


TUCSON ELECTRIC POWER COMPANY

2019 Preliminary Integrated Resource Plan

• JULY 1, 2019 •




Forward

This Preliminary Integrated Resource Plan outlines Tucson Electric Power's development of an energy portfolio that supports our reliable, affordable and increasingly sustainable service. I am proud to report that we are on track to achieve the renewable energy goals outlined in our previous IRP well ahead of schedule. So, as we develop our 2020 Integrated Resource Plan, we are working to set new, more ambitious goals, with expanded input from the community we serve.

In 2015, TEP set a goal to generate 30% of its power from renewable resources by 2030 – two times the state-mandated level of 15% by 2025. Thanks to several significant new projects, we will be approaching that goal nine years ahead of schedule. In 2021, production from our renewable energy resources will exceed 28% of TEP's retail sales, thanks in large part to three new projects that will come online in 2020:

- The 247-megawatt (MW) Oso Grande Wind Project in southeastern New Mexico, developed by EDF Renewables North America and owned by TEP.
- The 99-MW Borderlands Wind Project in western New Mexico, which will supply TEP energy through a power purchase agreement (PPA) with Borderlands Wind LLC, a subsidiary of NextEra Energy.
- The Wilmot Energy Center in southeast Tucson, including a 100-MW solar array and a 30-MW battery storage system, will supply TEP energy and storage capacity through a PPA with NextEra Energy.

While TEP will continue expanding our renewable energy resources, we are no longer satisfied to gauge our progress toward greater sustainability by counting kilowatts. Our commitment to serve the best interests of our current and future customers and stakeholders compels us to develop a revised goal focused on reducing carbon dioxide emissions. This new, more comprehensive goal, will be based on greenhouse gas reductions that reflect our proportional contribution toward limiting global temperatures to levels outlined in the 2015 Paris Agreement on climate change. To that end, we have enlisted the University of Arizona's Institute for the Environment to help us develop science-based targets that allow us to measure our steps toward a global solution.

Achieving these goals will require support and cooperation from our community. That is why we are expanding our stakeholder outreach through the creation of a new IRP Advisory Council. This group includes representatives of key stakeholder groups, including residential and business customers, local governments, public schools, low-income advocates, solar installers and environmental advocates. The council will meet monthly for workshops and in-depth discussions of key resource planning considerations. Combined with the feedback we receive through public workshops, the council's contributions will help TEP develop a long-term plan that satisfies our emission-reduction objectives while maintaining affordability and the balance and flexibility needed in our electric system.

Our IRP will address issues covered in several Arizona Corporation Commission dockets, including compliance with Arizona's renewable energy and energy efficiency standards and policies for emerging energy technologies. Going forward, we believe it would be most efficient and effective to incorporate consideration of these issues in a single, more comprehensive IRP docket so that utilities can review all potential resources in the proper context of their specific system. Additionally, this will allow utilities the flexibility to achieve greenhouse gas emission reductions and other objectives through the resource mix that best satisfies their unique, long-term energy needs.

Thank you for your interest in TEP's resource planning process. We look forward to working with our customers, our community and the Commission toward an updated plan that allows us to continue to provide our customers with reliable, affordable and sustainable energy service.

David G. Hutchens
President and CEO

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List of Acronyms

ACRONYMS

ACC – Arizona Corporation Commission
ADMS – Advanced Distribution Management System
BESS – Battery Energy Storage System
BTA – Biennial Transmission Assessment
CAISO - California Independent System Operator
CO_2 – Carbon Dioxide
CT – Combined Turbine
DG - Distributed Generation
DR – Demand Response
DSM – Demand Side Management
E3 – Energy and Environmental Economics
EE – Energy Efficiency
EHV – Extra High Voltage
EIA - Energy Information Administration
EIM – Energy Imbalance Market
EPRI – Electric Power Research Institute
ESTF – Energy Storage Task Force
EV – Electric Vehicles
FERC – Federal Energy Regulatory Commission
GHG – Greenhouse Gas
GW – Gigawatt
GWh – Gigawatt-Hour
Hg – Mercury
HV – High Voltage
IGCC – Integrated Gasification Combined Cycle
IRP – Integrated Resource Plan
ITC – Investment Tax Credit
kW – Kilowatt
kWh – Kilowatt-Hour
kW-yr – Kilowatt-Year
LACE – Levelized Avoided Cost of Energy
LCOE – Levelized Cost of Electricity
LTO – Long-Term Outlook
LSE – Load Serving Entity
MMBtu – Million British Thermal Units, also shown as MBtu
MW – Megawatt
MWh – Megawatt-Hour
NEC – Navopache Electric Cooperative

NERC - North American Electric Reliability Corporation
NGCC – Natural Gas Combined Cycle
NO_X – Nitrogen Oxide(s)
NPV – Net Present Value
NPVRR – Net Present Value Revenue Requirement
NREL – National Renewable Energy Laboratory
NTEC – Navajo Transitional Energy Company
NTUA – Navajo Tribal Utility Authority
O&M – Operations and Maintenance
PCM – Production Cost Model
PM - Particulate matter
PNM – Public Service Company of New Mexico
PPA - Purchased Power Agreement
PIRP – Preliminary Integrated Resource Plan
PTC – Production Tax Credit
R&D – Research and Development
REST – Renewable Energy Standard and Tariff
RICE – Reciprocating Internal Combustion Engine
RFP – Request for Proposal
RUCO - Residential Utility Consumer Office
SAT – Single-Axis Tracking
SCT – Societal Cost Test
SEPA – Smart Electric Power Alliance
SMR – Small Modular (Nuclear) Reactor
SRP – Salt River Project Agricultural and Improvement District
SO_2 – Sulfur Dioxide
SWEEP – Southwest Energy Efficiency Project
TEP – Tucson Electric Power Company
TOUA - Tohono O'odham Utility Authority
TRICO – Trico Electric Cooperative
UES – UniSource Energy Services
WECC - Western Electricity Coordinating Council

Chapter 1

OVERVIEW

Introduction

Tucson Electric Power Company's ("TEP" or "Company") 2019 Preliminary Integrated Resource Plan (PIRP) introduces and discusses the issues that TEP plans to analyze in detail as it develops the Final 2020 Integrated Resource Plan (IRP) due to be filed with the Arizona Corporation Commission (ACC or "Commission") on April 1, 2020. The purpose of this PIRP is to increase transparency into, and improve understanding of the IRP, and to provide the Commission, customers and other stakeholders with the background needed to offer meaningful feedback on the Company's future resource plans. TEP will consider stakeholder feedback it receives in developing the Final 2020 IRP.

In addition to providing a snapshot of TEP's current loads and resources, this PIRP provides an overview of the tools, methods, sources and assumptions TEP will use in developing the Final 2020 IRP. This PIRP also provides an update on near-term initiatives identified in the TEP 2017 IRP's Five-Year Action Plan[1] and the TEP 2018 Action Plan Update[2].

TEP is introducing several new initiatives during this IRP cycle that we believe will improve the relevance and usefulness of the IRP to the Commission, stakeholders and to our customers. First, we have formed an IRP Advisory Council to improve stakeholder engagement through in-depth discussions with a diverse group of customers, community leaders and advocacy groups. In addition, we have enlisted the University of Arizona to assist the Company in establishing science-based targets for reducing greenhouse gas ("GHG") emissions. Finally, we are introducing a new and more rigorous method for evaluating resource adequacy that goes beyond capacity planning for summer peak to include issues around over-generation, system regulation, and ramping needs.

Modernization of Arizona's Energy Rules

Arizona utility IRPs are developed in accordance with rules established by the Commission[3] and are heavily influenced by other Commission rules relating to the procurement of renewable energy, the implementation of energy efficiency and demand side management programs, and other initiatives. In August 2018, the Commission opened a rulemaking docket[4] to explore modifications to the Commission's energy rules ("Arizona Energy Rules").

[1] TEP 2017 Integrated Resource Plan, April 3, 2017, p 289; https://www.tep.com/wp-content/uploads/2017/04/TEP-2017-Integrated-Resource.pdf
[2] TEP 2018 Action Plan Update, April 30, 2018, https://www.tep.com/wp-content/uploads/2018/06/TEP-Action-Plan.pdf
[3] Arizona Administrative Code R14-2-701 et. Seq *Resource Planning and Procurement*
[4] In the matter of possible modification to the Arizona Corporation Commission's Energy Rules, August 17, 2018, RU-00000A-18-0284

TEP supports a re-examination of the Renewable Energy Standard and Tariff (REST) rules and we agree with the premise behind the Arizona Energy Rules docket[5] that any such re-examination should be comprehensive, including all energy policies before the Commission, both existing and proposed. It would be counterproductive to continue assessing related energy initiatives such as energy efficiency, baseload security, forest biomass energy, and electric vehicles in separate dockets and proceedings. These policy choices should be better aligned.

TEP is committed to the cost-effective deployment of clean resources and we have a history of appropriate early adoption of such technologies.

- In 1998, TEP began burning landfill gas in Unit 4 at the H. Wilson Sundt Generating Station ("Sundt").
- In 2003, TEP's solar facility at the Springerville Generating Station ("Springerville") was one of the largest photovoltaic ("PV") solar arrays in the world and demonstrated to produce energy at a levelized cost under $0.10/kWh[6].
- TEP ranked #2 in the nation for per-capita installed storage capacity in a 2017 ranking by the Smart Electric Power Alliance (SEPA)[7].
- In 2015, TEP voluntarily adopted a goal to generate 30% of its retail energy use from renewable resources by 2030, doubling the current mandate of 15% by 2025.

With the addition of three (3) new projects currently under contract, we will be approaching that 2030 goal nine (9) years ahead of schedule. In 2021, production from renewable energy resources is expected to exceed 28% of TEP's retail sales. In addition, TEP was early to recognize the need to reduce its reliance on baseload coal resources.

- In 2015, the Company ended the use of coal as a fuel at Sundt Unit 4 (130 MW).
- In 2017, TEP retired Unit 2 at the San Juan Generating Station ("San Juan") (170 MW).
- In the TEP 2017 IRP, the Company committed to further reduce its reliance on baseload coal through planned retirements at Navajo Generating Station ("Navajo") by the end of 2019 (168 MW) and Unit 1 at San Juan by the end of June 2022 (170 MW).

These retirements represent a 41% decrease (638 MW) in TEP's coal capacity since 2014.

Arizona needs a coordinated, integrated energy policy that incorporates resiliency, affordability, reliability, sustainability, innovation, economic development and resource diversity. Then each utility will develop its unique contribution to Arizona's overall policy objectives. The policy itself should not pick winners and losers, rather, utilities need the flexibility to select the resources that fit best within their existing portfolio. Achieving an appropriate balance between these objectives is a challenge and it only becomes more difficult when utilities lose flexibility through narrowly crafted mandates. If given a clear vision of Arizona's desired energy future, utilities, through their IRPs, can formulate a balanced path toward that future.

[5] Memorandum to Docket Control from Elijah O. Abinah, Director, Utilities Division; RE: Request for New Docket, dated August 17, 2018 *lists specific subjects to be considered in the rulemaking*
[6] http://www.physics.arizona.edu/~cronin/Solar/References/Shade%20effects/TEPSolar_Springerville.pdf
[7] https://sepapower.org/2018-top-10-winners/ TEP was ranked second in the nation for per-capita additions to its energy storage resources in 2017 with approximately 50 watts per customer. SEPA also ranked TEP third in the nation for adding 21 megawatts (MW) of battery storage systems to its local electric grid. https://www.tep.com/news/tep-ranks-among-nations-top-utilities-for-expanding-energy-storage

Planning Objectives

For a long-term plan to be credible to customers and regulators, and useful to the utility as a guide for decision-making, it needs to be focused on meaningful planning objectives. However, planning objectives are often times competing, therefore, the final plan needs to strike a balance between these objectives which involves trade-offs as one optimizes a final plan that represents the best overall outcome. For the Final 2020 IRP, TEP proposes to develop its plan based on the following key planning objectives.

- **Affordability for our customers must be our primary planning objective** – This objective will be measured based on the change in total net present value (NPV) revenue requirement and an estimate of the corresponding aggregated rate impact.
- **Reliability of Service** – All portfolios presented in the Final 2020 IRP will be capable of meeting anticipated customer demand in every hour during the planning horizon without load curtailment through a stochastic assessment of peak load, minimum load, 3-hour ramping, and 10-minute regulation.
- **Risk** – Portfolios will be evaluated against a wide range of future conditions to assess the impact on cost associated with unforeseen circumstances.
- **GHG Emission Reductions** – Rather than a renewable energy target, this objective, more directly focused on the sustainability challenge of climate change, will be measured by total system GHG emission reductions.

Stakeholder Involvement

We recognize the need for greater stakeholder involvement in the IRP process and the evolving energy needs of our customers. The roles that certain resources play within a utility's portfolio are changing.[8] Certain resources can serve multiple roles, and the overall model that utilities have traditionally relied on (central power stations serving load through transmission to a distribution grid) is no longer the only model available to serve customers' energy needs.

Therefore, as part of the 2020 IRP process, TEP has expanded its outreach efforts and formed an Advisory Council (AC) to allow for more in-depth discussions with stakeholders. TEP is holding monthly meetings of the AC from May 2019 through December 2019. Each meeting will focus on a specific issue(s) relating to the IRP, allowing the members of the AC and TEP to engage in detailed discussions. For some of the topics, TEP or other stakeholders will provide background information or analysis prior to the meeting so that all participants arrive at the meeting prepared to discuss the topic at hand. TEP will summarize the discussions in written minutes, and AC members will be encouraged to participate in public workshops to be held by TEP and the ACC. TEP will document these key outcomes from the AC and how those outcomes will be brought forward to be considered in the Final 2020 IRP.

[8] TEP 2017 IRP, p83. *A New Integration Approach to Resource Planning*

Membership on the AC is by invitation with the intent to represent the local perspective of a broad spectrum of points of view while keeping the size of the group to a manageable level. The AC includes individuals representing the following groups:

- **Customers**
  - Large customers
  - Small to medium sized customers
  - Residential customers (Residential Utility Consumer Office [RUCO])
  - Low income community
  - Seniors
- **Government**
  - Municipal
  - Pima County
  - State of Arizona
  - Federal Government
  - School District
- **Stakeholders and Special Interests**
  - Environmental Advocates
  - Energy Efficiency
  - Renewable Energy
  - Economic Development

In addition to the AC process, TEP will lead and/or participate in public workshops and Commission proceedings to present our plans for the IRP and to solicit feedback from interested community members. A list of public workshops and Commission proceedings required by Decision No. 76632[9], along with the overall schedule for the 2020 IRP cycle, is presented in Table 1.

[9] Dates reflected as modified by Decision No. 77176 (May 15, 2019).

Table 1 - 2020 IRP Public Workshops and Commission Proceedings

Topic	Responsibility	Timing
LSEs file PIRPs	LSEs	August 1, 2019
Portfolio Selection Workshop	TEP / ACC Staff	Within 60 days after filing the PIRP
PIRP Review	ACC Staff and Stakeholders	August 1, 2019 – September 1, 2019
Energy Efficiency post 2020 Workshop	ACC Staff	Not specified
PIRP Workshop	LSEs / ACC Staff	September 2019
ACC Open Meeting – Review PIRP	ACC	September 1, 2019 – November 15, 2019
Pre-filing Workshop – Final IRP	LSEs / ACC Staff	December 1, 2019 – January 15, 2020
Final IRPs Filed	LSEs	April 1, 2020
Comments due on Final IRPs	Stakeholders	July 1, 2020
LSE response to Stakeholder comments due	LSEs	August 15, 2020
ACC Staff Assessment and Proposed Order due	ACC Staff	November 2, 2020
ACC Open Meeting and Final Order	ACC	February 15, 2021

Chapter 2

ACTION PLAN UPDATE

TEP continually evaluates adjustments to the projects addressed in its Five-Year Action Plan (as updated in the TEP 2018 Action Plan Update) to respond to changing conditions and new opportunities. This section provides an update on specific projects and documents any changes to their implementation.

Resource Diversification Update

TEP's 2018 Action Plan Update described the Company's commitments to reduce its reliance on baseload generation resources. By 2022, TEP's portfolio diversification strategy will have reduced TEP's coal capacity by 638 MW since 2014. Below are updates on the Navajo and San Juan retirement plans.

Navajo Generating Station

In 2017, the owners of Navajo came to an agreement with the Navajo Nation to extend the land lease through December 2019. In addition, the plant operator, the Salt River Project Agricultural and Improvement District ("SRP") worked with a number of third-parties to find another entity to operate the plant after 2019, when the current owners cease operation of the plant. Those efforts have not identified any new entities willing to continue operation, therefore, the owners of Navajo intend to cease operations at the plant during the fourth quarter of 2019 and immediately commence decommissioning activities.

San Juan Generating Station

In TEP's 2017 IRP, the Company stated its intention to exit from its participation in San Juan when the current coal supply agreement ends in June 2022.[10] Subsequently, Public Service Company of New Mexico ("PNM") filed an IRP on July 3, 2017, which showed that its most cost effective portfolio would include the retirements of Units 1 and 4 at San Juan in 2022. Based on these results, TEP and PNM have committed to retiring San Juan Unit 1 by June 30, 2022.

