20-YEAR CONCEPTUAL SCENARIO REPORT

For the State of Colorado

To comply with

Rule 3627
of the
Colorado Public Utilities Commission
Rules Regulating Electric Utilities

February 1, 2022

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ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Term
2022 Scenario Report	2022 20-Year Conceptual Scenario Report
Black Hills or BHCE	Black Hills Colorado Electric, LLC d/b/a Black Hills Energy
CCPG	Colorado Coordinated Planning Group
CEII	Critical Energy Infrastructure Information
CEP	Clean Energy Plan
Commission or CPUC	Colorado Public Utilities Commission
Companies	Black Hills, Tri-State and Public Service
Company	Black Hills, Tri-State or Public Service
CPCN	Certificate of Public Convenience and Necessity
CPWG	Conceptual Planning Work Group
DER	Distributed Energy Resources
DG	Distributed Generation
ERP	Electric Resource Planning
EV	Electric Vehicle
FERC	Federal Energy Regulatory Commission
HVDC	High Voltage Direct Current
IOU	Investor Owned Utility
MW	Megawatts
NERC	North American Electric Reliability Corporation
Pathway Project	Colorado's Power Pathway Project
Public Service or PSCo	Public Service Company of Colorado
PV	Photovoltaic
RES	Renewable Energy Standard
Roadmap	Colorado Greenhouse Gas Pollution Reduction Roadmap
RTO	Regional Transmission Operator
SPP	Southwest Power Pool
SB07-100	Colorado Senate Bill 07-100
SCADA	Supervisory Control and Data Acquisition
Tri-State or TSGT	Tri-State Generation and Transmission Association, Inc.

Acronym or Abbreviation	Term
WECC	Western Electricity Coordinating Council

I. Executive Summary

Rule 3627, which was adopted by the Colorado Public Utilities Commission ("CPUC" or "Commission") in 2011, requires the preparation and biennial submission of 10-year transmission plans and conceptual long-range scenarios that consider a 20-year transmission planning horizon. The first 10-year transmission plan was submitted jointly by Black Hills Colorado Electric, LLC d/b/a Black Hills Energy ("Black Hills" or "BHCE"), Public Service Company of Colorado ("Public Service" or "PSCo"), and Tri-State Generation and Transmission Association, Inc. ("Tri-State" or "TSGT") (each referred to individually as a "Company" and collectively as the "Companies") on February 1, 2012. In 2012, the Companies were not required to submit 20-year conceptual scenarios. The first 20-Year Conceptual Scenario Report was filed in 2014, with subsequent reports filed in 2016, 2018 and 2020. This 2022 20-Year Conceptual Scenario Report ("2022 Scenario Report") has been jointly prepared and is being submitted by the Companies.

Scenario-based analysis is a technique for considering uncertainties that may impact decision-making in today's world based on potential future conditions. It may be useful when evaluating long-term investments despite the inability to accurately predict future conditions. While it is impossible to predict the future with complete accuracy, scenario development can assist with the identification of strategic choices that utility planners, project developers, regulators, and advocates may reasonably need to consider over a 20-year time period.

The scenarios offered in this filing include three provided by Black Hills, four from Tri-State, and four from Public Service. The Companies' scenarios generally address what the future state of the transmission system might look like in Colorado based on the occurrence of different factors or events, including changes in generation mix, load growth, load demand, social, economic, generation technology, transmission assumptions, and changing public policy requirements.

In addition to the Companies' scenarios, the Colorado Coordinated Planning Group ("CCPG") evaluated a scenario through the Conceptual Planning Work Group ("CPWG"). As with all CCPG activities, the CPWG was open to all interested stakeholders.

II. Overview of the Colorado 20-Year Conceptual Scenarios Analysis and Model Development

The 2022 Scenario Report identifies and assesses various credible future alternatives and provides information that can be used individually or in conjunction with utilities, coordinated planning organizations, lawmakers, and other industry stakeholders to further evaluate the ongoing transmission needs in the State of Colorado. These scenarios describe a set of economic, technological, and societal circumstances that the Companies believe could conceivably come to pass. Transmission planning study models are not developed to represent the 20-year conceptual scenarios.

Consistent with the requirements of Rule 3627(e), the Companies' conceptual scenarios discussed herein include, at a minimum:

- Reasonably foreseeable future public policy initiatives;
- Possible retirement of existing generation due to age, environmental regulations, or economic considerations;
- Emerging generation, transmission, and demand limiting technologies;
- Various load growth projections; and
- Studies of any scenarios requested by the Commission in the previous biennial review process.

III. Company Perspectives on Conceptual Scenarios Analysis

A. Black Hills

Black Hills recognizes the potential for 20-year conceptual planning to contribute to the development of 10-year transmission plans. While not all utilities and planning organizations will always agree about whether a particular future scenario is probable or realistic, simple consideration of the impacts of any and all given scenarios adds value to each Company's planning process. One distinction that sets Black Hills apart from some other entities in Colorado is that, as an electric utility under the jurisdiction of both the Federal Energy Regulatory Commission ("FERC") and the CPUC, we must consider potential future federal and/or state public policy initiatives that may not directly impact

other entities. When considering the large number of potential future scenarios for this report, Black Hills also had the opportunity to explore and draw on the implications of various driving factors experienced by its affiliate electric utilities in Wyoming and South Dakota.

