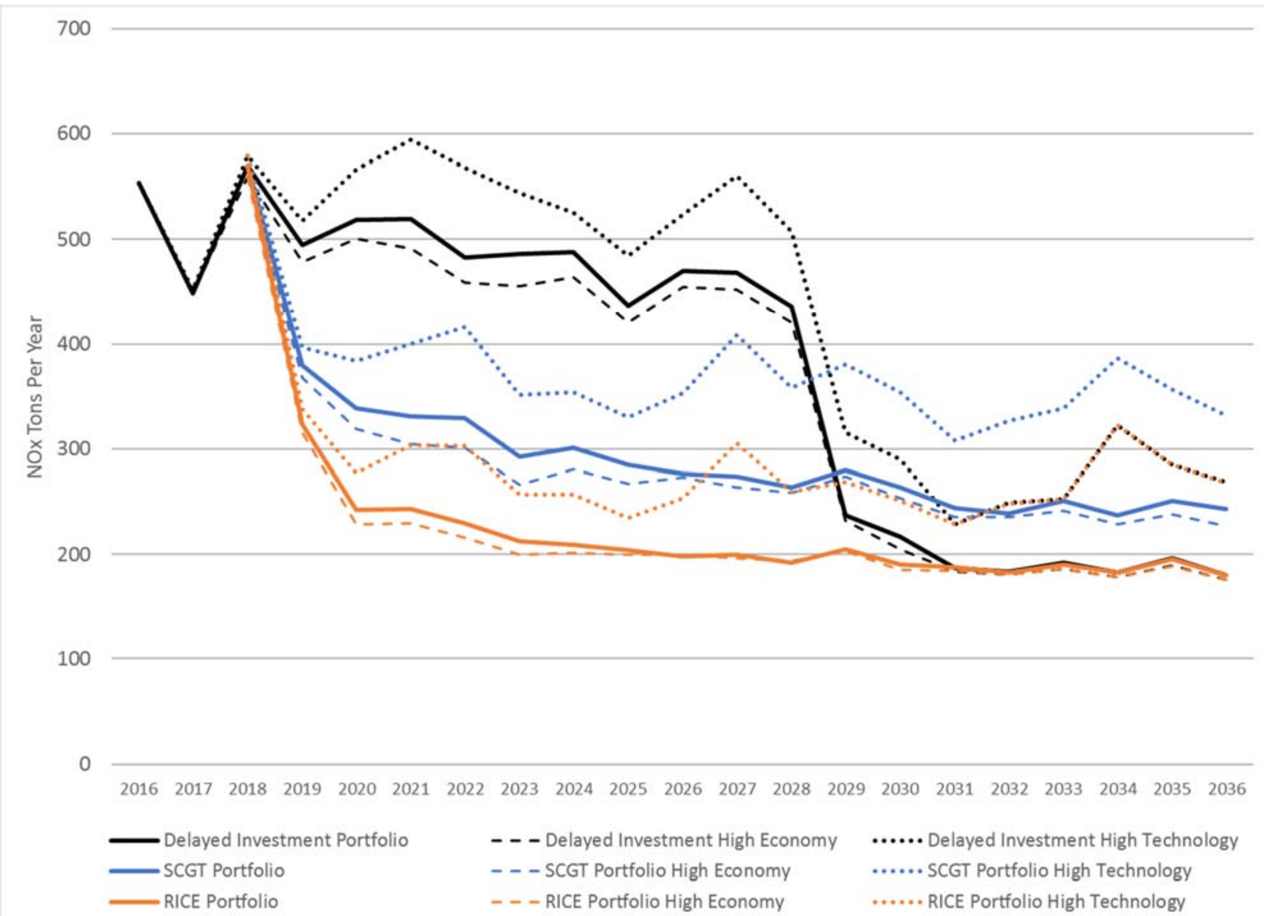
	High Econ Scenario	Base Case	High Tech Scenario
SCGT Portfolio			
Operating Costs	($2,580)	$2,169	$13,129
Fixed Costs	$142,761	$142,761	$118,060
Total	**$140,181**	**$144,930**	**$131,189**
RICE Portfolio			
Operating Costs	($59,420)	($43,776)	($22,704)
Fixed Costs	$53,153	$53,153	$53,153
Total	**($6,267)**	**$9,377**	**$30,449**