Gila River Power Station

TEP's 2018 Action Plan Update described how the Company plans to rebalance its resource portfolio with a portion of firm capacity sourced from faster ramping, more efficient natural gas resources. In anticipation of the coal unit retirements mentioned above, the Company entered into an agreement with SRP to acquire rights to 550 MW of capacity at the Gila River Power Station ("Gila River"). Gila River Unit 2 provides the Company with the opportunity to acquire a low cost flexible natural gas resource to help support future renewables while achieving significant reductions in emissions and water consumption in the near-term. In today's low-priced natural gas commodity market, Gila River Unit 2 is one of the lowest cost resources in the TEP portfolio.[11]

Reciprocating Internal Combustion Engine (RICE) Project

TEP's 2018 Action Plan Update described changes to the Company's plans for procuring flexible resources to accommodate the increasing penetration of intermittent renewable resources on its system. TEP's project

[10] TEP 2017 IRP at p. 259
[11] Based on 2019 forward market and natural gas prices, the full cost of operations at Gila River Unit 2 is projected to be less than 2.1¢/kWh.

involving the installation of ten (10) RICE generators at Sundt received its final Air Quality Permit from the Pima County Department of Environmental Quality on December 3, 2018. Construction of the facility commenced immediately upon receipt of the permit. TEP anticipates commercial operation of the RICE generators during the first quarter of 2020.

The RICE generators will have a combined nominal generating capacity of 182 MW and will replace two 1950s-vintage natural gas-fired steam boilers that will be retired prior to commercial operation of the RICE units. The steam boilers have a combined nominal capacity of 162 MW. The project is anticipated to result in a 60% reduction in local area nitrogen oxides ("NOx") emissions as well as a 70% reduction in local groundwater use.

Renewable Resources

As part of the 2018 IRP Action Plan Update, the Company made commitments to accelerate its plans to increase the build out of its utility-scale projects by conducting three separate requests for proposals (RFP) in order to secure additional low-cost solar and wind resources prior to the reduction of federal tax incentives. As a result of these RFP initiatives, TEP is on track to install an additional 446 MW of new wind and solar projects by the end of 2020. These commitments will increase the Company's renewable solar and wind capacity to approximately 723 MW and, along with customer sited generation, will enable TEP to serve approximately 28% of the Company's retail load with renewable energy starting in 2021. These projects are summarized in more detail below.

Solar Resource Projects

In September 2017, TEP entered into a 20-year Purchased Power Agreement (PPA) with Wilmot Energy Center, LLC, a subsidiary of NextEra Energy Resources, for 100 MW of PV single-axis tracking (SAT) solar energy and a 30 MW/120 MWh battery energy storage system (BESS). To accommodate the interconnection of the project to our system, TEP is developing the Sonoran Substation located south and east of the intersection of East Old Vail Connection and South Swan roads. The BESS will be charged directly from the adjacent solar system for at least 75% of its total annual energy for the first five years of operation. The solar system and BESS are anticipated to achieve commercial operation by December 2020.

Wind Resource Projects

In January 2017, TEP entered into a 20-year PPA with Borderlands Wind, LLC, a subsidiary of NextEra Energy Resources, for 99 MW of wind energy. The Borderlands Wind project will consist of 36 turbines located in Catron County, New Mexico and will connect to TEP's 345kV transmission system near Springerville. The system is anticipated to achieve commercial operation by December 2020.

The TEP 2018 Action Plan Update provided a status summary of TEP's effort to obtain high-quality, low-cost wind power. In its January 2018 RFP, TEP requested high capacity factor wind power (40 % or greater) that would complement its current renewable energy resources in terms of seasonal and diurnal energy generation.

In March 2018, TEP received several proposals for both PPAs and build-transfer-agreements (BTAs). After reviewing the proposals and meeting with several of the project developers, TEP entered into negotiations with respondent EDF Renewables North America ("EDF") on a BTA project in eastern New Mexico referred to as "Oso Grande". Oso Grande will provide up to 247 MW of capacity and is projected to achieve an average annual capacity factor of 45%. TEP entered into a contract with EDF in March 2019 and the project is scheduled to be in service by the end of 2020, which will enable TEP to secure the maximum value for federal production tax credits and result in a corresponding reduction in customer rate impacts.

Energy Storage Projects

In order to support the use of more renewables, the Company has made investments in grid balancing resources such as Lithium-ion ("Li-ion") BESSs. In 2017, the Company added three Li-ion BESSs totaling 21 MW to its resource portfolio. As mentioned above the additional 30 MW BESS at the Wilmot Energy Center project will increase the Company's total storage capacity to approximately 51 MW by the end of 2020.

Resources Adequacy Study

In past IRPs, TEP demonstrated resource adequacy by identifying resource portfolios that provide at least a 15% peak load planning reserve margin in each year. In its 2017 IRP, TEP also included an assessment of the operating flexibility of its resources by comparing the total 10-minute ramping capacity of its energy resources to the 10-minute ramping needs resulting from contingency requirements and expected changes in net load[12].

Given the increasing amount of renewable energy being planned, TEP hired Siemens Industry, Inc. ("Siemens") to help the Company enhance its methodology for assessing resource adequacy in terms of both capacity and flexibility for its Final 2020 IRP. The expected outcome of this work is to develop a resource adequacy methodology that determines at which point TEP's planned capacity and flexibility resources may be inadequate to serve retail load with high saturation levels of renewable resources. This will be done by examining various combinations of solar and wind power expansion scenarios, resulting in renewable energy penetration of up to 50% of retail sales. Siemens will use TEP's historic load and renewable energy variability to determine stochastically the amount of capacity and flexibility needed under such scenarios.

For each scenario, Siemens will identify the(i) peak net load, (ii) minimum net load, (iii) maximum 3-hour net load ramps (e.g., during sunrise and sunset), and (iv) maximum 10-minute net load ramps (e.g., during periods of rapid wind change and/or cloud cover). For each of these four criteria, the resource adequacy requirements will be compared to the resource capabilities of TEP's portfolio under six distinct scenarios during the year 2024. Any shortfalls in resources will be assumed to be provided through additional energy storage. The scenarios will then be evaluated using TEP's production cost model, at 10-minute intervals to verify that TEP's portfolio, plus any additional energy storage, will be sufficient to meet the four reliability criteria identified above.

Natural Gas Storage

TEP continues to evaluate and support the development of large scale, underground natural gas storage in Arizona. Natural gas storage within the state would improve the reliability of natural gas fired generation in responding to rapidly changing loads as a result of the intermittency caused by renewable resources. Moreover, due to the distance between Arizona's largest load pockets (Phoenix and Tucson) and the San Juan and Permian natural gas production basins, a state sourced natural gas storage facility would boost system resiliency. The boost is achieved by supplying natural gas during periods of shortfalls such as when the natural gas mainlines experience operational issues, and storing excess natural gas during periods when the natural gas mainlines have no operational limitations. Natural gas storage in Arizona is feasible, both technically and economically, if the project includes participation by all the major Arizona electric and natural gas utilities and with appropriate support from local and state government. TEP will continue to assess the need for, costs of, and benefits of natural gas storage in Arizona in relation to the specific portfolio options evaluated in the Final 2020 IRP[13].

[12] Net load is the retail and firm wholesale energy demand in a given period less the total renewable energy production during that same period.

[13] ACC Decision 76632 dated March 29, 2018 (Docket No. E-00000V-15-0094) ordered TEP and other load serving entities to *"address natural gas storage in greater detail in future IRPs, including a discussion of efforts to develop natural gas storage, the costs and benefits of natural gas storage, and risks resulting from a lack of market area natural gas storage in Arizona"*

Chapter 3

LOAD FORECAST

Introduction

In the IRP process, it is crucial to estimate the load obligations that existing and future resources will be required to meet for both short- and long-term planning horizons. As a first step in the development of the resource plan, a long-term load forecast is produced. This chapter will provide an overview of the anticipated long-term load obligations at TEP, a discussion of the methodology and data sources used in the forecasting process, and a summary of the tools used to deal with the inherent uncertainty surrounding a number of key forecast inputs.

The specific load and demand projections presented in this chapter represent TEP's December 2018 forecast. The Final 2020 IRP will be based on TEP's December 2019 forecast.

The sections in this chapter include:

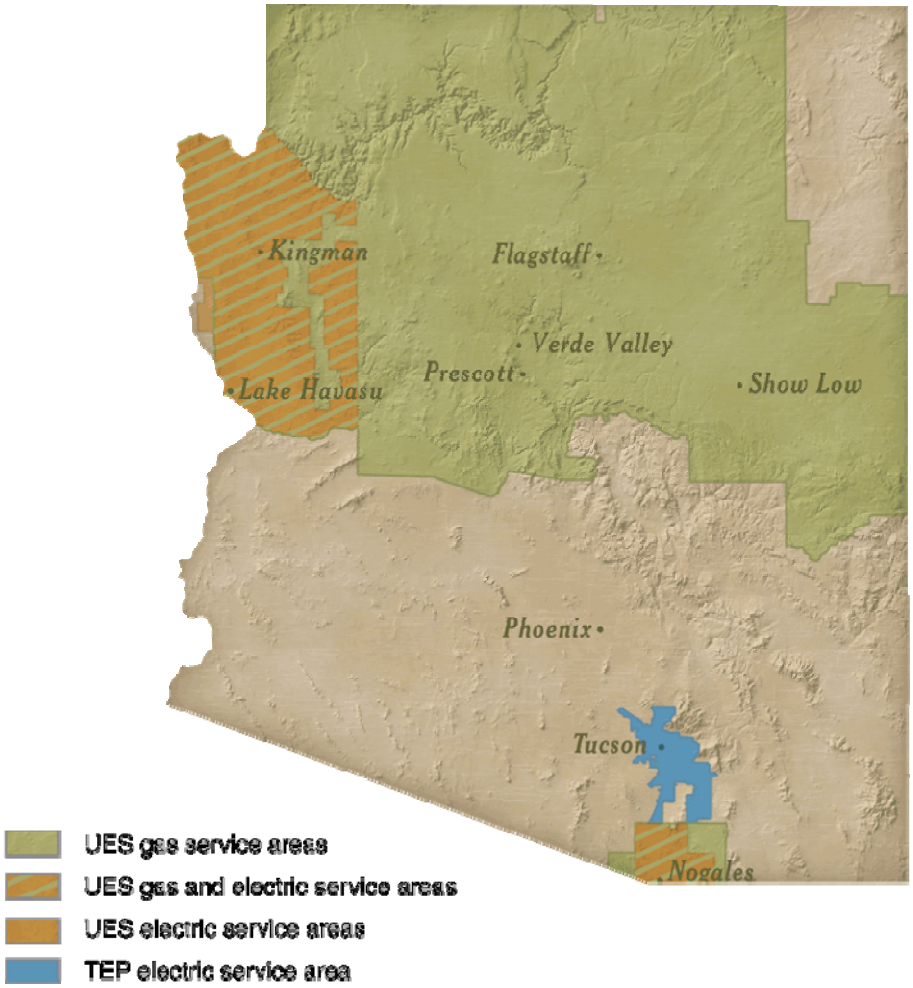
- **Company Overview:** TEP geographical service territory, customer base, and energy consumption by rate class
- **Reference Case Plan Forecast:** An overview of the Reference Case Plan forecast of energy and peak demand used in the planning process.
- **Wholesale Obligations:** An outline of the firm system requirements for wholesale electricity sales
- **Summary:** Compilation of results from this analysis

Company Overview

Geographical Location and Customer Base

TEP currently provides electricity to more than 425,000 customers in the Tucson metro area (Pima County). Pima County has experienced growth over the last decade and is estimated to have a population of approximately 1,030,000 people.

Map 2 - Service Area of Tucson Electric Power and Unisource Energy Services[14] (UES) Utilities

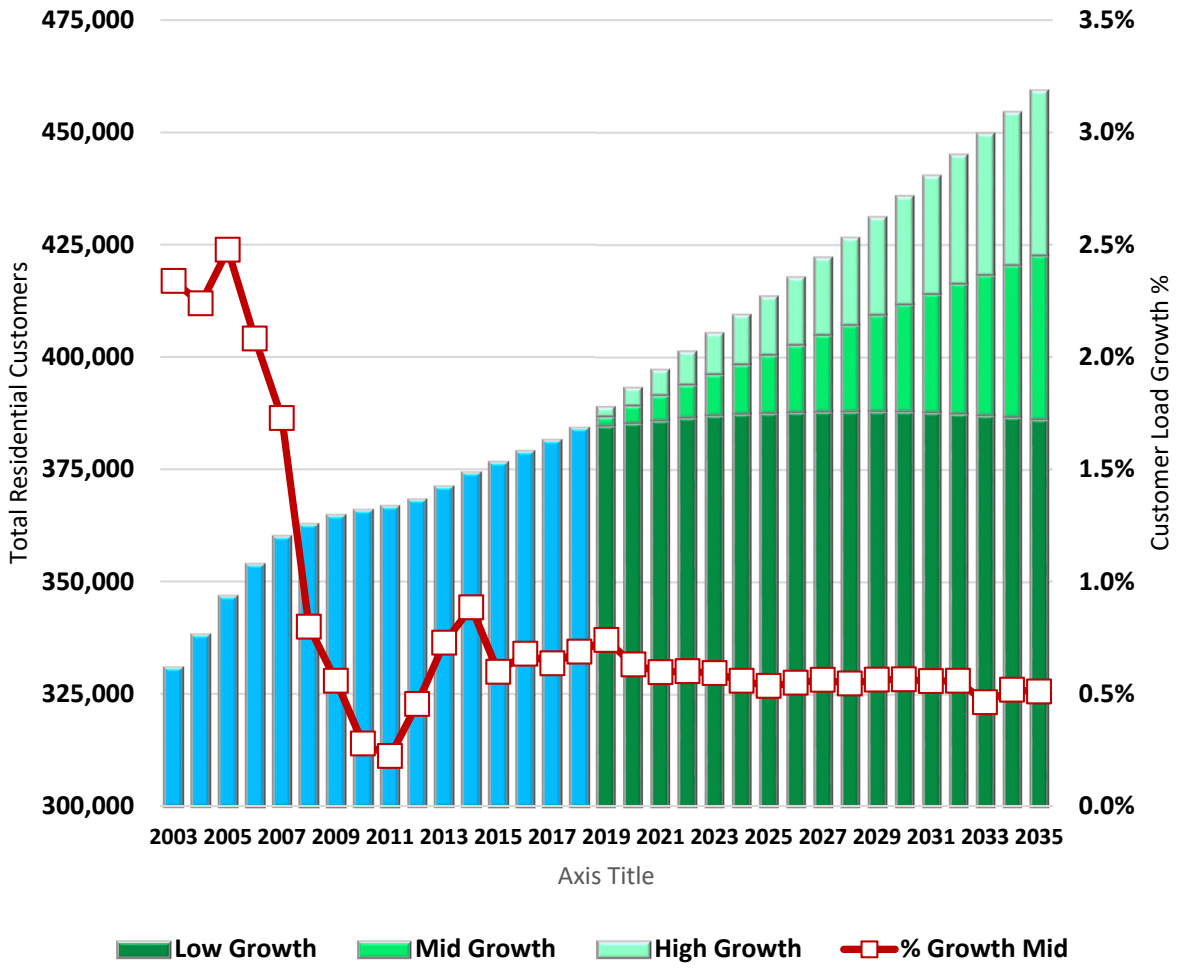


[14] Unisource Energy Services is a regulated utility providing electric and natural gas services in Arizona and is a sister company to Tucson Electric Power.

Customer Growth

In recent years, population growth in Pima County and customer growth at TEP have slowed dramatically compared to periods before 2008 because of the severe recession and subsequent economic weakness. While customer growth has rebounded somewhat from its recessionary lows, it is not expected to return to its pre-recession level. Chart 1 outlines the historical and expected customer growth in the residential rate class from 2003-2035. As customer growth is the most significant factor behind growth in TEP's load, the continuing customer growth will necessitate additional resources to serve the increased load in the medium term.