It is Black Hills' view that much of the planning work that previously has been performed within the various utilities and regional planning groups and reported in the preceding Rule 3627 20-Year Scenario Reports generally suggested transmission development to enhance reliability and connect planned and potential resources located along the southern and eastern part of Colorado to the Denver area load center. The increase of photovoltaic ("PV") and distributed generation ("DG") interconnections will have a growing impact on future transmission-scale renewables. The magnitude and timing of future transmission expansion, as well as the degree of participation from utilities and other entities, could be driven by any combination of factors mentioned in Rule 3627(e).

For the purposes of this filing, Black Hills provided updates to scenarios previously approved by the Commission. These scenarios provide dissimilar yet significant impacts to the transmission system while remaining plausible. There are no specific transmission plans associated with the scenarios described herein, but rather a general discussion of potential impacts and considerations.

Black Hills Scenarios

Included below is a brief summary of each of the scenarios explored by Black Hills. Full descriptions, including rationale, drivers and assumptions behind each scenario, can be found in Appendix A.

BHCE Scenario #1: Significant penetration of Distributed Energy Resources

This scenario recognizes potential increased penetration of Distributed Energy Resources ("DER"). This scenario focuses on development and growth of DER technologies. As public interest in DER continues to increase, the increased output can have an impact on system voltage and line flows that are much different than present-day system conditions. Increased efficiency and public interest in DER should be considered in transmission planning assessments and incorporated into transmission plans as appropriate. Recently, North American Electric Reliability Corporation ("NERC") has

taken an increased interest in DER and its potential for penetration on the transmission system through distribution transformers. The increased amounts of renewable resources on the distribution side are causing concerns for potential impacts to voltage and protection systems. Efforts have begun for tracking DER, especially on the distribution system, and studying its impact on the transmission system to continue assessing potential impacts of various levels of penetration.

BHCE Scenario #2: Significant Increase in End-Use Electrification

The scenario explores the impacts of substantial demand growth across the system, as well as a more pronounced demand peak due to widespread electrification of end-use processes such as manufacturing and transportation. This load growth would be pervasive across the state but particularly disruptive in urban areas, creating challenges in reliably delivering energy to meet the demand, but also managing potentially problematic power quality or stability issues. Peak demand growth as well as consumption pattern changes in areas of probable load development should be considered in transmission planning assessments and incorporated into transmission expansion plans as appropriate. Infrastructure improvements and expansions should be considered in planning assessments as the need for wider spread load increases, e.g., electric vehicle ("EV") charging stations at rest stops in remote areas.

BHCE Scenario #3: Significant Increase in Renewable Energy Resources and Battery Storage

This scenario considers the impact of an increased capacity of reduced carbon renewable energy resources and the changes of potential voltage profiles and the possible system changes in power flow. The various power output profiles of solar and wind generation, in conjunction with battery storage, can have unique impacts on the system voltages and flows when compared to current-day nonrenewable energy resources. The performance of increased renewable energy capacity and battery storage should be considered in transmission planning as appropriate. Battery storage as a standalone solution also should be considered as appropriate as advancements in technology improve battery life expectancy and cost-effectiveness.

B. Tri-State

Tri-State brings a unique perspective to the 20-year conceptual scenario planning process under Commission Rule 3627(e). While Black Hills and Public Service are investor-owned, vertically integrated electric utilities providing retail electric service in Colorado, Tri-State is a not-for-profit, generation and transmission cooperative providing wholesale electric power to its 42 Utility Members located in four states: Colorado, Nebraska, New Mexico, and Wyoming.

Unlike Black Hills and Public Service, Tri-State is a regional power provider and its transmission system is designed and operated without specific regard to individual state boundaries. Rather, Tri-State operates an integrated, interconnected, interstate transmission system to deliver reliable, affordable, and economic power to its Utility Members. There also are generation resource differences that influence Tri-State's long-range conceptual transmission scenario perspectives, as compared to other utilities. Tri-State's generation resources are located in Colorado, New Mexico, Wyoming, and Arizona and require an interstate transmission system that efficiently moves that power to its Utility Members in Colorado and elsewhere.

In addition to these fundamental differences in transmission system and generation resource considerations, Tri-State faces other considerations that are the same or similar to those that apply to Black Hills and Public Service, including compliance with Colorado's Renewable Energy Standard, dynamic market forces, a changing resource mix driven by federal and state legislative and public policy developments, and expanding deployment of distributed generation and other technologies.

Tri-State's view of the long-range conceptual future is not limited to possible developments in Colorado and must consider the load-serving, reliability, economic, social, and technological needs of all of its Utility Members and the states in which they are located. All of these considerations influence Tri-State's conclusions with respect to what may constitute "credible alternatives" for purposes of 20-year conceptual scenarios.

Tri-State's 2022 conceptual scenarios are summarized below. Full descriptions, including rationale, drivers and assumptions behind each scenario, can be found in Appendix B.

Tri-State Scenarios

In developing its scenarios for inclusion in the 2022 Rule 3627 filing, Tri-State considered key legislative, public policy, industry, and technology drivers that are likely to influence – possibly to a significant degree – the operation and evolution of Colorado's transmission system over the course of the next 20 years.