Environmental Analysis

Emissions

In addition to being the least-cost portfolio and possessing superior ramping and reliability attributes, the RICE Portfolio results in the greatest amount of NOx emission reductions. As shown in Chart 12, replacing Sundt Steam Units 1 and 2 with RICEs (equipped with modern, selective catalytic reduction technology) would reduce Tucson-area emissions by approximately 60%, or 300 tons per year. The emission reductions are large not only because the RICEs replace Steam Units 1 and 2, but because they can operate in lieu of Units 3 and 4 for much of the year, which have higher minimum operating limits and higher emission rates. Emissions are summed for all Tucson-area generators to account for any shifting of generation among local units, and also because ambient air concentrations of ozone, for which NOx is a precursor, and other air pollutants are affected by emissions throughout the Tucson area. On a TEP system-wide basis, the RICE Portfolio reduces NOx emissions by 3.2% and carbon dioxide emissions by 0.5%.

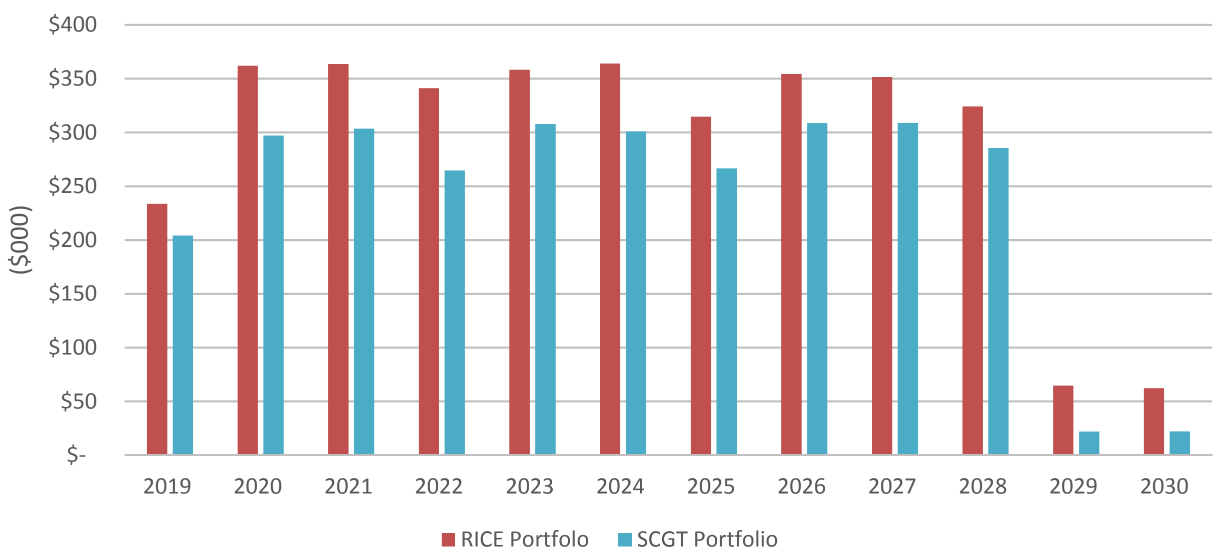
Chart 12 – Tucson-Area NOx Emissions under Each Portfolio and Scenario
(Sum of all units at Sundt, DeMoss Petrie, and North Loop)



Wastewater Generation

The RICE Portfolio also results in the greatest reduction in water consumption and the corresponding costs associated with discharging cooling tower blowdown to the sanitary sewer. RICEs use closed-loop radiators for engine cooling, which have very low make-up water requirements. Therefore, similar to the emissions analysis, as the RICE generators displace energy that would have been provided by the Sundt steam generating units, water consumption and the corresponding discharges are reduced. Chart 13 shows the annual savings in sewer discharge fees for the RICE and SCGT Portfolios relative to the Delayed Investment Portfolio. Over the period of 2019 through 2030, the RICE Portfolio results in total savings of approximately $3.6 million, while the SCGT Portfolio results in savings of approximately $3.0 million.