Chart 1 - TEP Residential Customer Growth Including Estimates for 2019-2035

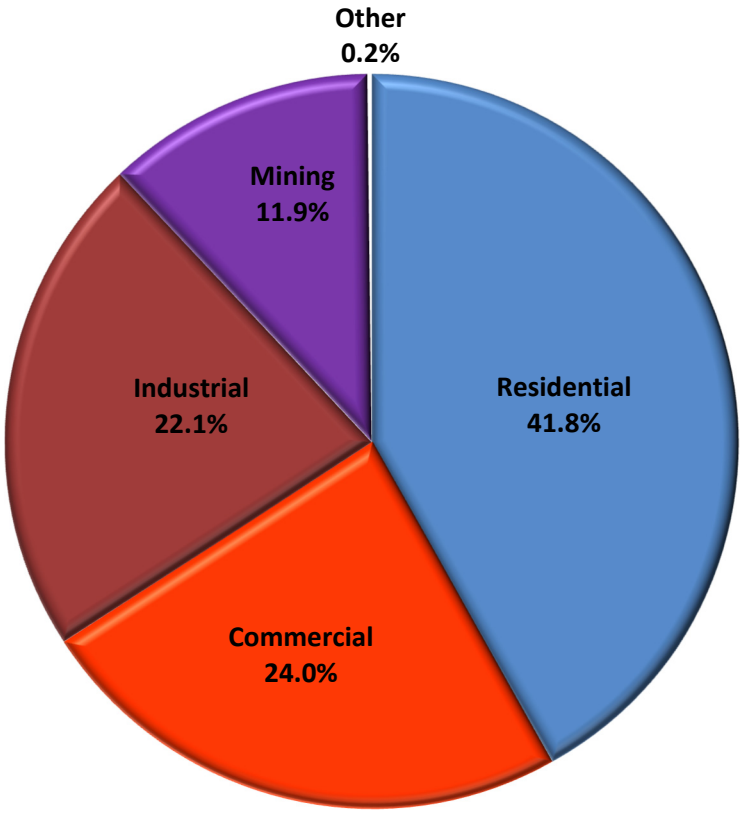


Retail Sales by Rate Class

In 2018, TEP experienced a peak demand of approximately 2,414 MW, a nearly 6% increase from 2016, with approximately 8,900 GWh of retail sales. Approximately 66% of 2018 retail energy was sold to the residential and commercial customers, with approximately 34% sold to the industrial and mining customers. Customer classes such as municipal street lighting, etc. accounted for the remaining sales.

Chart 2 gives a detailed breakdown of the estimated 2019 retail sales by rate class.

Chart 2 – Estimated 2019 Retail Sales % by Rate Class



Reference Case Plan Forecast

Methodology

The load forecast used in the TEP IRP process is produced using a "bottom up" approach. A separate monthly energy forecast is prepared for each of the major rate classes (residential, commercial, industrial, and mining). As the factors affecting usage in each of the rate classes vary significantly, the methodology used to produce the individual rate class forecasts also varies. However, the individual methodologies fall into two broad categories:

1) For the residential, commercial, and small industrial classes, forecasts are produced using statistical models. Inputs include factors such as historical usage, normal weather conditions (e.g. average temperature and dew point), demographic forecasts (e.g. population growth), and economic conditions (e.g. real gross county product and real per capita personal income).

2) For the industrial and mining classes, forecasts are produced for each individual customer. Inputs include historical usage patterns, information from the customers themselves (e.g. timing and scope of expanded operations), and information from internal company resources working closely with the mining and industrial customers.

After the individual monthly forecasts are produced, they are aggregated (along with any remaining miscellaneous consumption falling outside the major categories) to produce a monthly energy forecast for the Company. Following this aggregation, the retail load is reduced by the amount of customer Energy Efficiency (EE) and Distributed Generation (DG) anticipated in each year.

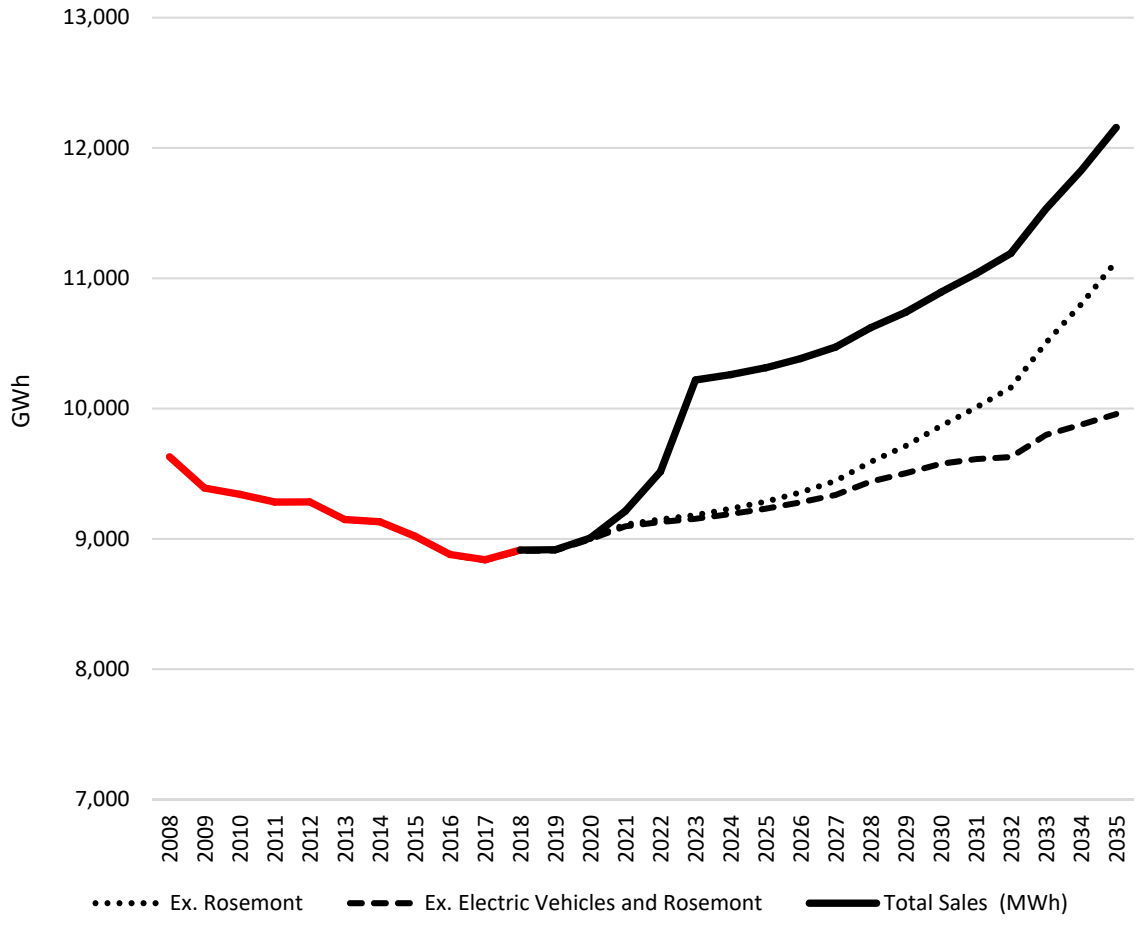
TEP used a different approach in forecasting DG resources and Electric Vehicle (EV) loads as these have significant impacts on load projections. Using an econometric model, DG growth is projected to slow from an average annual rate of 61.9% for the 2008-2018 period to 4.3% for the 2018-2028 period. This is largely a reflection of the maturation of the DG market and the establishment of a mechanism for reimbursing DG owners for excess energy transferred to the grid. The current market for EVs is still largely uncertain. To estimate the market penetration of EVs, TEP used a national EV forecast and adjusted a few assumptions to more closely relate the forecast to Pima County. The primary assumptions are that Pima County is less economically affluent than some parts of the United States and vehicles have a longer life expectance due to climatological reasons. Both of these factors suggest that vehicle turnover rates are slower in Pima County, so the Company is using an average vehicle age of 14 years instead of the 12-year average in the United States.

After the monthly energy forecast for the Company is produced, the anticipated monthly energy consumption is used as an input to estimate the peak demand. The peak demand model is based on historical relationship between hourly load and weather, calendar effects, and sales growth. Once these relationships are estimated, 60+ years of historical weather scenarios are simulated to generate a probabilistic peak load forecast.

Reference Case Plan Retail Energy Forecast

TEP's weather normalized retail energy sales fell significantly from 2008, immediately preceding the Great Recession, through 2017. In 2018, a rebound in commodity prices allowed mining load to return to historical levels and economic development caused weather normalized sales to increase compared to 2017. As shown on Chart 3, the underlying sales forecast is showing an expected annual growth rate of 0.7% in the 2020-2035 period. Including the forecasted growth in electric vehicle use, that estimated growth rate could increase to 1.4% and after accounting for the Rosemont mine project, that growth rate further increases to 2.0%. These forecast growth rates are all below the historical 2.5% growth rate in the 1993 to 2008 period, prior to the Great Recession.

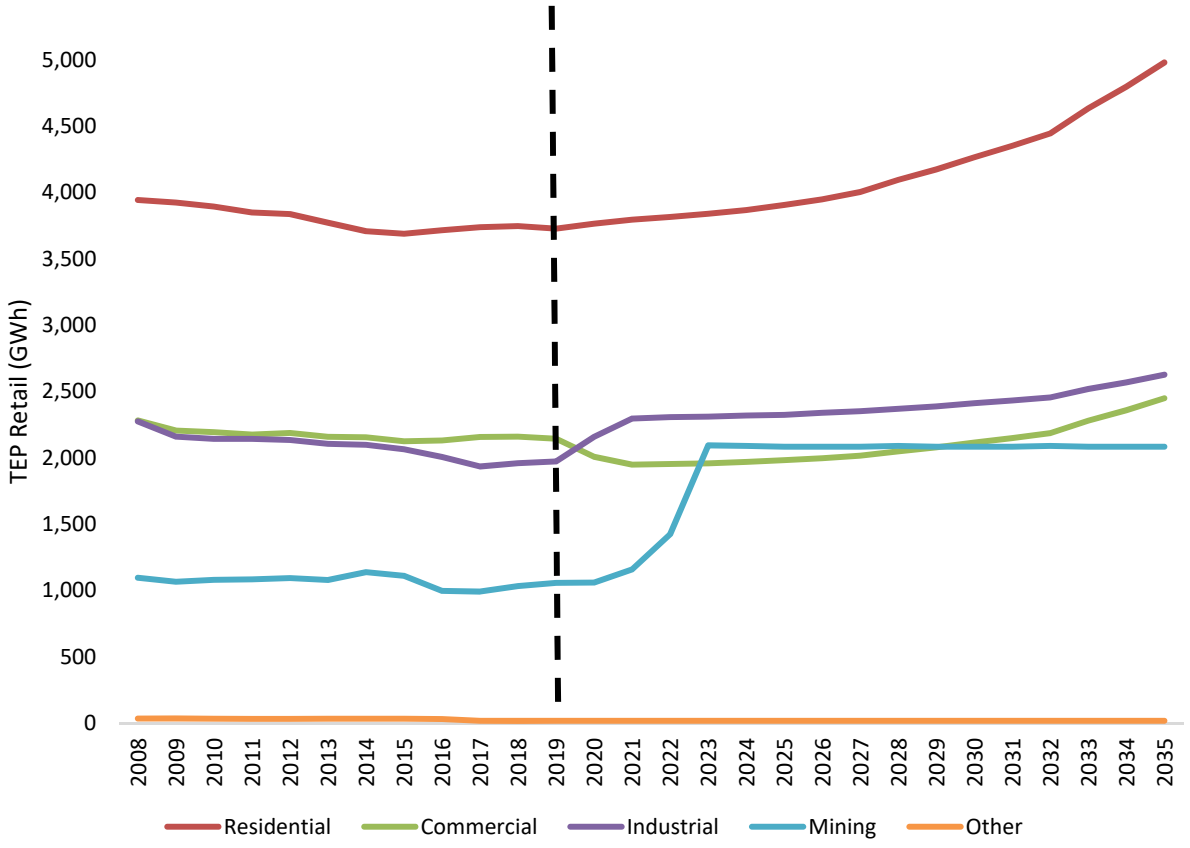
Chart 3 - Reference Case Plan Retail Energy Sales, Weather Normalized Historical



Reference Case Plan Retail Energy Forecast by Rate Class

As illustrated in Chart 4, the Reference Case Plan forecast assumes significant short-term changes for the next few years followed by slow steady growth starting in 2024. However, the growth rates vary significantly by rate class. The energy sales trends for each major rate class are detailed in Chart 4.

Chart 4 - Reference Case Plan Retail Energy Sales by Rate Class

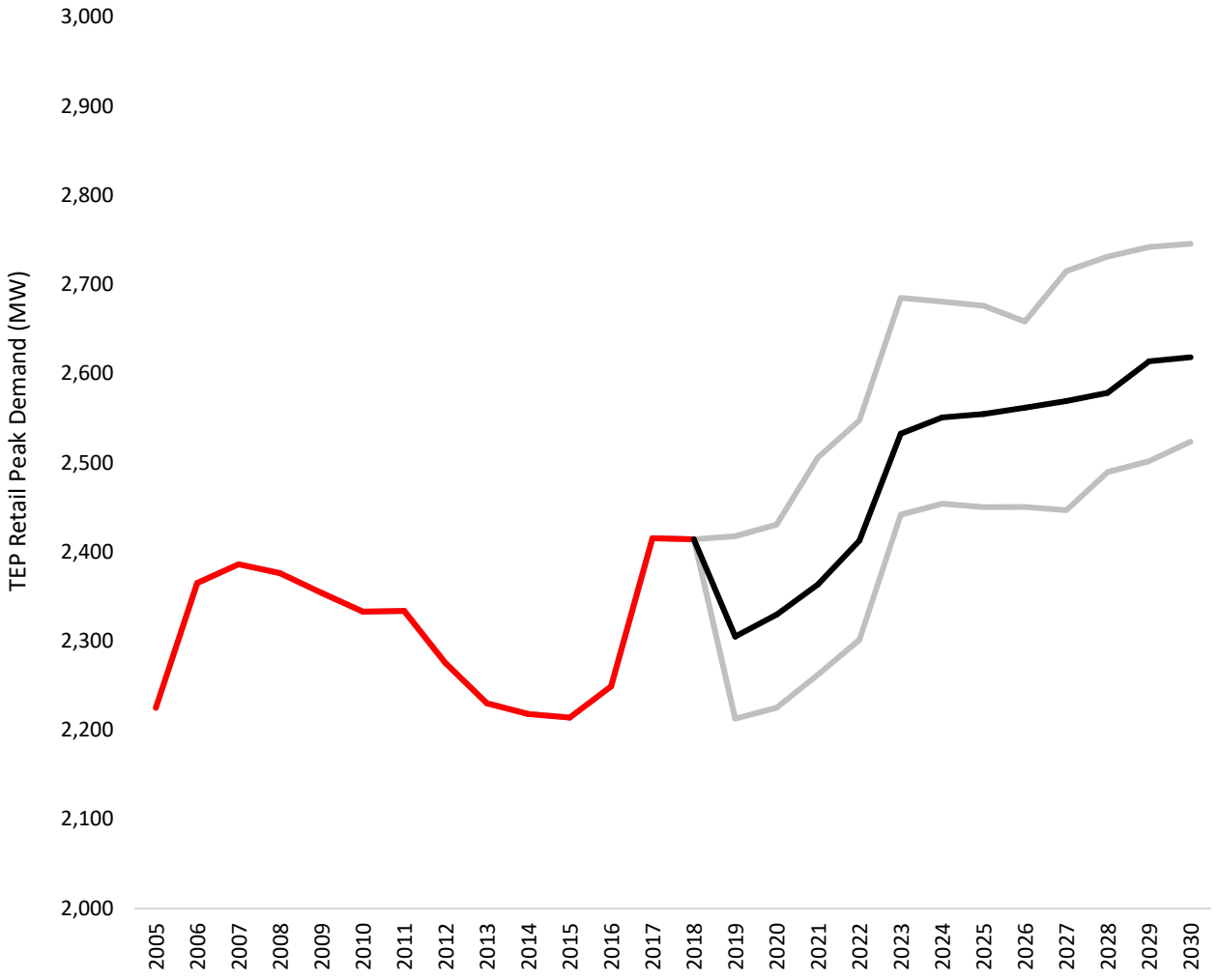


After experiencing consistent year over year growth throughout the past, residential, commercial and industrial energy demand remained nearly flat from 2008 through 2018. Both are assumed in the Reference Case Plan to increase steadily after 2019. Mining sales are assumed to expand due to the Rosemont mine project.

Reference Case Plan Peak Demand Forecast

As show in Chart 5 below, peak demand is expected to drop in 2019 based on the assumption of a return to normal weather although the upper confidence band shows it could remain relatively unchanged. Similar to the sales forecast, as the mining class expands and electric vehicles become more common, the retail peak demand is expected to grow.

Chart 5 - Reference Case Plan Peak Demand



Data Sources Used in the Forecasting Process

As outlined above, the Reference Case Plan forecast requires a broad range of inputs (demographic, economic, weather, etc.) For internal forecasting processes, TEP utilizes a number of data sources:

- IHS Global Insight
- The University of Arizona Forecasting Project
- Arizona Department of Commerce
- U.S. Census Bureau
- National Oceanic and Atmospheric Administration (NOAA)

Risks to Reference Case Plan Forecast and Risk Modeling

As always, there is a large amount of uncertainty with regard to projected load growth. Some of the key risks to the current forecast include:

- Local and regional general economic conditions
- Structural changes to customer behavior
- Volatility in industrial metal prices and associated shifts in mining consumption
- Efficacy of EE programs (i.e. percentage of load growth offset by demand side management programs)
- Technological innovations (e.g. electric vehicle penetration)
- Volatility in demographic assumptions (e.g. higher or lower population growth)
- Regulatory changes (e.g. introduction of a price on Carbon emissions)

Because of the large amount of uncertainty underlying the load forecast, it is crucial to consider the implications to resource planning if TEP experiences significantly lower or higher load growth than projected. For this reason, load growth is one of the fundamental factors considered in the risk analysis process that will be undertaken as part of the Final 2020 IRP. Specifically, the performance of each potential resource portfolio is considered over 100 iterations of potential load growth (along with correlated gas and power prices in each case).