Drivers identified in 2022 have many similarities to those discussed in Tri-State's 2020 20-Year Conceptual Scenarios. The increasing role of distributed energy resources discussed in 2022 Scenario 1 is consistent with a similar discussion in the 2020 Scenario 1. Likewise, increased east-west interconnection discussed in 2022 Scenario 2 is consistent with a similar discussion in the 2020 Scenario 2, and 2022 Scenario 3, Increased Energy Storage, is consistent with a similar discussion in the 2020 Scenario 3. It is not surprising that these scenarios continue to be relevant in the 20-year conceptual context. 2022 Scenario 4, 100% Renewable Energy by 2050, was not discussed in the 2020 20-Year Conceptual Scenarios, and is being included this year to reflect new possibilities related to recent legislation and policy positions in Colorado.

TSGT Scenario #1: Increased Role of Distributed Energy Resources

DER continue to play an increasing role in Colorado's energy mix. This scenario focuses on the growth of distributed energy technologies such as solar photovoltaic generation, advancements in energy storage, and increased interest in and deployment of other distributed resources such as community wind, geothermal, biomass, small and micro hydropower, coal mine methane, synthetic gas produced by pyrolysis of municipal solid waste, and recycled energy, as well as associated public policy developments. This scenario assumes continued and significant advancement and growth of such resources coupled with low load growth and higher efficiency, and considers the potential impact of such resources on the transmission system.

TSGT Scenario #2: Increased East-West Interconnection

This scenario focuses on increased coordination and transfer capabilities between the Eastern and Western Interconnections. This scenario focuses specifically on the potential for new DC-Tie facilities, improvements to existing DC-Tie facilities, and the construction of new DC transmission lines. Tri-State's participation in the Western Energy Imbalance Service, and the Southwest Power Pool's ("SPP") approval of terms and conditions to expand its regional transmission organization footprint into the Western Interconnection further increase the relevance of this scenario.

TSGT Scenario #3: Increased Energy Storage

Energy storage will likely play an increasing role in Colorado's energy mix. This scenario assumes significant advancement and growth of energy storage technology and considers the potential impact of such resources on the transmission system. In addition to serving as a resource to meet peak demand, energy storage also has important implications for transmission. In particular, energy storage, in appropriate cases, has the potential to defer or replace more traditional transmission projects. While energy storage costs have been falling quickly, energy storage is currently a relatively expensive way to meet these needs, and the energy storage capacities necessary to address transmission issues are generally very large. Nevertheless, should the price of energy storage continue to fall, storage may become a more significant component of Tri-State's transmission system planning. If this becomes the case, some new traditional transmission projects, such as those related to congestion relief, could be deferred or modified to the extent that a more cost-effective energy storage solution exists. While storage is unlikely to replace transmission projects primarily related to serving new load, it may have a substantial effect on other types of projects to the extent that storage can serve as an alternative.

TSGT Scenario #4: 100% Renewable Energy by 2050

Renewable Energy will play an increasing role in Colorado's energy resource mix. This scenario assumes significant advancement and growth of renewable energy and energy storage technology and considers the potential impact of such resources on the transmission system. This scenario focuses on the growth of renewable energy resources such as solar PV, geothermal, wind, biomass (from plants), and hydro power.

C. Public Service

Public Service, one of four utility-operating company subsidiaries of Xcel Energy Inc., is an investor-owned utility ("IOU") serving approximately 1.5 million electric customers in the State of Colorado. Public Service accounts for approximately 50% of the state's electric sales. Its electric system peaks in the summer with a 2021 peak customer demand of approximately 7,200 Megawatts ("MW"). The entire Public Service transmission network is located within the State of Colorado and consists of nearly 5,000 circuit miles of transmission lines. Colorado is on the eastern edge of the Western Electricity Coordinating Council ("WECC") region, also referred to as the Western Interconnection, which operates asynchronously from the Eastern Interconnection. The Public Service transmission system has an interconnection point with the transmission system of another Xcel Energy operating company, Southwestern Public Service Company, since December 31, 2004, via a jointly owned tie line with a 210 MW High Voltage Direct Current ("HVDC") back-to-back converter station. The Public Service retail service territory includes the Denver-Boulder metro area, as well as the I-70 corridor to Grand Junction, the San Luis Valley, Greeley, Sterling, and Brush. The Company's largest retail electric customer is EVRAZ North America, an industrial steel mill located in Pueblo.

Public Service participates in CCPG, WestConnect, and WECC planning forums, including the subcommittees and working groups that perform transmission scenario analyses. Scenario outlooks differ from 10-year transmission analyses because the number of unknown factors to consider increases significantly with each year into the future. While 10-year plans tend to identify specific or conceptual transmission projects, the longer-term scenario analysis generally results in narrative descriptions of what major drivers to the power supply market might look like from a transmission perspective in the future. These drivers include generation mix, load growth, load demand, transmission assumptions, and pending public policy requirements. Potential impacts to the transmission system are not described in terms of specific projects, but by conceptual descriptions of different drivers and scenarios that may impact transmission.

Scenario investigation can be informative to decision makers, especially during times of high uncertainty and risk as a result of factors such as uncertain economic conditions, changing environmental policy priorities, changes in penetration of renewable energy mix, and changes in efficiency standards. In the utilities industry, 10-year transmission planning analysis is sometimes referred to as "just-in-time planning" because the average time to analyze, site, permit, and construct transmission facilities to meet a known need is approximately seven to 10 years. Longer-term scenario analyses can help provide indicators and drivers that could prompt changes in the transmission solutions. This allows decision makers to make better-informed decisions for long-term based assets.