Chart 13 - Sewer Discharge Fee Savings Relative to the Delayed Investment Portfolio



Renewable Integration

To illustrate how RICEs would be used to integrate renewable energy into TEP's system, hourly AURORAxmp results were extracted for July and December 2024, a year in which renewable energy production is expected to be twice the level of 2017, but only two-thirds towards TEP's goal of 30 percent renewables. As seen in Chart 14, in the summer, RICEs are expected to complement renewable energy intermittency by ramping up generation as TEP's predominantly solar-based renewable energy portfolio produces less energy. This generation is sustained for an additional three hours after the beginning of sunset to help meet TEP's peak load, which is progressively unmet by the declining renewable energy production.

Chart 15 shows how RICEs are expected to complement renewable energy in the winter. In this case, RICEs tend to operate at the start and end of the daily renewable energy generation cycle. This enables TEP to smoothly integrate the renewable energy into its balancing area. Note, in both summer and winter RICE generation is reduced to near-zero output when not needed for renewable integration. As discussed above, this helps reduce emissions and water use in the Tucson area while maintaining system reliability.

Finally, AURORAxmp was run in a 1-minute dispatch mode for July 2024 to better understand how RICEs could be dispatched on a sub-hourly basis, particularly since large changes in renewable energy generation can occur in as little as 10 minutes. For this analysis, the 1-minute renewable energy generation data shown above in Chart 4 was used as input to AURORAxmp, as opposed to an hourly generation profile. In addition, the ramp rates for RICEs and other units were adjusted to reflect their sub-hourly ramp-up and ramp-down capabilities. As shown in Chart 16, RICEs are dispatched on a minute-by-minute basis as the primary means for balancing electricity supply and demand when renewable energy supply is significantly variable. No other resources in TEP's portfolio are capable of cost-effectively balancing renewable energy generation in this way.

Chart 14 - Average Renewable Energy and RICE Generation (July 2024)

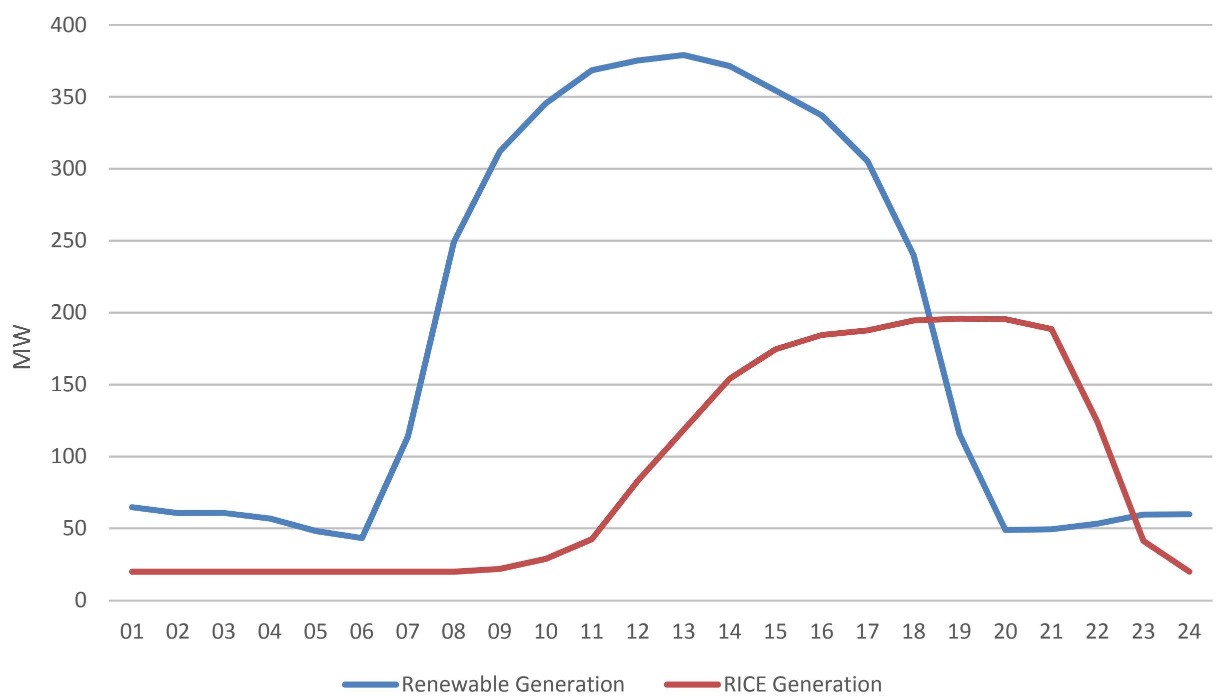


Chart 15 - Average Renewable Energy and RICE Generation (December 2024)