Firm Wholesale Energy Forecast

In addition to retail sales directly to customers, TEP is currently under contract to provide firm wholesale energy to four utility customers:

1) Tohono O'odham Utility Authority (TOUA) through August 2019
2) Navajo Tribal Utility Authority (NTUA) through December 2022
3) TRICO Electric Cooperative ("TRICO") through December 2024
4) Navopache Electric Cooperative (NEC) through December 2040

TEP's firm wholesale obligations based on current contracts are shown in Table 2 below. It is important to note that no contract extensions have been assumed; however, there is a possibility that any or all agreements could be extended. TEP will evaluate the need for any changes to its resource portfolio to accommodate additional wholesale load prior to entering any new agreements.

Summary of Load Forecast

A summary of the Retail and Firm Wholesale Load Forecast is presented on Table 2, including reductions in load due to the impact of DG and EE.

Table 2 - TEP Forecast Summary

Retail Sales, GWh	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Residential	3,765	3,795	3,815	3,840	3,868	3,907	3,949	4,004	4,096	4,174	4,266	4,371	4,493	4,635	4,798	4,981
Commercial	2,007	1,948	1,953	1,958	1,969	1,982	1,996	2,016	2,049	2,078	2,115	2,159	2,213	2,280	2,359	2,449
Industrial	2,158	2,296	2,307	2,311	2,319	2,324	2,339	2,351	2,370	2,388	2,411	2,440	2,478	2,519	2,569	2,627
Mining	1,059	1,158	1,424	2,094	2,089	2,084	2,084	2,084	2,090	2,084	2,084	2,084	2,090	2,084	2,084	2,084
Other	17	16	17	17	16	16	16	16	16	16	16	16	16	16	16	16
Total Retail	9,006	9,213	9,516	10,220	10,261	10,313	10,384	10,471	10,621	10,740	10,892	11,070	11,290	11,534	11,826	12,157

Residential Sales Growth %	0.99%	0.80%	0.53%	0.66%	0.73%	1.01%	1.07%	1.39%	2.30%	1.90%	2.20%	2.46%	2.79%	3.16%	3.52%	3.81%
Commercial Sales Growth %	-6.35%	-2.94%	0.26%	0.26%	0.56%	0.66%	0.71%	1.00%	1.64%	1.42%	1.78%	2.08%	2.50%	3.03%	3.46%	3.82%
Industrial Sales Growth %	9.43%	6.39%	0.48%	0.17%	0.35%	0.22%	0.65%	0.51%	0.81%	0.76%	0.96%	1.20%	1.56%	1.65%	1.98%	2.26%
Mining Sales Growth %	0.19%	9.35%	22.97%	47.05%	-0.24%	-0.24%	0.00%	0.00%	0.29%	-0.29%	0.00%	0.00%	0.29%	-0.29%	0.00%	0.00%
Other Sales Growth %	0.00%	-5.88%	6.25%	0.00%	-5.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total Retail Sales Growth %	1.00%	2.30%	3.29%	7.40%	0.40%	0.51%	0.69%	0.84%	1.43%	1.12%	1.42%	1.63%	1.99%	2.16%	2.53%	2.80%
Customer Count, 000	431	433	436	438	441	443	445	448	450	453	455	458	460	462	465	467

Table 2 - TEP Forecast Summary (Continued)

Firm Wholesale, GWh	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
TRICO	31	1	7	19	22	0	0	0	0	0	0	0	0	0	0	0
NEC	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129
NTUA	19	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0
TOUA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Firm Wholesale	179	150	156	148	151	129	129	129	129	129	129	129	129	129	129	129

Peak Demand, MW	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Retail Demand	2,355	2,400	2,425	2,517	2,543	2,582	2,567	2,578	2,567	2,594	2,615	2,659	2,661	2,663	2,683	2,726
Retail Demand Growth %	1.26%	1.99%	1.06%	3.75%	0.97%	1.58%	- 0.58%	0.45%	- 0.46%	1.04%	0.86%	1.66%	0.09%	0.08%	0.72%	1.64%

Peak Demand, MW	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
TRICO	85	85	85	85	85	0	0	0	0	0	0	0	0	0	0	0
NEC	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
NTUA	15	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0
TOUA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Firm Demand	144	144	144	129	129	44	44	44	44	44	44	44	44	44	44	44

Total Retail & Firm Wholesale	2,499	2,544	2,569	2,646	2,672	2,626	2,611	2,622	2,611	2,638	2,659	2,703	2,705	2,707	2,727	2,770

Chapter 4

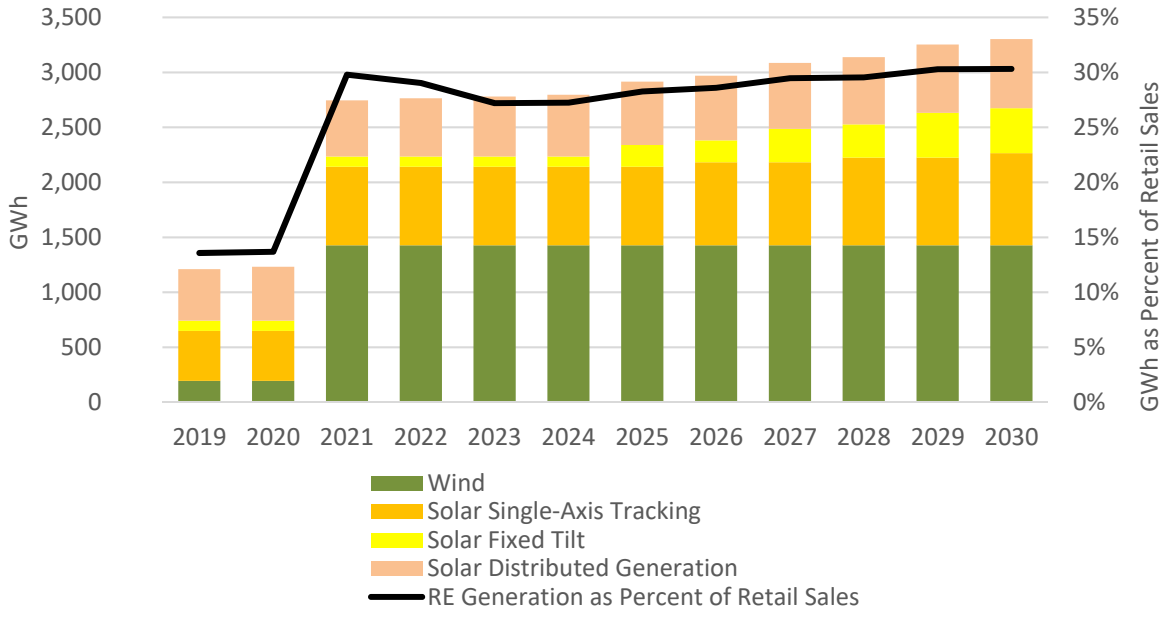
PRELIMINARY LOADS AND RESOURCES

A critical component to the IRP planning process is the assessment of firm load obligations compared to a utility's firm resource capacity. This chapter presents a preliminary summary of the Company's future load obligations and the resources available to meet that obligation. The preliminary assessment of resource capacity includes existing resources and new resources under contract as well as the assumptions regarding the addition of new renewable resources needed to achieve the Company's goal to serve 30% of our retail load by 2030. This preliminary assessment targets a 15% reserve margin in order to cover any system contingencies related to unplanned outages on its generation and transmission system.

TEP's Updated Renewable Resource Portfolio

In 2018, renewable energy generation served 13% of retail sales, with most of that energy sourced from solar resources. By the end of 2020, the portion of retail sales expected to be served by renewable energy will increase to nearly 28%, with half of that energy supplied by wind power. The addition of 100 MW of solar at the Wilmot Energy Center, 99 MW of wind at Borderlands, and 247 MW of wind at Oso Grande in eastern New Mexico will constitute this increase. After 2021, our assumption is that any additional renewable energy will be solar from a mix of single-axis tracking, fixed tilt, and distributed generation systems, as shown in Chart 6.

Chart 6 - Renewable Energy Generation from Resources Assumed in the Preliminary IRP

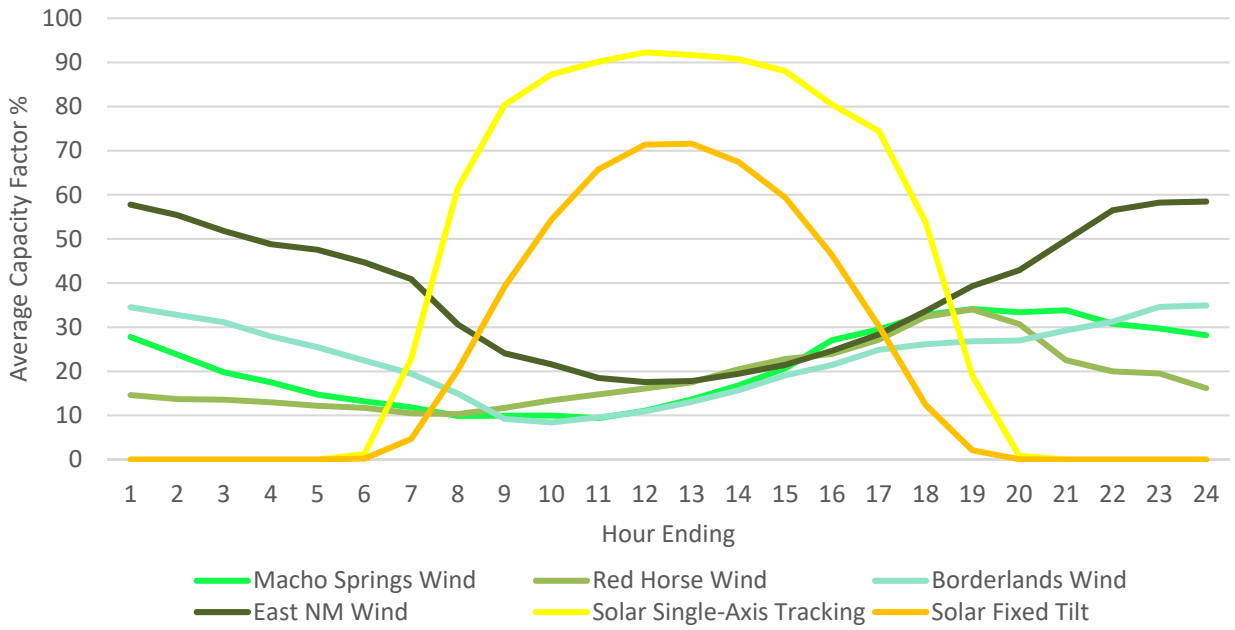


Renewable Resource Contribution to Meeting Peak Demands

TEP's peak demand historically occurs between 5 and 6PM in the summer[15]. To determine the contribution of TEP's current portfolio of variable renewable energy sources to meeting peak demand, TEP examined the capacity factors of its renewable resources during these hours in the months of June through August.[16] The capacity factors during these times at TEP's wind sites range from 23 to 27%. At TEP's fixed tilt and single-axis tracking sites, the capacity factors during these times average 35 and 69%, respectively.

As the amount of solar power on TEP's system increases, the net peak load (i.e., the load remaining after the contribution of renewable energy resources) will tend to occur later in the day. Since solar power decreases later in the day, this will have the effect of reducing the contribution of future solar capacity to peak demand. TEP's wind resources, on the other hand, tend to increase production late in the day on average. Chart 7 compares the output of two typical TEP solar power plants to its current and expected wind plants in the months of June through August. Because wind power increases during sunset, their inclusion in the portfolio reduces the shift of the net load into later hours of the day, thus slowing the reduction in the contribution to peak demand provide by future solar resources.

Chart 7 - Average Capacity Factors at TEP Solar and Wind Plants During June – August



[15] As a result of the Company's new solar and wind resource commitments, TEP plans to reevaluate the net coincident peak demand and the incremental contribution of new renewable resources to TEP's system as part of the Final 2020 IRP planning cycle.
[16] For Borderlands and Oso Grande wind, TEP relied on wind resource assessment data provided by the project developers.

Energy Efficiency and Demand Response

TEP's EE program development through 2020 will continue to target compliance with the Arizona Energy Efficiency Standard ("EE Standard") of a cumulative energy savings of 22%. From 2021 through the end of the planning period, the preliminary load and resource assessment assumes annual energy savings based on an assessment of "achievable potential" in energy savings from EE programs conducted by the Electric Power Research Institute (EPRI).[17] By 2035, this offset to future retail load growth represents a reduction in TEP's system peak demand of 284 MW. TEP's Final 2020 IRP will replace this assumption of EE growth with an evaluation of specific EE measures or groups of measures as demand-side resources within our production cost-modeling platform (see Chapter 5, Energy Efficiency Assumptions).

TEP Loads and Resources

Table 4 summarizes TEP's gross retail peak demands by year based on its December 2018 load forecast projections. These demands are broken down by customer class and the Company's assumptions on coincident peak load reductions from distributed generation and energy efficiency. In addition, TEP includes a summary of projected firm wholesale customer demands. Finally, Table 4 summarizes the Company's reserve margin positions based on the capacity resources shown in Table 5.

Table 5 summarizes TEP's firm resource capacity based on its current planning assumptions related to its coal and natural gas resources. Table 5 also reflects TEP's plan to source 30% of its retail loads from renewable generation resources by 2030. Additional resources such as demand response programs, short-term market purchases along with capacity sourced from its battery storage projects are also shown in the TEP resource portfolio.

[17] Electric Power Research Institute, *U.S. Energy Efficiency Potential Through 2035*, dated April 2014. http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001025477

Table 4 – Firm Load Obligations, System Peak Demand (MW)

Demand (MW)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Residential	1,456	1,481	1,489	1,508	1,533	1,565	1,565	1,580	1,578	1,601	1,621	1,653	1,661	1,670	1,688	1,719
Commercial	755	768	772	782	795	811	811	819	818	830	840	857	862	866	875	892
Industrial	405	412	415	420	427	436	436	440	439	446	451	460	463	465	470	479
Mining	137	158	191	269	269	269	269	269	269	269	269	269	269	269	269	269
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gross Retail Peak Demand	**2,753**	**2,819**	**2,867**	**2,979**	**3,024**	**3,081**	**3,081**	**3,108**	**3,104**	**3,146**	**3,181**	**3,239**	**3,255**	**3,270**	**3,302**	**3,359**
Distributed Generation	-256	-267	-277	-286	-295	-303	-310	-316	-322	-327	-332	-336	-340	-343	-346	-349
Energy Efficiency	-142	-152	-165	-176	-186	-196	-204	-214	-215	-225	-234	-244	-254	-264	-273	-284
Net Retail Peak Demand	**2,355**	**2,400**	**2,425**	**2,517**	**2,543**	**2,582**	**2,567**	**2,578**	**2,567**	**2,594**	**2,615**	**2,659**	**2,661**	**2,663**	**2,683**	**2,726**
Firm Wholesale Demand	144	144	144	129	129	44	44	44	44	44	44	44	44	44	44	44
Total Forward Sales	300	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reserve Requirements	375	382	385	397	401	394	392	393	392	396	399	405	406	406	409	416
Total Firm Load Obligations	**3,174**	**3,026**	**2,955**	**3,043**	**3,073**	**3,020**	**3,003**	**3,015**	**3,003**	**3,034**	**3,058**	**3,108**	**3,111**	**3,113**	**3,136**	**3,186**
Reserve Margin, MW	378	598	503	428	403	468	493	500	451	442	432	303	211	210	192	151
Reserve Margin, %	14%	23%	20%	16%	15%	18%	19%	19%	17%	17%	16%	11%	8%	8%	7%	5%