Public Service believes that conceptual scenario analysis also has helped promote greater integration between transmission planning and generation planning, as demonstrated by the Company's application for Commission approval of a Certificate of Public Convenience and Necessity ("CPCN") for Colorado's Power Pathway Project (the "Pathway Project"), an approximately 560-mile 345 kV loop transmission project on the Eastern Plains, and its 2021 Electric Resource Plan ("ERP") and Clean Energy Plan ("CEP").[1] Projects identified in the 10-year planning process, even though conceptual, have helped inform the Company's proactive approach to transmission planning ahead of the 2021 ERP and CEP. By advancing these conceptual plans ahead of the resource planning process, Public Service provided stakeholders, including developers and communities, advanced notice of the Company's need to expand the transmission system to meet public policy requirements such as SB07-100 and SB19-236. While these policies will drive the Company's near-term planning and investment cycle, the 20-year scenarios will help inform the Company's efforts as it monitors developments that will come after the major compliance milestone of 2030 and toward a carbon-free electric system by 2050, consistent with Public Service's goals and Colorado policy.

In March 2021, Public Service filed its 2021 ERP and CEP in Proceeding No. 21A-0141E to implement the requirements of Senate Bill 19-236. This plan laid out Public Service's vision to transform its coal generation fleet and dramatically expand the use of renewable

[1] Colorado's Power Pathway Project is pending before the CPUC in Proceeding No. 21A-0096E. The Company's 2021 ERP and CEP is pending before the CPUC in Proceeding No. 21A-0141E.

energy in Colorado. In a partial settlement agreement filed in the 2021 ERP and CEP in November 2021, Public Service provided planned generation capacity data for 2030, while providing additional anticipated directional changes in capacity through 2050. This information is provided in the table below. While capacity data past 2030 does not have the same level of certainty as that contained within the planning period, it is instructive in demonstrating how capacity changes are currently expected to occur. The 2042 data included in this table aligns with the 20-year period in this Report.

Resource Type	**2030 Planned Capacity (MW)**	**2042 Directional Analysis (MW)**
Coal	500	0
Firm Dispatchable Resources (including combined cycle, combustion turbine, pumped hydro, and battery storage)	6,055	8,209
Utility-Scale Solar	4,701	6,147
Wind	5,888	6,979

Public Service Long-Term View

Public Service continues to be interested in elements of the future scenarios that were described in the 2020 Scenario Report. Because potential future scenarios are numerous, and due to the uncertainties mentioned above, the long-term view of the build-out of the state's transmission system is uncertain. Public Service's generation and transmission systems sit at the precipice of transformational change driven by recent developments in policies enacted by the state and plans for which the Company is seeking Commission approval. These new elements – the Pathway Project and the 2021 ERP and CEP – have given better shape to Public Service's view of the future state of Colorado's transmission system over the next decade and have influenced changes to the scenarios that Public Service puts forward in this 20-Year Report. Based on the Company's goals, interest from customers and policymakers, and driven by technology change, there is one fundamental priority that Public Service anticipates will drive the next 20 years of change in the electric sector in Colorado: decarbonization. Nevertheless, while the approval and implementation of these near-term plans will drive

change for Public Service through 2030, the Company still sees longer-term uncertainty driven by policy, technology, and consumer interest. The scenarios identified by Public Service in this report help provide alternative viewpoints of a future that has the common destination of a carbon-free electric system.

Transmission expansion is a major component of the transformation of Colorado's electric sector across Public Service's four scenarios. Based on these scenarios, Public Service sees four common elements of transmission development that are likely to be needed in Colorado over the next 20 years. These elements include: 1.) increased transmission to deliver energy within the growing Front Range load center; 2.) increased transmission capacity to interconnect and deliver wind and solar resources developed on Colorado's Eastern Plains; 3.) increased transmission capacity to interconnect and deliver solar resources developed in the San Luis Valley; and 4.) increased transmission links to neighboring regions. While the scale and complexity of these common elements vary by scenario, the common elements will continue to guide Public Service's ongoing long-term planning efforts.

Public Service Scenarios

In the planning cycle leading to the 2018 and 2020 20-Year Conceptual Scenario Reports, Public Service consistently contemplated three possible scenarios among others. Those three included:

1. Regional Market Dispatch
2. Significant Load Growth
3. High Penetration of Distributed Energy Resources

While aspects of these scenarios generally remain of interest to Public Service, several of the factors described in Public Service's long-term view have influenced changes to Public Service's 20-year scenarios, including the removal of the "Regional Market Dispatch" scenario and incorporation of those discussions in the 10-year report. Additionally, Public Service has added two additional scenarios of interest: one based on the nationwide infrastructure initiatives being discussed by policymakers and utility industry stakeholders to accelerate the broad decarbonization of the power grid in the

United States, and another scenario based on the potential for rapid technological advances that represent a step change in the industry's decarbonization efforts.