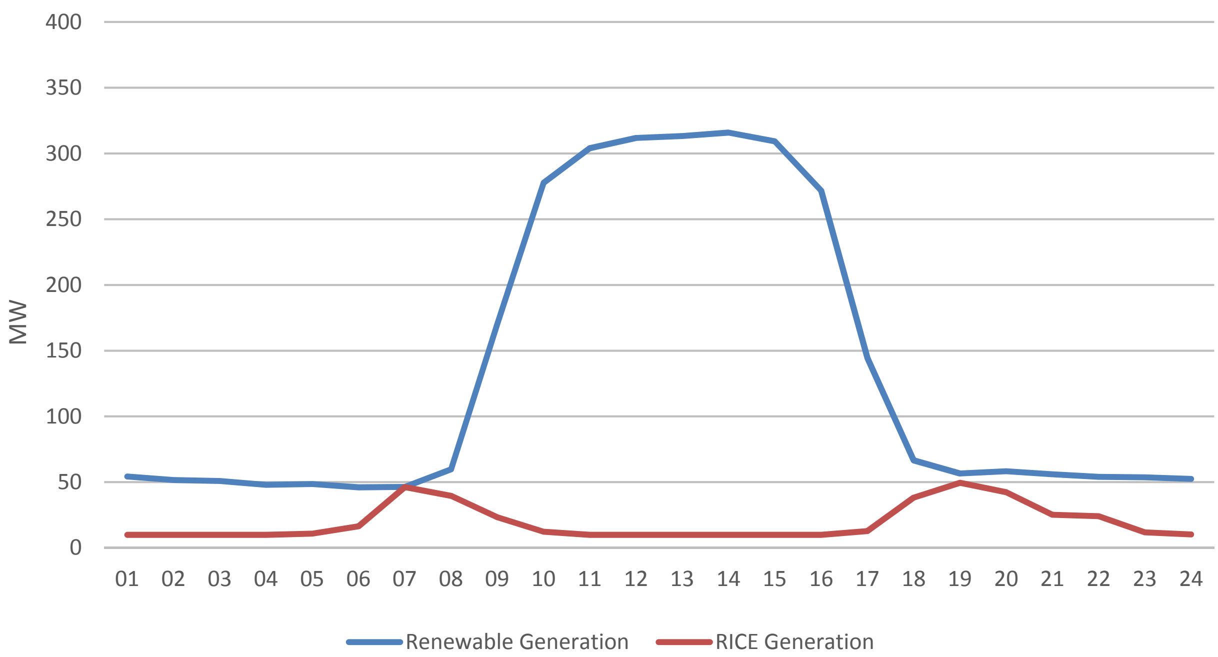
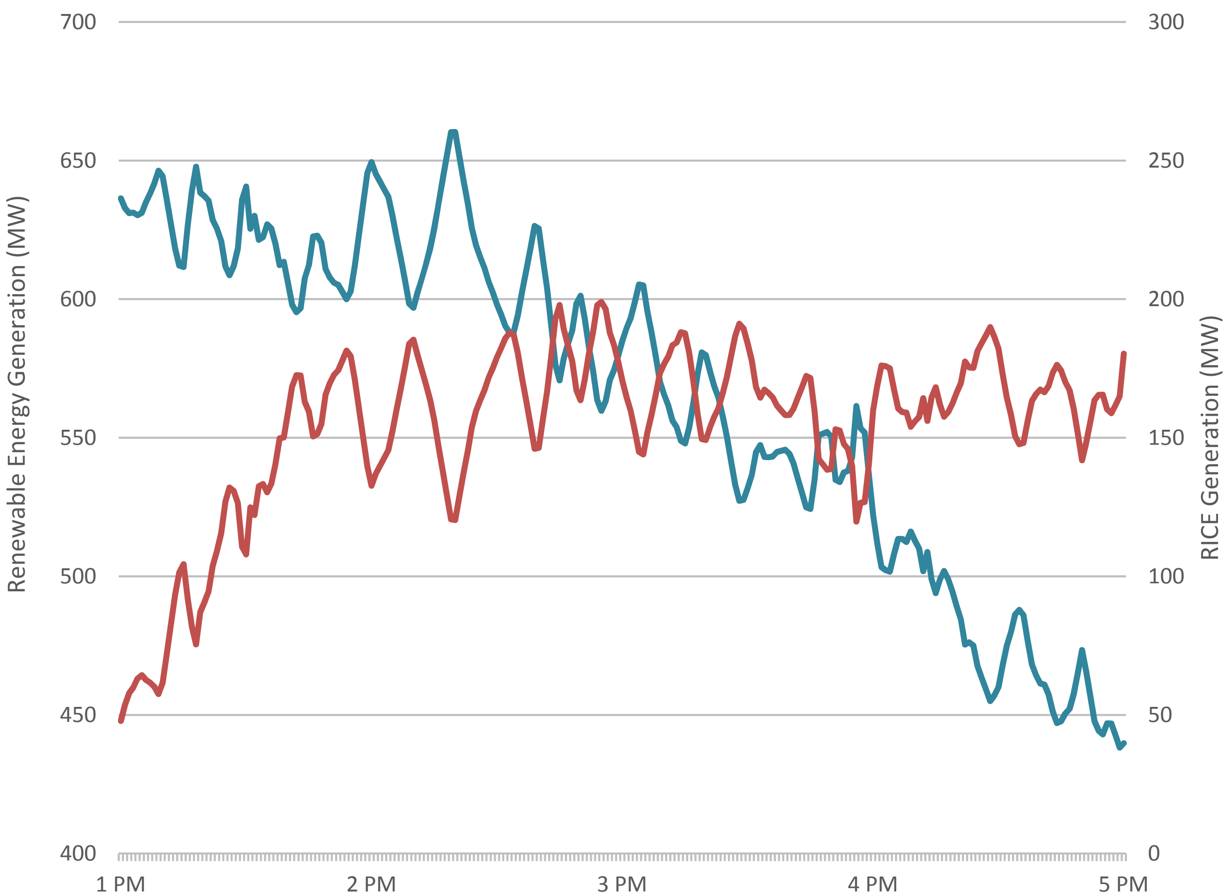