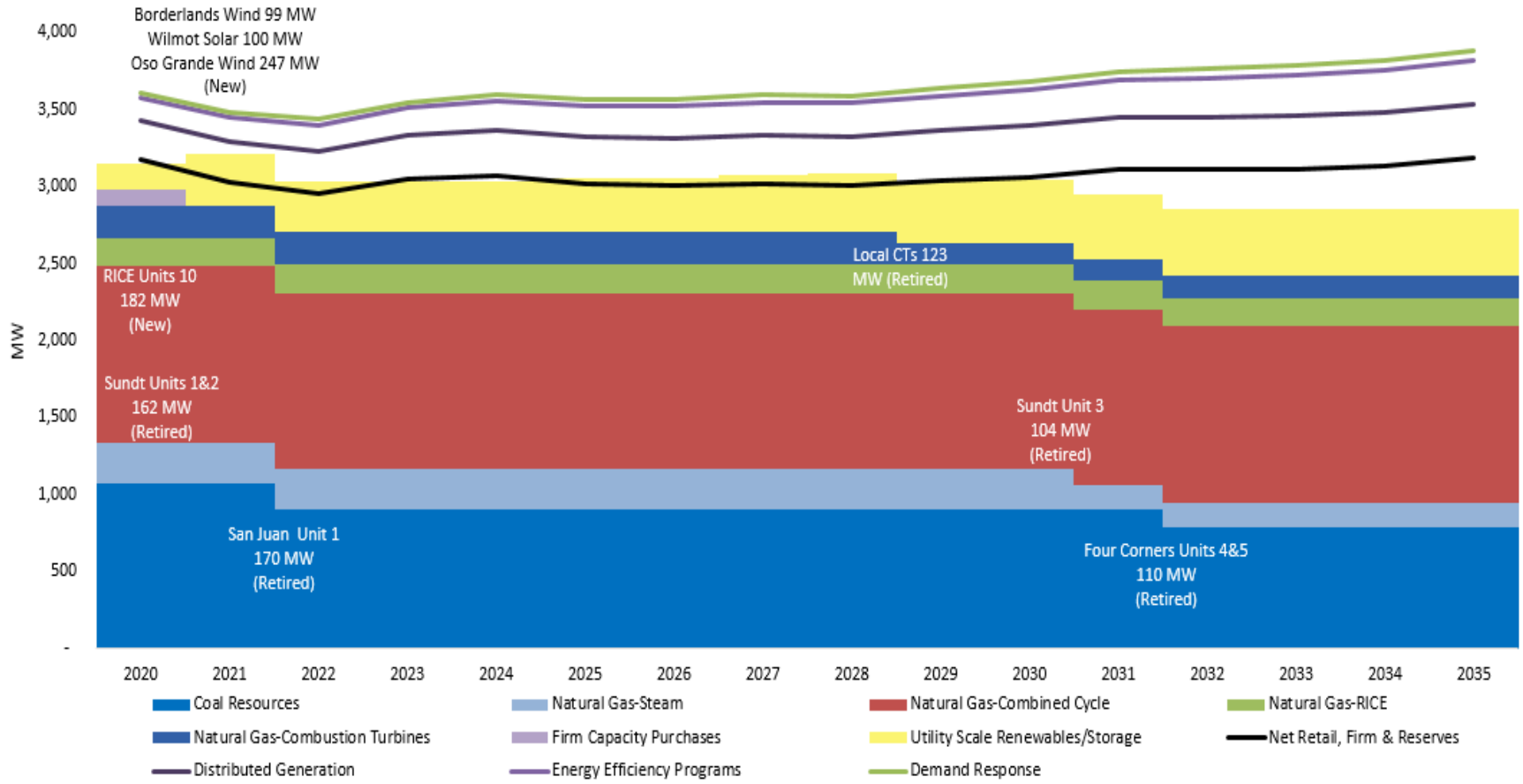
Table 5 – Capacity Resources, System Peak Demand (MW)

Firm Resource Capacity (MW)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Four Corners	110	110	110	110	110	110	110	110	110	110	110	110				
San Juan	170	170														
Springerville	793	793	793	793	793	793	793	793	793	793	793	793	793	793	793	793
Remote Coal Resources	**1,073**	**1,073**	**903**	**903**	**903**	**903**	**903**	**903**	**903**	**903**	**903**	**903**	**793**	**793**	**793**	**793**
Sundt 1-4	260	260	260	260	260	260	260	260	260	260	260	156	156	156	156	156
Luna Energy Facility	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184
Gila River Power Station	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962
Rice Units	182	182	182	182	182	182	182	182	182	182	182	182	182	182	182	182
DeMoss Petrie CT	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71
North Loop CT 1-4	91	91	91	91	91	91	91	91	20	20	20	20	20	20	20	20
Sundt CT 1-2	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Total Natural Gas Resources	**1,800**	**1,800**	**1,800**	**1,800**	**1,800**	**1,800**	**1,800**	**1,800**	**1,729**	**1,729**	**1,729**	**1,625**	**1,625**	**1,625**	**1,625**	**1,625**
Utility Scale Renewables[18]	145	295	294	293	292	309	317	333	342	358	367	383	401	400	399	399
Demand Response	34	36	38	40	42	44	46	48	50	52	54	57	59	61	64	66
Total Renewable & EE Resources	**179**	**331**	**332**	**333**	**334**	**353**	**363**	**381**	**392**	**410**	**421**	**440**	**460**	**461**	**463**	**465**
Short-Term Market Resources	**110**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Future Storage Resources	15	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Total Firm Resources	**3,177**	**3,242**	**3,073**	**3,074**	**3,075**	**3,094**	**3,104**	**3,122**	**3,062**	**3,080**	**3,091**	**3,006**	**2,916**	**2,917**	**2,919**	**2,921**

[18] The renewable coincident peak values in this table represent each individual project's alignment with the system peak. In the Final 2020 IRP, TEP intends to quantify the diminishing capacity value of incremental renewable energy due to net peak shift into later hours.

Chart 8 combines the data from Table 4 and Table 5 to show graphically how our firm resources compare to our current firm obligations.

Chart 8 – TEP's 2016 Preliminary Loads and Resource Assessment



Chapter 5

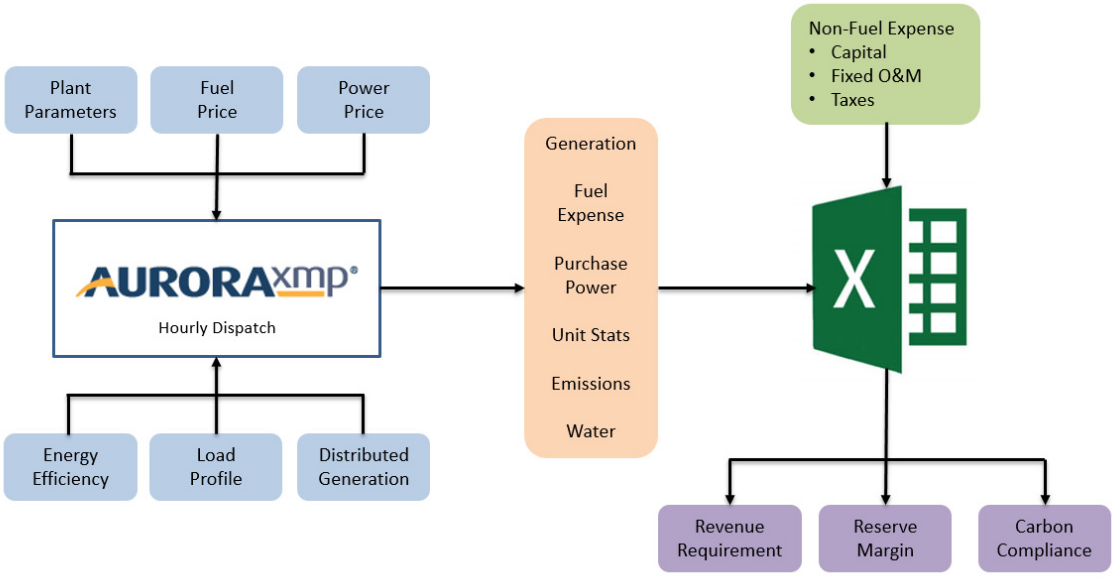
RESOURCE MODELING ASSUMPTIONS

Chapter 5 presents a description of the modeling inputs, framework and tools TEP will use to develop its Final 2020 IRP. Input assumptions for parameters external to TEP's system are based on independent third-party sources as available. Internal parameters are based on a combination of independent third-party sources and historical operations.

Production Cost Modeling

TEP uses Aurora[19] for its resource planning production cost modeling. Aurora is a chronological economic dispatch simulation model that is used to represent the behavior and performance of a portfolio of resources under a set of operating and market conditions specified by the user. Inputs include hourly and peak load, plant design and operating parameters, and commodity prices. The model outputs include generation levels and the resulting costs of various resources as well as the overall production cost of the portfolio. These production costs are combined with capital and other fixed (i.e., non-fuel) expenses to determine the total revenue requirement of the portfolio (see Figure 1).

Figure 1 - Production Cost Modeling Platform



[19] https://energyexemplar.com/products/aurora-electric-modeling-forecasting-software/

Historically, the revenue requirements of a portfolio could be adequately determined by considering how customer load, and the least-cost resources dispatched to serve that load, change from hour to hour over the course of the year and the planning horizon. However, increasing amounts of renewable energy creates a variability in supply that greatly exceeds the variability in customer load. This variability occurs at a time scale of minutes, as well as hours. Thus, to quantify the operational and revenue requirement impacts of renewable energy, as well as the technologies and procedures needed to integrate this energy, it is becoming increasingly important to conduct resource dispatch analyses at the sub-hourly level. This has become well recognized in utility resource planning.[20] [21]

While IRP models, including Aurora, have been recently upgraded to perform sub-hourly analyses, using them at this scale is more resource-intensive and time-consuming. With this in mind, planning experts have recommended 1) determining where greater modeling complexity is meaningful and 2) the continued use of simpler screening tools in parallel with more complicated models.[22]

Consequently, TEP has taken progressive steps towards including more sub-hourly analysis in its integrated resource planning. In its 2017 IRP, TEP examined the 10-minute variability of its renewable resources and projected that variability into the long-term forecast based on the amount of renewable resources included in its Reference Case Plan. This variability was then used to compare the Company's 10-minute ramping requirements versus the 10-minute ramping capabilities of its portfolio. In the 2018 Action Plan Update, TEP conducted additional analysis of 10-minute renewable energy data, as well as Aurora modeling at sub-hourly intervals to quantify the benefits of installing RICE units at Sundt. As part of this work, TEP ran Aurora at various sub-hourly intervals and determined that 10-minute intervals provided the best balance between capturing the dispatch effects of fast-response resources, such as batteries and RICE units, and limiting database sizes and computer run times to manageable levels.

More recently, TEP has sponsored sub-hourly dispatch modeling as part of its process for evaluating participation benefits in the Energy Imbalance Market (See Page 44). TEP is also in the process of evaluating its flexible capacity needs under high renewable energy penetration scenarios using sub-hourly analysis of its net load and sub-hourly dispatch modeling with Aurora (see Resource Adequacy Study, Chapter 2).

As with any modeling exercise, the results are dependent on the inputs to the model. Appendix A lists several key model inputs for TEP's existing resources. While it is not practical or even useful to list each of the thousands of individual input values the model uses, TEP intends to provide as much transparency as can reasonably be afforded to stakeholders in our IRP process.

Science-Based Greenhouse Gas Emission Reduction Target

TEP believes that the most cost-effective means of achieving meaningful GHG emission reductions is to evaluate resource portfolios that specifically target maximizing emission reductions while maintaining its core function of providing affordable, reliable energy to its customers. There is growing industry interest to establish utility-specific GHG emission reduction targets based on global emissions scenarios that are projected to limit global temperature change to levels outlined in the 2015 Paris Agreement on climate

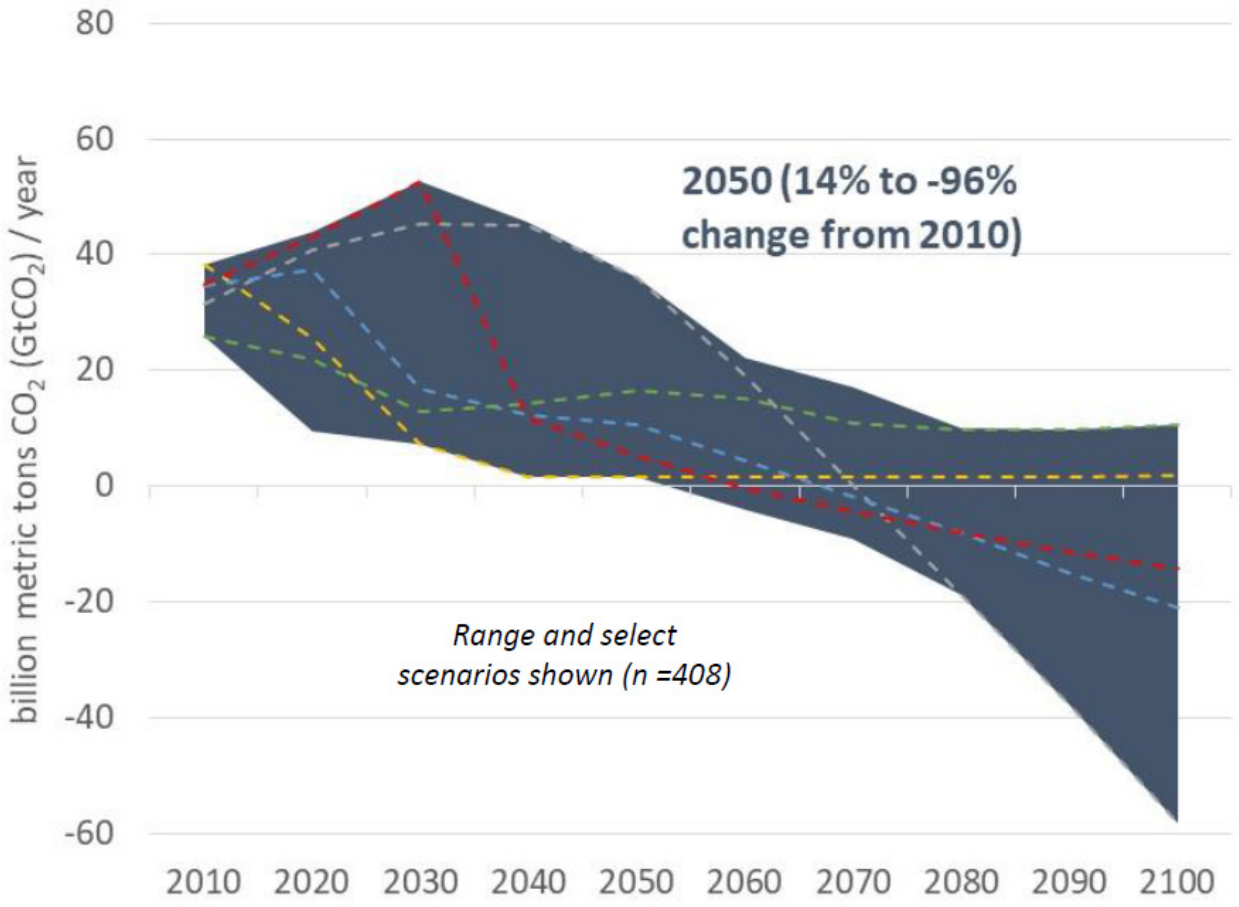
[20] In June 2018, the National Association of Regulatory Utility Commissioners issued a resolution that planning frameworks and modeling tools should model the full spectrum of services that energy storage and flexible resources are capable of providing, including sub-hourly services; https://pubs.naruc.org/pub.cfm?id=BF35538B-B75F-6495-0F61-9D9BBA61D76F

[21] The Washington State Utilities and Transportation Commission issued guidance that the benefits of storage and other flexible resources be evaluated on a sub-hourly basis using an external model, such as EPRI's StorageVet tool, then deducted from the resource's cost in the IRP to obtain a net cost; https://www.utc.wa.gov/docs/Pages/DocketLookup.aspx?FilingID=UE-151069

[22] https://emp.lbl.gov/sites/all/files/lbnl-1006269.pdf

change. These targets are commonly referred to as "Science Based Targets" (SBTs). Figure 2 presents the full range of 408 distinct scenarios as compiled by EPRI[23].

Figure 2 - Range of Global Science Based Target Scenarios



While organizations have drafted protocols for voluntary emission reduction targets,[24] [25] [26] there is no consensus around the appropriate level and pace of emission reductions that any specific company should make. The University of Arizona's Institute for the Environment (UAIE) is highly respected for its world-class experts in climate science and in particular the regional impacts of global temperature change. TEP is collaborating with the UAIE to provide the scientific background and context for TEP to develop GHG emission targets as part of the Final 2020 IRP.

[23] Electric Power Research Institute, *Grounding Decisions: A Scientific Foundation for Companies Considering Global Climate Scenarios and Greenhouse Gas Goals*, October 2018
[24] Task Force on Climate Related Financial Disclosures (TCFD), *Recommendations of the Task Force on Climate-related Financial Disclosures*, June 2017;
[25] Science Based Targets Initiative (SBTi), *Sectoral Decarbonization Approach (SDA): A method for setting corporate emission reduction targets in line with climate science*, 2015
[26] Science Based Targets Initiative (SBTi), *Science-based Target Setting Manual, Draft, Version 3.0,* April 4, 2017

Energy Efficiency Assumptions

Since 2011, TEP's focus on EE has been providing cost effective programs to meet the targets established in the EE Standard. TEP's portfolio of programs incorporates elements of the most successful EE programs across North America and are designed in consideration of the Tucson market. A substantial amount of information including evaluations, program plans and studies were used to develop specific programs for TEP. With input from Navigant, RUCO and the Southwest Energy Efficiency Project (SWEEP), TEP also used a benchmarking process to review the most successful EE programs from across the country, with a focus on successful Desert Southwest programs to help shape the portfolio.