Public Service Scenario #1: Accelerated Climate Action

This scenario builds on the previous "Significant Load Growth" scenario consistent with the Governor's Roadmap to 100% Renewable Energy by 2040 and the Colorado Greenhouse Gas Pollution Reduction Roadmap ("Roadmap") to demonstrate the impacts of both accelerated decarbonization of Colorado's electric sector as well as the increased drivers of electric demand represented in the Roadmap. This scenario broadens the scope beyond previous report scenarios to include additional demand drivers such as population growth, EVs, and beneficial electrification growth partially due to natural gas to electric conversions in the Denver Metro Area, northeast Colorado and the Western Slope.

The Roadmap provides illustrative examples of the impacts that this scenario has on generation resources and demand. The Roadmap's "HB19-1261 Scenario" demonstrates a pathway for generation and load that is consistent with Colorado's statutory carbon reduction goals. While this scenario does not include 2042 data to allow for complete alignment with the time period in this 20-Year Report, the rate of change demonstrated between 2020 and 2040 is nevertheless useful for understanding the evolution in Colorado's electric sector. The HB19-1261 Scenario shows a doubling of electric load between 2020 and 2040. Because of the compounding effects of meeting more load while transforming the sources of electric generation, changes to the state's generation fleet are more substantial. This scenario sees the phaseout of coal generation by 2040, gas-fired generation holding relatively steady, wind capacity increasing by approximately six times current amounts and utility-scale solar capacity increasing nearly 30 times. New technologies not currently used at large scale in Colorado also are major contributors, with clean dispatchable technologies growing to over 7 GW and utility-scale storage growing by over 4 GW of capacity between 2020 and 2040.

Public Service Scenario #2: High Penetration of Distributed Energy Resources

This scenario contemplates a future in which DER would serve a significant portion of utility load, which could result in a reduced need for transmission expansion. Public Service anticipates that customer interest and improving economics could drive greater adoption of distributed solar, energy storage, and flexible loads. Energy storage in particular would serve as a major driver in this scenario, as the pairing of distributed storage with solar would be expected to improve the economics and operational benefits of both technologies. Although this scenario potentially could slow the investment of new transmission development, transmission may be necessary to address other drivers and changes in energy delivery and to maximize the benefits and value of distributed resources. This scenario continues to be of interest to Public Service. It is important to note Public Service has implemented over 600 MW of DER on its system through solar programs such as Solar*Rewards and Solar*Rewards Community, and Public Service expects to continue to enable customer adoption of DERs in the coming years. In its RES Plan filed in December 2021, Public Service has proposed plans that would lead to the adoption of over 700 MW of additional distributed solar resources through 2025.

Based on analysis provided in Public Service's 2021 ERP and CEP, increased DER generation capacity is anticipated to serve as a replacement for utility-scale solar on the Public Service system. In this scenario, Public Service expects that additional generating capacity located in the Denver Metro Area would increase relative transmission needs in that part of the state, while the reduced need for utility-scale solar generation could reduce transmission needs in southern Colorado and the San Luis Valley.

Public Service Scenario #3: Nationwide Infrastructure Initiatives

This scenario focuses on substantially increased coordination and transfer capabilities between the Eastern, Western, and ERCOT Interconnections and the construction of a national-scale energy grid to enable higher penetrations of renewable energy. Under this scenario, Public Service anticipates the development of new DC-Tie facilities, improvements to existing DC-Tie facilities, and the construction of a new HVDC transmission network to enable wind and solar generation in remote parts of the central and southwestern United States to be delivered to major coastal population centers.

Public Service Scenario #4: Technological Advancements

This scenario addresses the potential for the rapid acceleration in the development and deployment of new technologies that help enable a carbon-free power system: zero-carbon dispatchable generation resources, long-duration energy storage, flexible loads, and advanced transmission technologies. In this scenario, Public Service's 20-Year transmission plans would be impacted by the advent of larger-scale zero-carbon generation technologies such as advanced nuclear reactors, hydrogen, or carbon capture on new or existing fossil-fueled generators. Energy storage also would play a major role under this scenario as new low-cost, long-duration storage technologies could economically solve seasonal variability in renewable energy output. Furthermore, advanced transmission technologies could further enhance the reliability, resiliency, and efficiency of the transmission grid. There is a range of outcomes for transmission needs in this scenario, as technologies would have competing pressures on transmission development. The need for further transmission system expansion also could be reduced relative to renewable-heavy scenarios as some zero-emitting firm dispatchable technologies would function similarly to existing large-scale central-station generators. Energy storage creates uncertainty for transmission development. While energy storage has the ability to offset or delay the need for transmission in some circumstances, it also can be used to enable higher renewable energy adoption, which would increase the need for transmission infrastructure to interconnect and deliver remotely located generation resources.

IV. 20-Year Base Case Scenario

The 20-year planning model reflecting peak and off-peak conditions is developed through CCPG from a 10-year WECC planning model, as discussed in more detail in the Joint Utilities 10-Year Report. The 20-year planning models reflect projected renewable energy development based on current Renewable Energy Standard ("RES") requirements for investor-owned utilities and cooperatives, as well as conceptual transmission projects. The projected renewable development in the 20-year model that may not be part of an approved resource plan is assumed to exist within the model to meet renewable energy targets. The assumed renewables are located based on known

areas with potential for renewable development and can at times require conceptual transmission projects to incorporate the resources into the model.