Chart 16 - Renewable Energy and RICE Generation on a Typical Day in July 2024



Chapter 5

CONCLUSIONS

As demonstrated in Chapter 2, TEP must meet challenging new ramping requirements associated with increasing amounts of renewable generation on its system. The results of this study show that incorporating RICE technology into TEP's generation portfolio represents the most cost effective approach to meeting this increased ramping need. The installation of 200 MW of RICE generators at Sundt results in TEP's customers realizing a NPV savings of approximately $135 million relative to a portfolio incorporating the same capacity of SCGT technology.

The replacement of the older steam generating units with modern, efficient RICE technology also results in meaningful reductions in local air emissions and water consumption. Incorporating RICE technology results in reductions in local area NO_X emissions of approximately 60%. These reductions are meaningful given that NOx is a precursor for ground-level ozone and the Tucson area is very close to non-attainment status for the ozone ambient air quality standard. In addition, the incorporation of RICE technology shows reductions in wastewater generation, with sewer fee savings of approximately $3.6 million.

Finally, as part of TEP's portfolio diversification strategy, replacing Sundt Steam Units 1 and 2, which were commissioned in 1958 and 1960, with modern, flexible, natural gas-fired generation will significantly enhance TEP's ramping capabilities, thus supporting the Company's goal of serving 30% of retail load with renewable energy by 2030. Taking advantage of low-cost, utility-scale renewable energy is a key component of TEP's effort to rebalance its resource portfolio over the long-term. This resource diversification will help contribute to minimizing long-term CO_2 risks while locking in low-cost sustainable sources of energy for decades to come.