TEP develops a suite of programs and presents those programs to the Commission for approval in the form of an Implementation Plan. The Implementation Plans include an analysis of EE and Demand Side Management (DSM) cost-effectiveness focused primarily on the calculation of specific Energy Efficiency metrics, using the Societal Cost Test (SCT), which is the cost test identified in the EE Standard as the key perspective for determining the cost-effectiveness of EE measures and programs. In the past, the programs approved through the EE Implementation Plans were incorporated into the IRP without significant consideration of how those programs intersected with electricity demand patterns, electricity market transactions, and TEP's resource portfolio.

TEP's Final 2020 IRP will include an explicit evaluation of EE programs and measures within this broader context. Programs and measures will continue to be evaluated for cost-effectiveness using the SCT and other applicable metrics. Then those programs and measures will be constructed as supply-side resources within Aurora such that the costs and benefits of the programs include their impacts on peak demand and overall portfolio dispatch economics.

There are a number of options for evaluating EE programs as supply-side resources within the IRP. One option is to calculate the difference between the Levelized Avoided Cost of Energy (LACE) and the Levelized Cost of Energy (LCOE) for the program or measure. The LACE is determined by conducting two simulations of the portfolio where one contains the EE program and one does not, then dividing the NPV of production costs savings by the NPV of total energy avoided by the EE program. The LCOE is simply the NPV of the cost of the program over the NPV of the lifetime energy saved. If the LACE is greater than the LCOE, the program is cost effective within the portfolio. Another option would be to evaluate the EE programs in a capacity expansion simulation, where the model selects resources to add to the portfolio based on their long-term value.

ACC Decision No. 76632 requires ACC Staff to "conduct one or more EE workshops to allow stakeholders to provide input regarding the future of EE beyond the 2020 expiration date" of the EE Standard. TEP will work with Staff and stakeholders through these workshops to determine a method of evaluating EE that provides the best outcome for customers in terms of affordability, reliability and environmental performance.

Renewable Integration

TEP previously announced a corporate goal of generating enough renewable energy to meet 30% of its retail sales by the year 2030. In 2018, renewable resources supplied about 13% of retail energy. By 2021, this is expected to increase to about 28%.

As discussed in its prior IRP, there are a number of integration issues related to high penetrations of renewable energy. From a resource planning perspective (e.g., not including transmission and distribution issues), these include:

- **Meeting Peak Demand**

  While it is reasonable to expect some solar and wind power during hours of peak demand, it is impossible to know precisely how much they will contribute during those peaks, unless backed up by considerable amounts of energy storage or firm capacity. In addition, as more solar power is brought onto the system, the peak "net load" – i.e., load net of renewable resources – will shift to later hours, when solar power is no longer available. This will reduce the ability of future solar resources to contribute to the peak net load, unless the peak net load is shifted earlier by wind power, demand side programs, or energy storage.

- **Managing Over Generation**

  During certain times of the day and year, under high renewable energy penetration scenarios, the amount of renewable energy being generated can exceed TEP's ability to accept that power. This happens because the amount of renewable energy plus the amount of "must run" energy exceeds the demand for power. Must run energy is the minimum level of energy that must be supplied from certain generating units to meet reliability requirements relating to voltage control or for meeting ramping requirements during sunset when solar energy drops off.

- **Following Load During Sunrise and Sunset**

  In portfolios with large amounts of solar power, TEP must have the flexibility to reduce generation from non-solar resources by large amounts during sunrise, and to increase them by large amounts during sunset.

- **Balancing Intra-Hour Variations in Renewable Power**

  In any portfolio with large amounts of intermittent renewable power, TEP must have the flexibility to rapidly increase or decrease output from other resources on a sub-hourly basis in order to maintain a balance between energy demand and energy supply.

TEP has evaluated these integration issues by examining the historic patterns of net load and extrapolating the results based on future assumptions of renewable energy deployment. In its Final 2020 IRP, TEP will also be examining these issues stochastically, using the variability observed in load and renewable energy at several renewable sites to estimate the likelihood of exceeding the above four flexibility criteria under different renewable penetration assumptions. (See Resource Adequacy Study, Chapter 2). This resource adequacy study will indicate the points at which TEP may need to add more flexible capacity to its system. In the Final 2020 IRP, we will evaluate strategies to meet these flexibility needs, such as:

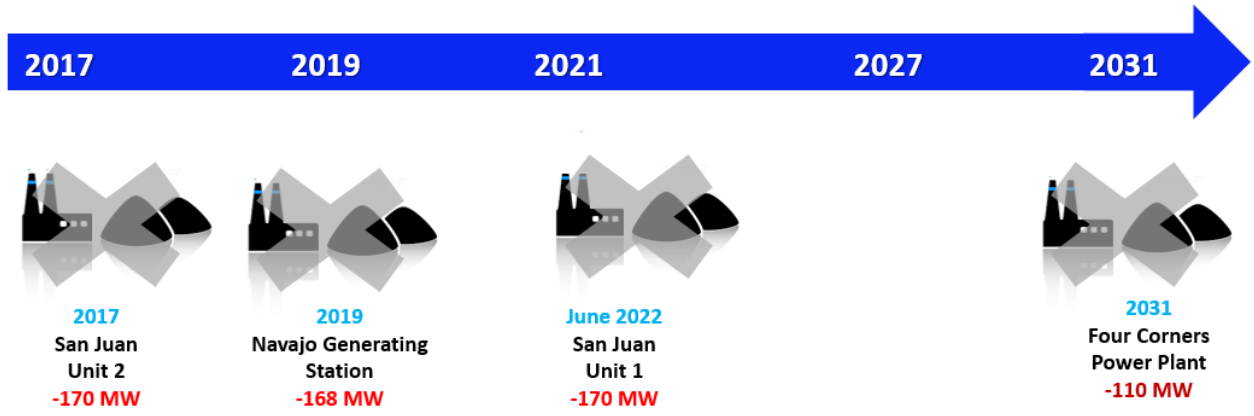
- Enhance operating capabilities of existing thermal resources
- Add energy storage resources as they become cost effective
- Add new, fast-starting, fast-ramping thermal resources
- Curtail renewable energy output during times of over generation
- Enhance operating capabilities of existing and new renewable energy plants to provide ancillary services
- Diversify renewable energy resources, both geographically and technologically

- Joining an energy imbalance market to manage intra-hour variations, and use other market transactions to help manage other flexibility issues
- Improve renewable energy forecasting
- Implement rates and demand side programs that enhance the flexibility of TEP's system

Coal Assumptions

As discussed above and in more detail in the TEP 2017 IRP and the TEP 2018 Action Plan Update, TEP is reducing the capacity of coal-fired generation in its portfolio through a series of planned retirements, see Figure 3.

Figure 3 - TEP Coal-Fired Generation Unit Retirements



These retirements also represent a consolidation of TEP's coal-fired assets in Springerville. TEP is the operator of Springerville and owns 100% of Units 1 and 2 at the facility. Units 1 and 2 have been TEP's primary baseload resources since they came online in 1985 and 1990, respectively. However, as TEP introduces more variable energy resources into the portfolio, traditionally baseload resources like Springerville need to be able to ramp down or otherwise change their dispatch to accommodate the intermittency and variability energy resources.[27]

Springerville has distinct attributes that add value to a diverse portfolio. For one, Springerville is a reliable and cost-effective resource during times when load requirements call for higher levels of round the clock energy or as a hedge against potential volatility in natural gas prices. In addition, Springerville can store up to 60 days of coal on site. Coal-fired generation is TEP's only source of energy that is not dependent on fuel availability on an hourly basis.

On the other hand, coal-fired generation is by far the most significant contributor to TEP's direct GHG emissions. Any further reduction in emissions will have to involve a corresponding reduction in coal-fired generation. In the Final 2020 IRP TEP will conduct a detailed evaluation of the best and highest use for Springerville within the portfolio that accommodates meaningful emission reductions without abandoning

[27] TEP 2017 IRP, p 68, *Operational Challenges*

the other vital services that Springerville provides until those services can be met by new cost effective resources.

Energy Storage

TEP is actively evaluating multiple potential uses for energy storage in our system and we anticipate that renewables with energy storage will comprise the vast majority of resource additions going forward. As required by Decision No. 76632, TEP must evaluate energy storage as a potential solution for distribution and transmission needs in our system. The Company is also following the technology advances in large-scale (>10 MW) energy storage, specifically as it relates to the development of long duration (4 hours or greater), energy storage systems that can provide load shifting, peak capacity and other services.

As described in Chapter 2, TEP has contracted Siemens to conduct a resource adequacy study that will provide insights into the timing and specific need for energy storage systems. Based on the results of that study, TEP will model energy storage systems with various configurations for the Final 2020 IRP. The evaluation of energy storage will require modeling these systems at sub-hourly intervals due to the very short durations for which these resources are committed.

The timing for introducing energy storage systems is a critical planning determinant as it has a significant impact on the cost of the resource. BESSs have experienced significant reductions in cost over the past several years and are expected to see additional cost reductions going forward. Table 6 shows the forecast capital cost reductions for a BESS.

Considering these declining costs and the time value of money, TEP can significantly reduce the NPV cost of BESSs by delaying the purchase of those system until such time that they are needed in the system. As an example of these potential savings, Table 6 presents NPV costs of otherwise identical BESSs but with different deployment dates.

Table 6 - Comparison of Net Present Value Cost Based on Year of Installation[28]

Year Installed	CapEx ($/kW)	Fixed O&M ($/MW-yr)	Variable O&M ($/MWh)	NPV (2020$)
2020	$2,866	$8,645	$2.50	$88,657,303
2025	$2,331	$8,113	$2.20	$72,653,500
2030	$2,109	$7,581	$1.91	$65,727,485

Representative system is 30 MW, 8-hour duration, 350 cycles per year, 90% round-trip efficiency

[28] NREL Annual Technology Baseline, 2018, Storage Calculations

Energy Imbalance Market

Energy Imbalance Markets (EIMs) are specialized wholesale power markets designed to help Control Areas,[29] such as TEP's, to balance the sub-hourly intermittent characteristics of wind and solar power. An EIM aggregates the variability of loads and resources across the footprints of its participating balancing areas and dispatches resources to achieve the least-cost balance of electric demand and supply in real time (e.g., 5- to 15-minute intervals).

In December 2016, Energy and Environmental Economics ("E3") completed a study for TEP, which estimated that joining the California Independent System Operator ("CAISO") Western EIM could have benefits for TEP of approximately $6 million per year (lower bound). Since then, PNM and SRP, which have significant transmission connections with TEP, have announced their intention to join the Western EIM[30]. The expansion of the Western EIM, including parties connected to TEP's system, could improve the Company's access to EIM market opportunities and at the same time non-EIM bilateral trading opportunities are being reduced as others enter the EIM market. Thus, an updated analysis was completed in November 2018, which estimated annual benefits of $13.6 million. Based on these considerations, TEP signed an agreement with the CAISO in May 2019 to join the Western EIM beginning in April 2022.

[29] A Control Area is an electric power system or combination of electric power systems to which a common automatic control scheme is applied in order to instantaneously match all loads and resources at all times.
[30] Arizona Public Service Company, which also has transmission connections with TEP, began participating in the Western EIM in October 2016.

Chapter 6

MARKET AND FUEL ASSUMPTIONS

Modeling the performance of a resource portfolio involves making 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 scenarios to better assess whether a portfolio is robust under varying conditions. Because certain market conditions do not move independently of each other, alternative future scenarios must be identified that capture a range of future conditions yet represent plausible outcomes in terms of the relative movement of different market forces.

For the Final 2020 IRP, TEP will develop a base case set of market assumptions and two alternative future scenarios for modeling the performance of each resource portfolio. Discrete and varying economic drivers that represent three separate forecasts of forward market conditions characterize these three scenarios.

TEP subscribes to Wood Mackenzie's North America Power and Renewables suite of research products. Wood Mackenzie ("WoodMac") is an industry leading research, analysis and consulting firm with expertise in energy related fields including upstream and downstream natural gas markets, coal pricing, as well as power markets. The North America Power and Renewables subscription includes a Long-Term Outlook (LTO), which is a comprehensive integrated forecast of energy demand and supply based on their independent analysis of key economic drivers.

The LTO includes fuel prices by basin and delivery point and the corresponding power market energy and capacity prices at various hubs. In addition, the LTO includes scenarios corresponding to "high" and "low" natural gas prices. TEP intends to use an updated version of the WoodMac LTO as the primary input for future fuel and market prices. Decision No. 76632 requires the IRP to consider a "wide variety of natural gas priced scenarios, therefore, depending on the range between the "high" and "low" scenarios, TEP may consider additional scenarios, to test more extreme conditions.

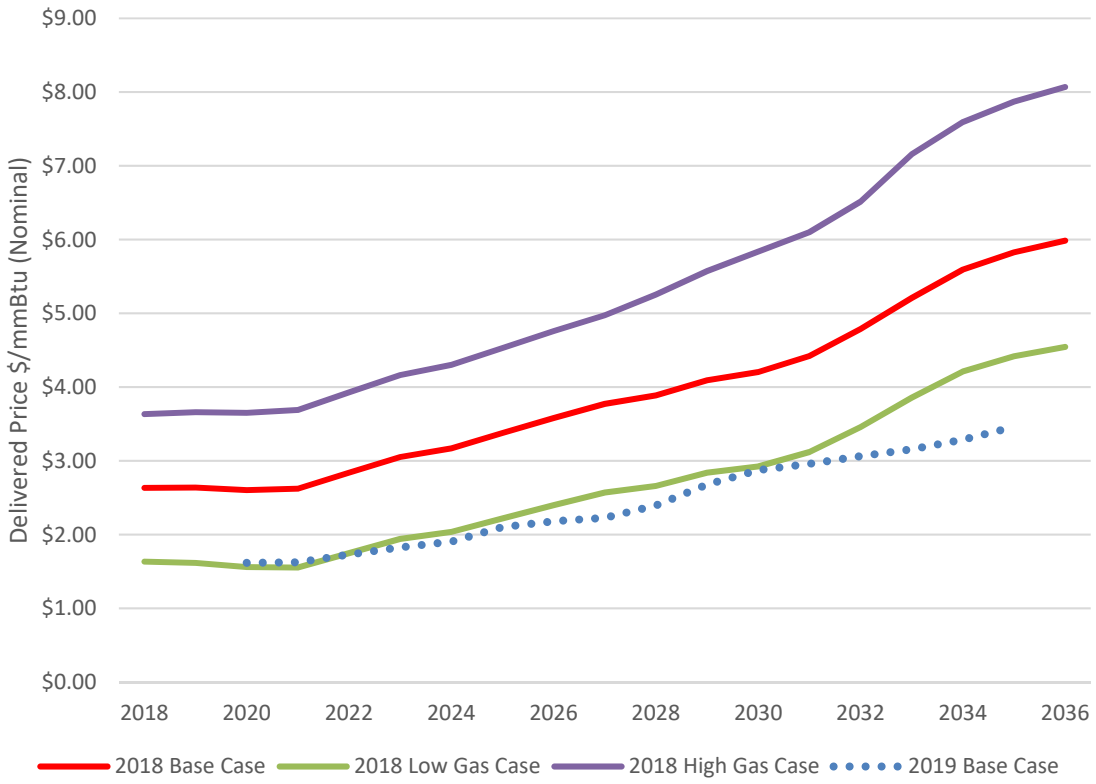
The LTO includes forecasts for CO_2 emission prices for jurisdictions where emission pricing applies (e.g. California). In addition, the LTO includes a scenario[31] in which future Federal regulations result in emission prices for CO_2 emitted from electric generating units. TEP's Final 2020 IRP will include scenarios with and without a Federal program resulting in emission prices for CO_2.

[31] The Wood Mackenzie 2018 H1 LTO includes a "Federal Carbon Case", which implements a $2/short ton price on CO_2 emitted from power plants beginning in 2028, escalating $2/short ton each year thereafter.