Detailed analysis is not performed on the 20-year planning models due to the increasing levels of uncertainly looking beyond the five and 10-year horizons. The levels of uncertainty increase greatly beyond the one- to five-year timeframe due to many unknown variables that may impact the transmission system in the future, such as future resource plans, state legislation, load growth, and technological advancements, amongst many others. Any single variable could have significant impacts to the model and the associated reliability results, making prudent transmission planning impossible if based on purely long-term models. Long-term models beyond 10 years into the future are best served as informative to help gain insight into potential system needs to maintain reliability. The 20-year planning models are available once required WECC non-disclosure agreements are executed, due to their source WECC planning model data, as also discussed in more detail in the Joint Utilities 10-Year Plan and Appendix Q.

The scenario presented in this filing contemplates that the requirements for utilities to serve demand with renewable energy will be modeled at thirty percent (30%) for IOUs such as Public Service and Black Hills, twenty percent (20%) for Tri-State, and ten percent (10%) for all other utilities. Furthermore, Public Service's and Black Hills' resources obtained through Self-Builds and Power Purchase Agreements are modeled in compliance with Senate Bill 19-236.

The power flow models are created using Siemens PTI PSS/E software and available upon request made to Colorado Coordinated Planning Group (CCPG) Chair. These models may be used by interested stakeholders to perform conceptual analyses for long-term planning horizon. Due to WECC policy governing all derivations of WECC base cases and their classification as Critical Energy Infrastructure Information ("CEII"), a non-disclosure agreement is required between WECC and the requester. As reflected in Appendix Q to this filing, the Companies are providing the Commission and interested stakeholders with instructions on how to access confidential WECC model data through WECC. In December 2021, Company representatives also conducted a presentation to

representatives of CPUC Staff and the Utility Consumer Advocate explaining how they could access this information.

2022 Scenario Analysis Appendices

Appendix A

Black Hills Scenarios

Black Hills Scenario #1: Significant Penetration of Distributed Energy Resources

1. *Description*

This scenario considers potential impacts of an increase of both distributed resources capacity and efficiency. Present and future public opinion may continue the push for an increase of distributed resources on the power system. Significant levels of distributed generation under off-peak conditions may result in power flows not typically found in the current system and not typically considered.

2. *Rule 3627 (e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonable foreseeable future policy initiatives	X
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	X
(III)	Emerging generation, transmission and demand limiting	X
(IV)	Various load growth projections	X
(V)	Requested by Commission	

3. *Assumptions and Drivers*

- Public policy initiatives coupled with continued public interest toward rooftop/-community solar may increase the current distributed capacity.
- Typical power output curves for renewable resources may interact with typical load curves to cause flows and voltages not seen in the current system.
- Decreased cost and increased efficiency of DER
- Increased large-scale DER additions

4. *Indicators*

- One of the primary indicators of increased DER penetration would be a decrease of rooftop/community solar costs and/or development that may increase the efficiency of any DER generation.

5. *Potential Benefits and Transmission Impacts to Colorado*

The impact of distributed generation may result in the power system experiencing power flow not typically observed in the current system. This could be a positive and a negative impact depending on location of energy resources. It could allow for

more available transmission capacity due to reduced power flows, as distributed generation can serve load without consuming space on transmission lines. A possible negative impact may include the need for increased reactive power capacity to maintain voltage during lighter load conditions.

Black Hills Scenario #2: Significant Increase in End-Use Electrification

1. *Description*

This scenario considers a significant increase in the development of customer loads distributed across the system due to widespread conversion of end-use processes to be electric-driven. As emission reduction targets from the power sector are achieved, a shift in focus to other areas such as transportation and industrial processes is likely to occur. While this could place an immediate burden on the distribution system infrastructure as well as system operators, there also are risks that should be considered for the transmission system.

A driver for this scenario is a proliferation of renewable energy resources coupled with the retirement of carbon-based generation, which has the potential to present its own set of issues related to voltage deviations, etc. that could be particularly problematic on weaker parts of the transmission and sub-transmission system.

This scenario could be evaluated at a high level through the evaluation of an increased load forecast scenario in planning assessments, assuming minimal dispatchable thermal generation online.

2. *Rule 3627 (e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonable foreseeable future policy initiatives	**X**
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	**X**
(III)	Emerging generation, transmission and demand limiting	**X**
(IV)	Various load growth projections	**X**
(V)	Requested by Commission	

3. *Assumptions and Drivers*

- Emerging technologies in the EV industry and increasing effective ranges of EVs make EV ownership more broadly desired.
- Technological advances in heat pump technology can provide an alternative to carbon-based heat sources for residential and commercial applications.
- The increase of installed residential and commercial charging stations due to the increasing ownership of EV.

4. Indicators

- Increased sales and public interest of EVs and installation of residential and commercial charging stations across the electric system.

- Potential increases in sales of heat pump technology could indicate a continuing increase of potential energy need previously served with a non-electric solution.

5. Potential Benefits and Transmission Impacts to Colorado

Significant distributed demand growth can have an impact on the local and regional transmission system. If load assumptions used in planning assessments under-estimate the demand, it can materially alter transmission plans of any size. Not only are capacity and voltage issues of concern, but another consideration is the loss of life impacts to transformers. Extensive EV charging under peak conditions impacts the capacity of the electric grid. Alternatively, off-peak charging may result in prolonged periods of increased transformer temperatures rather than the typical cool-down period. If not designed properly to operate in these conditions, transformer loss of life could result.

As transmission plans are developed, there should be close coordination with utility and industry stakeholders to ensure appropriate load assumptions are considered.

Black Hills Scenario #3: Increase in Renewable Energy Resources and Battery Storage

1. *Description*

This scenario considers the impacts of carbon regulations that may reduce the use of higher carbon-intensive resources and increase the use of lower carbon-intensive resources. A change in Colorado's generation portfolio may require improvements to the transmission system to ensure reliability and power delivery capabilities from typically more isolated generation centers to load centers in more centralized locations.

2. *Rule 3627 (e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonable foreseeable future policy initiatives	X
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	X
(III)	Emerging generation, transmission and demand limiting	X
(IV)	Various load growth projections	X
(V)	Requested by Commission	

3. *Assumptions and Drivers*

Current Colorado policy continues to show an increased interested in carbon emission reduction and places a greater focus on renewable energy generation. With utilities adopting clean energy plans, the amount of thermal carbon-based generation on the system is being reduced.

4. *Indicators*

- Increased public and political interests in a reduction of carbon emissions.
- Development of more efficient and reliable battery storage to help dampen out potential issues during peak time power consumption.

5. *Potential Benefits and Transmission Impacts to Colorado*

The increased implementation of generation with reduced carbon output can have both negative and positive effects on the transmission system. The existing power system typically delivers power from centralized generation facilities to customers. With changes to how power is generated, there may be upgrades and additions to the system to ensure continued reliability. The different power output capabilities of lower carbon emission generation may present issues when they are unable to output maximum power. This could indicate the need for either battery storage or generation

that is able to operate should load increase above the available renewable output capabilities.

Another challenge that comes from an increase of renewable resources lies in finding a suitable location for large wind or solar farms. Such land may be scarce in locations that act as load centers. This land also may be at long distances from local load. This may require additional transmission lines to reliably serve load.

Benefits to increasing the renewable profile of Colorado exist despite the challenges in this scenario. An increase in renewable generation may require additional transmission infrastructure. Increased infrastructure may help to reduce loading on existing transmission and could negate the need for upgrades or rebuilds. Additionally, power flow from existing carbon-intensive generation facilities can cause large power flows through systems when the normal paths to load are unavailable. Adding renewables may provide an opportunity to reduce potential through flow issues that can occur during outages on existing transmission.

Appendix B

Tri-State Scenarios

TSGT Scenario #1: Increased Role of Distributed Energy Resources

1. *Description*

DER continues to play an increasing role in Colorado's energy mix. This scenario focuses on the growth of distributed energy technologies such as solar PV generation, advancements in energy storage, and increased interest in and deployment of other distributed resources such as community wind, geothermal, biomass, small and micro hydropower, coal mine methane, synthetic gas produced by pyrolysis of municipal solid waste, and recycled energy, as well as associated public policy developments. This scenario assumes continued and significant advancement and growth of such resources coupled with low load growth and higher efficiency, and considers the potential impact of such resources on the transmission system.

2. *Rule 3627(e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	**X**
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	
(III)	Emerging generation, transmission and demand limiting technologies	**X**
(IV)	Various load growth projections	**X**
(V)	Scenarios Requested by Commission in 2020 biennial review process	

3. *Assumptions and Drivers*

- The price of solar photovoltaic continues to fall.
- There is continued interest in and increased penetration by community-based and behind-the-meter business models that make solar PV available to more consumers.
- There is increased interest in and development of behind-the-meter and in-front-of-the-meter DER by Member Systems due to opportunities provided under Tri-State's partial requirements contracts.
- Energy storage technologies, particularly batteries, continue to improve and prices continue to fall, leading to wider deployment both in front of and behind the meter.
- Technological advances and regulatory policies are prompting utilities to explore the various applications of energy storage such as demand response, peak shaving, integration of renewables, and ancillary services.
- Existing and potentially increased state renewable energy standards and carbon reduction policies continue to drive the need for renewable resources at both the

utility and consumer levels. These policy drivers are complemented by changing market forces that result in competitive prices for renewable resource generation.

- Siting and permitting of central station power plants will become increasingly difficult.

- State regulatory policies involving interconnection, distribution system planning, and energy storage continue to evolve to drive increased levels of DER penetration.

4. Potential Benefits and Transmission Impacts to Colorado

An increase in DERs has the potential to delay or eliminate the need for new utility generation resources and significant transmission expansion, particularly if the DERs produce power during periods of peak demand. Distributed generation also has the potential to provide back-up power and reduce utility costs to the end user.

A potential consequence of high penetrations of distributed generation is that it can pose challenges to entities responsible for grid reliability. DERs are not always constructed at the location that is most beneficial to grid operations, and are not necessarily sized to meet system requirements. Furthermore, the wide range of DER types and sizes create uncertainties as to their operations and reliability. At high concentrations, DERs can impact the frequency and voltage performance of the local grid, especially following disturbances. The magnitude of their impact can be analyzed and incorporated into grid modeling, but only if the responsible entities participate in the analysis process.

TSGT Scenario #2: Increased East-West Interconnection

1. *Description*

This scenario focuses on increased coordination and transfer capabilities between the Eastern and Western Interconnections. This scenario focuses specifically on the potential for new DC-Tie facilities, improvements to existing DC-Tie facilities, and the construction of new DC transmission lines. Tri-State's participation in the Western Energy Imbalance Service, and the SPP's approval of terms and conditions to expand its regional transmission organization footprint into the Western Interconnection further increase the relevance of this scenario.