Natural Gas Price Forecast

Chart 9 shows WoodMac's 2018 LTO[32] forward price forecast for Arizona delivered natural gas under base case, high case, and low case scenarios along with the 2019 base case LTO[33]

Chart 9 – Natural Gas Price Forecast for Arizona Delivery

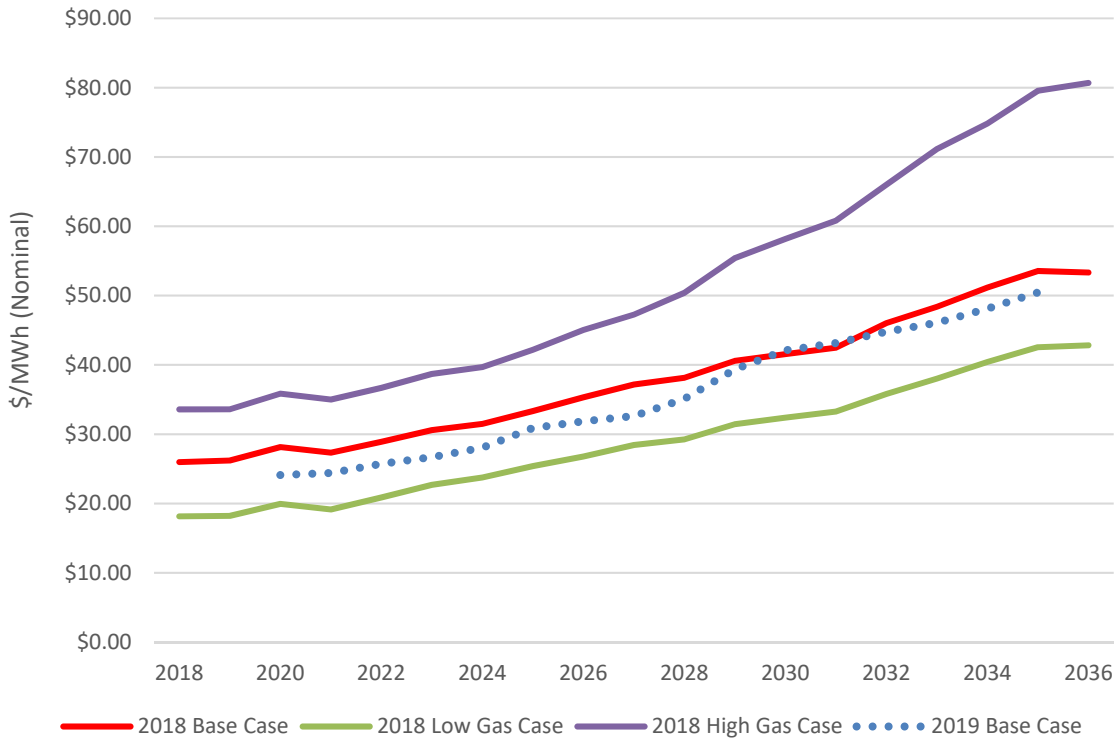


[32] Wood Mackenzie H1 2018 No Federal Carbon Case Long Term Outlook
[33] Wood Mackenzie H1 2019 Long Term Outlook

Palo Verde (7x24) Market Prices

WoodMac's 2018 LTO forward price forecast for 7x24 Palo Verde wholesale market prices is presented in Chart 10 under base case, high case, and low case scenarios along with the 2019 base case LTO.

Chart 10 - Palo Verde (7x24) Market Prices



Chapter 7

RESOURCE OPTIONS AND ECONOMIC ASSUMPTIONS

The starting point for any portfolio analysis is the utility's existing suite of resources. As a vertically integrated utility, TEP is required to have sufficient generation, transmission, and distribution assets to (i) serve customer load, and (ii) for planning purposes, meet load from five years out through the end of the planning period with firm resources (as opposed to relying on short-term market purchases). The vast majority of these assets have long economic lives, and the degree of amortization varies widely.

The treatment of existing resources in the IRP requires close attention to their remaining useful lives to limit the economic impact of simultaneously paying for a resource and its replacement. The Final 2020 IRP will include an evaluation of all existing resources including an assessment of how those resources may be used differently to extract the maximum value out of them until they are no longer needed. A list of the current existing resources, including key modeling assumptions is included in Appendix A.

There is a broad spectrum of potential future resources that could be deployed to meet a specific utility need. For purposes of the Final 2020 IRP, TEP will use the following criteria to identify resources that will be considered as future additions to the portfolio:

- Resources are similar to those that have been successfully deployed at TEP;
- Resources are similar to those that that have been successfully deployed by utilities with characteristics similar to TEPs and for services similar to those needed by TEP; or
- Resources are of particular interest to regulators or stakeholders to evaluate a specific policy objective.

Table 7 provides a brief overview of the types of generating resources that will be considered for evaluation in the resource planning process for the Final 2020 IRP. For each technology type a brief summary of potential risks and benefits are listed. In addition, attributes such as costs, siting requirements, dispatchability, transmission requirements and environmental potential are summarized.

Table 7 - Resource Matrix

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

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

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

To keep the list of potential future resources manageable, TEP has eliminated certain resources from consideration as future portfolio additions due to the low likelihood that those technologies would be implemented in TEP's territory within the 15-year planning horizon. These technologies include:

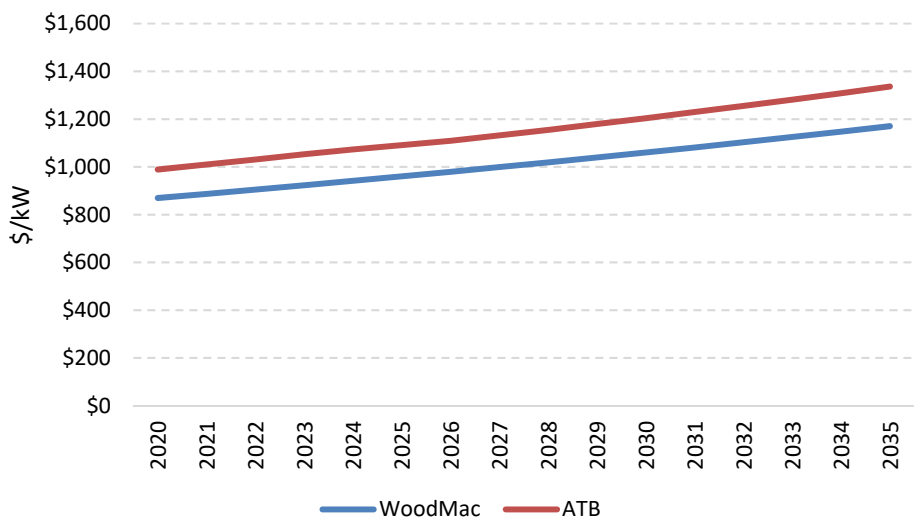
- Conventional Hydroelectric
- Pulverized coal (subcritical or super critical)
- Integrated Gasification Combined Cycle (IGCC)
- Small Modular Nuclear Reactors

However, in the case that a particular technology is bid into an all-source request for proposal issued by TEP, it would be considered equally with all other technologies based on the specific criteria established in the request for proposal.

Comparison of Resources

Generation planning and resource analysis requires reliable, independent, and up-to-date information and data regarding the resources to be considered as future additions to the resource portfolio. For TEP's Final 2020 IRP, data relating to the cost and performance of potential future resources will be based on independent, third-party sources that are widely-used in utility IRPs. Chart 11 through Chart 14 show a comparison of capital cost forecasts, from widely-used third-party sources,[34] for certain thermal and renewable resources. The charts demonstrate the varying range of costs, even within each technology.

Chart 11 - Combustion Turbine Capital Cost Forecast



[34] Wood Mackenzie, *H1 2018 Federal Carbon Case Long Term Outlook;*
National Renewable Energy Laboratory, *2018 Annual Technology Baseline (ATB)*, https://atb.nrel.gov/;
US Energy Information Administration (EIA), *Annual Energy Outlook 2019*, Release date January 24, 2019, https://www.eia.gov/outlooks/aeo/

Chart 12 – Solar Single-Axis Tracking Capital Cost Forecast

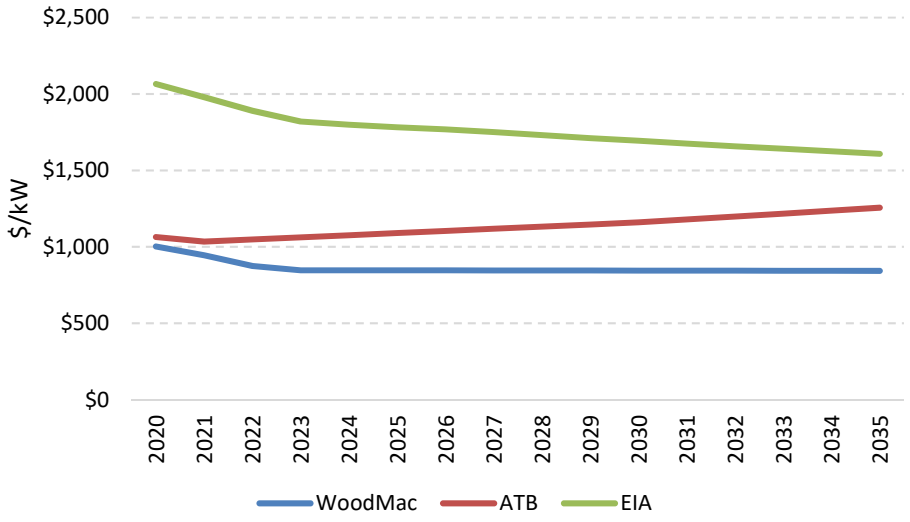


Chart 13 - On-Shore Wind Capital Cost Forecast

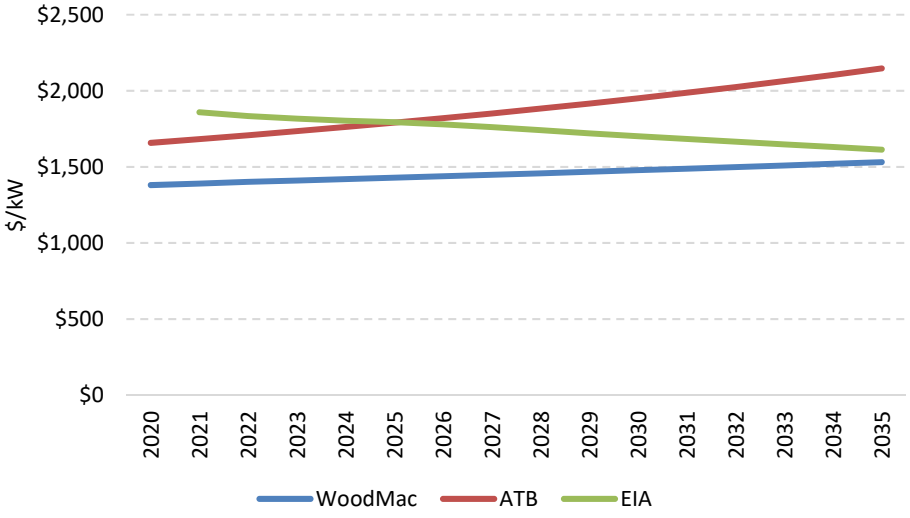
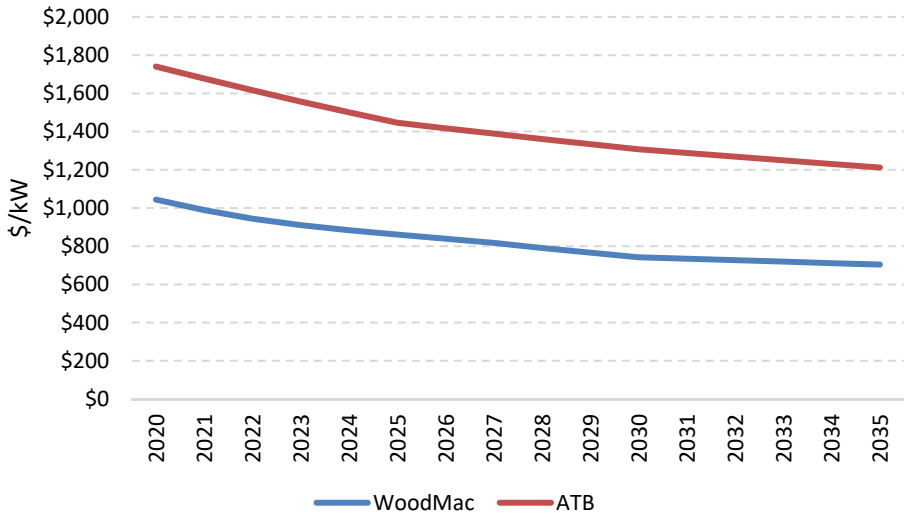


Chart 14 - Battery Storage (4-Hour) Capital Cost Forecast



TEP intends to use an updated version of the WoodMac LTO as the primary source for future capital cost curves (i.e. the change in nominal capital costs over time) in the Final 2020 IRP. TEP will collect and evaluate the most current data from other sources to test the reasonableness of the proposed capital cost inputs[35]. Using the derived capital cost projections for each of the technologies being considered, TEP will calculate yearly nominal capital cost factors for each technology that will be multiplied by the 2019 capital cost to derive the capital cost of that technology in future years. Capital cost factors derived from currently available sources are presented in Appendix B. See Appendix C for a summary of cost and performance data on future resources that will be incorporated into the modeling for the Final 2020 IRP.

TEP will also consider other sources of cost and performance data identified by stakeholders provided those sources are independent (they do not represent an advocacy position), transparent, and have a history of use in utility IRPs.

[35] Decision No. 76632 requires TEP and other load serving entities to include in future IRPs "and analysis of a reasonable range of storage technologies and chemistries; and an analysis of anticipated future energy storage cost declines…"

Transmission and Distribution Assumptions

Transmission Overview

Transmission resources are a key element in TEP's resource portfolio. Adequate transmission capacity must exist to meet TEP's existing and future load obligations. TEP's resource planning and transmission planning groups coordinate their planning efforts to ensure consistency in development of its long-term planning strategy. On a statewide basis, TEP participates in the ACC's Biennial Transmission Assessment (BTA) which produces a written decision by the ACC regarding the adequacy of the existing and planned transmission facilities in Arizona to meet the present and future energy needs of the state in a reliable manner. The Commission concluded in its most recent BTA[36] decision that the existing and planned transmission system is adequate to reliably serve the needs of the state during the study period.

Ten-Year Transmission Plan

TEP annually reviews its Extra High Voltage (EHV) and High Voltage (HV) transmission system to identify upgrades to the existing system, as well as new facilities, to meet system performance requirements based on load and resource assumptions for the following ten years. The result of this plan is a list of "planned" and "conceptual" projects with individual project descriptions.

Generating resource needs that are identified through the IRP process are included in the ten-year transmission plan. Transmission projects that are identified through the ten-year transmission plan are not directly incorporated into the IRP modeling as the Aurora model is run in a "zonal" simulation, meaning that the transfer capability between zones is represented by a single set of values versus multiple, individual paths. However, "planned" transmission projects that are expected to increase the transfer capability between zones are reviewed, and adjustments to the transfer capability are made as appropriate.

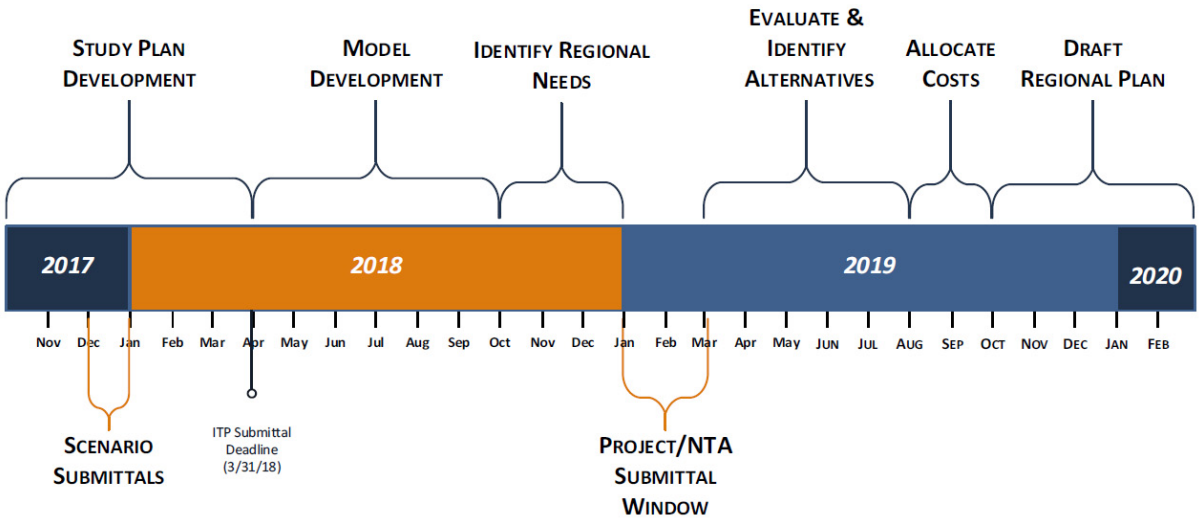
Regional Planning

TEP actively participates in the regional transmission planning and cost allocation process of WestConnect as an enrolled member of the Transmission Owners with Load Service Obligations ("TOLSO") sector in compliance with FERC Order No. 1000 ("FERC Order 1000"). This final rule reforms FERC's electric transmission planning and cost allocation requirements for public utility transmission providers. WestConnect is composed of utility companies providing transmission of electricity in the western United States working collaboratively to assess stakeholder and market needs and develop cost-effective enhancements to the western wholesale electricity market.

[36] Arizona Corporation Commission Tenth Biennial Electric Transmission Assessment for 2018 Through 2027, Docket No. E-00000D,17-0001, November 27, 2018

Preparation for the WestConnect biennial regional transmission planning and cost allocation process covering the period January 1, 2018 through December 31, 2019 began in the fourth quarter of 2017. A schedule for the current planning cycle is presented in Figure 4.

Figure 4 - WestConnect 2018-2019 Planning Cycle Timeline



WestConnect assesses transmission planning models incorporating different scenarios to identify the need for new transmission. The key deliverable is a regional transmission plan that selects regional transmission projects to meet identified reliability, economic, or public policy, (or combination thereof) transmission needs. At the February 13, 2019 meeting of the Planning Management Committee (PMC), the PMC voted to approve the recommendation of the Planning Subcommittee that no regional transmission needs were identified in the current planning cycle.

Therefore, TEP's Final 2020 IRP will not include an assessment of regional transmission projects that could be developed through the WestConnect process.

Other Regional Transmission Projects

Other large projects proposed for interconnection in eastern and southeastern Arizona may influence TEP's long-term resource planning decisions. TEP's Final 2020 IRP will evaluate the progress of and prospects for these projects to be completed and the impact a completed project could have on TEP's resource planning. A list of key regional projects is presented in Table 8.

Table 8 - Regional Transmission Projects

Project Name	Description	Developer	Status
Nogales DC Intertie	150 MW DC, asynchronous interconnection between the electric grids in southern Arizona and the northwest region of Mexico	Nogales Transmission L.L.C an indirect subsidiary of Hunt Power, L.P. and MEH Equities Management Company a subsidiary of UNS Energy Corporation	Certificate of Environmental Compatibility was approved by the ACC in November 2017. Presidential Permit was received in 2018. FERC granted the project authority to sell transmission rights at negotiated rates on the line. Construction will commence pending sufficient subscriptions for service.
SunZia	Double-circuit 500kV line between central New Mexico, near Ancho and the proposed Pinal Central substation near Casa Grande, Arizona.	Southwestern Power Group II/MMR Group	Project approval by New Mexico Public Utilities Commission (PUC) is being held pending determination of a complete and final route. FERC granted the project authority to sell transmission rights at negotiated rates on the line.
Southline	**New Build** - 345kV double-circuit line between the existing Afton Substation, south of Las Cruces, New Mexico, and the existing Apache Substation, south of Wilcox, Arizona **Upgrade** - 230kV double-circuit line between the Apache Substation and the existing Saguaro Substation northwest of Tucson, Arizona. The upgrade section will also interconnect at TEP's Vail, Tortolita and DeMoss Petrie substations.	Southline Transmission, L.L.C., a subsidiary of Hunt Power	Certificate of Environmental Compliance was approved by the ACC in February 2017. New Mexico PUC approval was received in August 2017. FERC granted the project authority to sell transmission rights at negotiated rates on the line. Project design of the Upgrade portion is under way with WAPA. Construction will commence pending sufficient subscriptions for service and land acquisition. TEP is working with the project developer on interconnections to the TEP system at three locations
Western Spirits Clean Line	Approximately 140-mile transmission from northwestern New Mexico to the San Juan Substation (at the San Juan Generating Station).	Renewable Energy Transmission Authority of New Mexico ("RETA") and Pattern Development	Approval of the route was received from RETA. Bureau of Indian Affairs issued a Grant of Easement in 2017. FERC granted Pattern authority to sell transmission rights on the line at negotiated rates.

Distribution Planning

TEP is continually modernizing the distribution grid in order to operate the grid more safely, efficiently, and reliably while integrating new energy technologies. Current modernization programs include; the installation of a foundational communication network, the implementation of an Advanced Distribution Management System (ADMS), a two-way metering system, an enhanced asset management program, and the evaluation of micro-grids. An ADMS is the central software application that will provide distribution supervisory control and data acquisition, outage management and geographical information in a single interface providing improved visibility to TEP operations personnel. By combining the information from these systems into a single view, an electrical distribution system model can be created for both real-time applications and planning needs. The single view improves situational awareness of the distribution system by providing additional information to operators that was not readily available in the past. Access to more information and system data will allow the opportunity for more in-depth analysis of evolving customer energy use patterns, which can be used to evaluate how customers' use of solar and storage, and charging electric vehicles impacts supply-side resource decisions.

Further integration of distribution, transmission, and supply-side planning will be a continuous, long-term process. Some of the initial steps TEP has taken in regard to this integration is the creation of an internal Energy Storage Task Force (ESTF). TEP formed the ESTF to continuously evaluate and coordinate energy storage opportunities. The ESTF discusses utility-scale and customer-sited projects. Examples of utility-scale projects include three battery installations currently connected to TEP's system and TEP's planned 30 MW Wilmot Energy Center battery installation. Future storage projects being evaluated include third party proposed projects in TEP's interconnection queue and potential projects throughout the TEP distribution network where energy storage could address power quality issues. Examples of customer-sited projects discussed by the ESTF include large customer installations such as at military bases to support resiliency initiatives, and a joint project between TEP and EPRI called the Resource Aggregation and Integration Network ("Project RAIN"). Project RAIN is a pilot program to explore how distributed generation and energy storage might be combined with flexible loads (such as electric vehicle chargers or smart thermostats) to respond optimally to dynamic system needs.

In addition, TEP has incorporated energy storage as an option for addressing identified transmission and distribution needs (See Energy Storage, Chapter 5). The Final 2020 IRP will describe how TEP intends to utilize technology to add more sensing and measurement devices and new methods for managing and operating the distribution system, and how the use of this technology can be integrated into the Company's broader resource planning.

Chapter 8

PORTFOLIO SELECTION

This Chapter provides a description of how TEP intends to identify the portfolios that will be analyzed in the 2020 Final IRP. The following conditions must be represented in at least one of the portfolios to be analyzed, according to Decision No. 76632:

- The addition of fossil fuel resources is no more than 20% of all the resource additions.
- Energy storage capacity in the portfolio equals 20% of system peak demand, at least 50% "clean energy resources,"[37] with at least 25 MW of these "clean energy resources" as renewable biomass operating at a minimum 60% capacity factor, and at least 20% of DSM.

Based on previous IRPs and given the general public interest in adoption of renewable and energy storage technology, TEP anticipates the following portfolios will be of interest.

- High energy storage portfolio
- High renewable energy portfolio
- No coal portfolio

In addition to requiring the two portfolios mentioned above, Decision No. 76632 requires TEP to hold a public workshop within 60 days after filing this PIRP for the sole purpose of discussing each portfolio that will be analyzed as part of the Final 2020 IRP ("Portfolio Workshop"). TEP intends to utilize the Portfolio Workshop to present the results of the Resource Adequacy Study discussed in Chapter 2. The Resource Adequacy Study will be key in identifying both the timing of additional resources as well as the specific reliability requirement that additional resources are needed to address.

As discussed in Chapter 1, TEP has formed an IRP Advisory Council to guide its development of the Final 2020 IRP. Through monthly in-depth discussions with the Advisory Council, TEP anticipates the identification of numerous portfolio options. TEP will model the portfolios that are of interest to the Advisory Council members and discuss the results with the members. Based on the results of the Resource Adequacy Study and discussion during the Portfolio Workshop and Advisory Council meetings, TEP will select a set of portfolios to be analyzed for the Final 2020 IRP.

[37] Clean energy resources refer to resources that operate with zero net emissions beyond that of steam.

Chapter 9

FUEL, MARKET AND DEMAND RISK ANALYSIS

For the Final 2020 IRP, TEP plans to develop explicit market risk analytics for each candidate portfolio through the use of computer simulation analysis using Aurora. Specifically, a stochastic based dispatch simulation will be used to develop a view on future trends related to fuel prices,[38] wholesale market prices, and retail demand. The results of this modeling will then be employed to quantify the risk uncertainty and evaluate the cost performance of each portfolio. This type of analysis ensures that the selected portfolio not only has a reasonable expected cost, but also is robust enough to perform well against a wide range of possible load and market conditions.

As part of the Company's Final 2020 IRP, TEP plans to conduct risk analysis around the following key variables:

- Natural Gas Prices
- Wholesale Market Prices
- Retail Load and Demand
- Delivered Coal Prices
- GHG Emission Prices

TEP currently has ownership shares in four coal-fired power plants in Arizona and New Mexico; however, two of those plants (Navajo and San Juan) are scheduled for retirement in the early part of the planning period. Therefore, the coal price sensitivity analysis will be focused on coal pricing for Springerville and the Four Corners Power Plant. TEP plans to model coal prices based on contract indices and escalators that are driven by the coal market outlook to establish coal price projections for the TEP fleet.

[38] Both natural gas and coal.

Chapter 10

CLOSING

This PIRP presents TEP's initial set of assumptions, sources and methodologies to be used in developing the Final 2020 IRP. As such, TEP views this report as the "starting point" for what we intend to make a highly interactive and transparent process of shaping Tucson's energy future. TEP will solicit input from a broad cross-section of interested parties in order to frame a future that delivers high reliability at an affordable rate, while meeting aggressive environmental performance standards.

APPENDIX A

EXISITING RESOURCES

Tucson Electric Power Preliminary Integrated Resource Plan
Appendix A
Existing Resources

Design Characteristics

Resource	Unit Capacity (MW)	Ownership Percentage	TEP Capacity (MW)	Year In Service	Retirement Date	Fuel Supply	Environmental Controls			
							SO2	NOx	PM	Hg
Coal										
Four Corners 4 (TEP)	785	7%	55	1969	Jul-2031	Navajo Mine (New Mexico), Jul. 2031	WFGD	SCR	FF	WFGD, FF, CaBR2
Four Corners 5 (TEP)	785	7%	55	1970	Jul-2031	Navajo Mine (New Mexico), Jul. 2031	WFGD	SCR	FF	WFGD, FF, CaBR2
San Juan 1 (TEP)	340	50%	170	1976	Jun-2022	San Juan Mine (New Mexico), June 2022	WFGD	SNCR	FF	ACI, FF
Springerville 1	387	100%	387	1985	Dec-2045	El Segundo (New Mexico), Dec. 2020	SDA	LNB SOFA	FF	ACI, FF, CaBR2
Springerville 2	406	100%	406	1990	Dec-2050	El Segundo (New Mexico), Dec. 2020	SDA	LNB SOFA	FF	ACI, FF, CaBR2
Natural Gas Combined Cycle										
Gila River Unit 2	550	100%	550	2001	Dec-2048	Kinder Morgan/ Transwestern	NA	SCR	NA	NA
Gila River Unit 3	550	75%	413	2001	Dec-2048	Kinder Morgan/ Transwestern	NA	SCR	NA	NA
Luna Energy Facility	555	33%	185	2006	Dec-2051	Kinder Morgan	NA	SCR	NA	NA

| ACI – Activated Carbon Injection | $CaBR_2$ – Calcium bromide (added to coal) | FF – Fabric filter (Bag House) | LNB SOFA – Low NOx burners - Separated over fire air |

| SDA – Spray Dryer Absorber | SCR – Selective Catalytic Reduction | SNCR – Selective non-Catalytic Reduction | WFGD – Wet Flue Gas Desulfurization | NA – Not Applicable |

Operating Characteristics

Resource	Heat Rate (MMBtu/ kWh)	Forced Outage Rate (%)	Must Run (Months)	Ramp Rate (MW/min)	Min Up Time (hours)	Min Down Time (hours)	Emission Rates (lbs/mmBtu)				
							CO2	SO2	NOX	Hg	PM10
Coal											
Four Corners 4 (TEP)	9,800	16	Jan-Dec	6	16	8	205	0.049	0.098	0.000002	0.0100
Four Corners 5 (TEP)	9,800	16	Jan-Dec	6	16	8	205	0.028	0.098	0.000002	0.0100
San Juan 1 (TEP)	10,117	18	Jan-Dec	1	24	12	210	0.033	0.050	0.000001	0.0060
Springerville 1	10,053	6.75	Jan-Dec	3	24	24	210	0.266	0.169	0.000006	0.0090
Springerville 2	9,486	5.75	Jan-Dec	4	24	24	210	0.267	0.176	0.000006	0.0090
Natural Gas Combined Cycle											
Gila River Unit 2	7,280	5		6	10	10	119	0.0006	0.008	NA	0.0000
Gila River Unit 3	7,400	5		7	10	10	119	0.0006	0.008	NA	0.0040
Luna Energy Facility	7,250	5		16	10	10	119	0.0006	0.011	NA	0.0040

Tucson Electric Power Preliminary Integrated Resource Plan
Appendix A
Existing Resources

Design Characteristics

Resource	TEP Capacity (MW)	Year In Service	Retirement Date	Fuel Supply	NOx Controls
					NOx
Natural Gas Steam Turbine					
H. Wilson Sundt ST3 (Irvington)	104	1962	Dec-2030	Kinder Morgan	LNB
H. Wilson Sundt ST4 (Irvington)	156	1967	Dec-2048	Kinder Morgan	LNB SOFA
Natural Gas Combustion Turbine					
H. Wilson Sundt GT1 (Irvington)	25	1972	Dec-2027	Kinder Morgan	None
H. Wilson Sundt GT2 (Irvington)	25	1972	Dec-2027	Kinder Morgan	None
DeMoss Petrie GT (TEP)	75	2001	Dec-2046	Southwest Gas	DLN1
North Loop 1-3	75	1972	Dec-2027	Southwest Gas	None
North Loop 4	21	2001	Dec-2046	Southwest Gas	Water Injection
Natural Gas RICE					
RICE 1-10	182	2020	Dec-2050	Kinder Morgan	SCR

| LNB – Low NOx Burner | LNB SOFA – Low NOx Burners - Separated Over Fire Air | DLN1 - Dry Low NOx Burner |SCR – Selective Catalytic Reduction |

Operating Characteristics

Resource	Heat Rate (MMBtu/ kWh)	Forced Outage Rate (%)	Must Run (Months)	Ramp Rate (MW/min)	Min Up Time (hours)	Min Down Time (hours)	Emission Rates (lbs/mmBtu)				
							CO2	SO2	NOX	Hg	PM10
Natural Gas Steam Turbine											
H. Wilson Sundt ST3 (Irvington)	10,900	5		2	8	6	119	0.0035	0.199	NA	0.004
H. Wilson Sundt ST4 (Irvington)	10,167	7.5	May-Oct	5	8	6	119	0.0006	0.160	NA	0.004
Natural Gas Combustion Turbine											
H. Wilson Sundt GT1 (Irvington)	15,000	5		5	8	6	119	0.0035	0.177	NA	0.008
H. Wilson Sundt GT2 (Irvington)	15,000	5		5	8	6	119	0.0035	0.211	NA	0.008
DeMoss Petrie GT (TEP)	11,500	5		5	2	2	119	0.0035	0.044	NA	0.007
North Loop 1-3	15,000	5		5	2	2	119	0.0006	0.166	NA	0.008
North Loop 4	10,500	5		5	2	2	119	0.0006	0.166	NA	0.008
Natural Gas RICE											
RICE 1 & 2	8,190	2	Jan-Dec	10	0	0	119	0.0006	0.010	NA	0.012
RICE 3 & 4	8,190	2	May-Oct	10	0	0	119	0.0006	0.010	NA	0.012
RICE 5-10	8,190	2		10	0	0	119	0.0006	0.010	NA	0.012

APPENDIX B

NEW RESOURCE COST FACTORS

Tucson Electric Power Preliminary Integrated Resource Plan
Appendix B
New Resources Cost Factors

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

Base Year: 2017

APPENDIX C

NEW RESOURCE COST AND PERFORMANCE DATA

Tucson Electric Power Preliminary Integrated Resource Plan
Appendix C
New Resource Cost and Performance Data

Input Assumption	Unit	Gas CT - Aero	Gas CT - Frame	Gas NGCC - Conventional Wet Cooled	Reciprocating Engines	Nuclear	Solar Thermal Six Hour Storage	Solar PV - Fixed Tilt (1-20 MW)	Solar PV - Tracking (>20 MW)	Wind - Onshore	Battery Storage
Capacity Degradation	%/yr	0.05%	0.05%	0.00%	0.00%	0.20%	1.00%	0.50%	0.50%	0.00%	1.00%
US Avg Installed Cost	$/kW	$ 1,250	$ 825	$ 1,000	$ 1,000	$ 7,500	$ 6,925	$ 1,850	$ 1,250	$ 1,350	$ 1,477
Fixed O&M	$/kW-yr	$ 29.30	$ 30.05	$ 33.30	$ 12.00	$ 70.00	$ 80.00	$ 10.00	$ 13.00	$ 30.00	$ 9.00
Variable O&M	$/MWh	$ 3.50	$ 3.75	$ 2.00	$ 4.50	$ 6.00					
Heat Rate	Btu/kWh	9,800	10,500	7,200	8,500	10,400					
Property Tax	%	1.00%	1.00%	1.00%	1.00%	1.00%	0.50%	0.50%	0.50%	0.50%	0.50%
Insurance	%	0.50%	0.50%	0.50%	0.50%	0.50%	0.01%	0.25%	0.01%	0.01%	0.01%
Resource Life	yrs	30	30	30	30	30	35	20	20	30	20
MACRS Term	yrs	20	20	20	20	20	5	5	5	5	5

Base Year: 2017