2. *Rule 3627(e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	X
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	
(III)	Emerging generation, transmission and demand limiting technologies	X
(IV)	Various load growth projections	X
(V)	Scenarios Requested by Commission in 2020 biennial review process	

3. *Assumptions and Drivers*

- Several Colorado utilities have joined SPP's Western Energy Imbalance Service.
- Several western utilities are actively evaluating membership in an expanded SPP Regional Transmission Operator ("RTO") in the Western Interconnection.
- One anticipated advantage of membership in SPP is the possibility of operating the transmission system and associated generating assets in the Eastern and Western Interconnections as a single, optimized market.
- Full realization of these benefits may require the construction of improved or new facilities linking the two interconnections. If the initial market operations are successful, this could create an incentive to increase the transfer capacity between the two interconnections.
- The cost of future DC-ties or DC-lines could be subject to the SPP planning and cost-allocation process.

4. *Potential Benefits and Transmission Impacts to Colorado*

Increased east-west interconnection would result in many of the same benefits and impacts discussed above with respect to participation in an organized market, although

they are separate concepts. Better east-west interconnection could complement market participation, but is not necessary for such market participation to occur. Instead, east-west interconnection would allow resources on Colorado's system to be used more readily on the SPP system, and vice versa. Under this scenario, resources could be dispatched across the entire SPP footprint.

In general, this scenario could result in potential production savings costs from increased interconnection and the ability to schedule greater power flows between the eastern and western systems. Because the increased interconnection could provide more system flexibility, generation reserve requirements may be reduced and some new transmission projects may be avoided through regional solutions that also provide local transmission benefits.

It is possible that the costs of improvements to existing DC-Ties as well as the costs of constructing new DC-Ties or DC lines between the Eastern and Western Inter-connections would be allocated among the SPP membership, thereby potentially sparing Colorado utilities costs that would have been required if they sought to undertake such system improvements on their own.

TSGT Scenario #3: Increased Energy Storage

1. ***Description***

Energy storage will likely play an increasing role in Colorado's energy mix. This scenario assumes significant advancement and growth of energy storage technology and considers the potential impact of such resources on the transmission system. In addition to serving as a resource to meet peak demand, energy storage also has important implications for transmission. In particular, energy storage, in appropriate cases, has the potential to defer or replace more traditional transmission projects. While energy storage costs have been falling quickly, energy storage is currently a relatively expensive way to meet these needs, and the energy storage capacities necessary to address transmission issues are generally very large. Nevertheless, should the price of energy storage continue to fall, storage may become a more significant component of Tri-State's transmission system planning. If this were the case, some new traditional transmission projects, such as those related to congestion relief, could be deferred or modified if a more cost-effective energy storage solution exists. While storage is unlikely to replace transmission projects primarily related to serving new load, it may have a substantial effect on other types of projects to the extent that storage can serve as an alternative.

2. ***Rule 3627(e) Application***

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	**X**
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	
(III)	Emerging generation, transmission and demand limiting technologies	**X**
(IV)	Various load growth projections	
(V)	Scenarios Requested by Commission in 2020 biennial review process	

3. ***Assumptions and Drivers***

- The price of energy storage technologies, particularly batteries, continues to fall over time, making batteries a more cost-effective transmission alternative.
- New storage technologies emerge that allow for greater storage capacities to serve transmission needs.
- Higher penetrations of renewables require additional storage on the system.
- Energy storage-related legislation continues to drive the use of storage.

4. Potential Benefits and Transmission Impacts to Colorado

In this scenario, storage is used as an alternative to traditional transmission projects, allowing those projects to either be deferred, modified, or avoided altogether. Further, in this scenario, storage would be used to address and ameliorate transmission congestion and allow existing transmission assets to be utilized more effectively. These developments potentially would reduce the number and/or size of new transmission projects and also could potentially reduce associated transmission costs. Similarly, the increased addition of energy storage also could result in a more robust transmission system that may be better able to accommodate maintenance of transmission lines and ensure continued reliable power delivery during unscheduled transmission line outages. Finally, increased storage capacity on the system is likely to increase the ability to integrate additional renewables and improve reliability due to the dispatching challenges associated with variable resources. While traditional transmission projects likely would continue to be necessary for serving new loads, as well as for certain other functions for which storage is not a practical alternative, increased energy storage has the potential to create significant transmission benefits in Colorado.

TSGT Scenario #4: 100% Renewable Energy by 2050

1. *Description*

Renewable energy will play an increasing role in Colorado's energy resource mix. This scenario assumes significant advancement and growth of renewable energy and energy storage technology and considers the potential impact of such resources on the transmission system. This scenario focuses on the growth of renewable energy resources such as solar PV, geothermal, wind, biomass (from plants), and hydro-power.

2. *Rule 3627(e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	**X**
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	**X**
(III)	Emerging generation, transmission and demand limiting technologies	**X**
(IV)	Various load growth projections	
(V)	Scenarios Requested by Commission in 2020 biennial review process	

3. *Assumptions and Drivers*

- The price and efficiency of renewable energy resources continues to fall over time.
- The price of energy storage technologies, particularly batteries, continues to fall over time, making batteries a more cost-effective transmission alternative.
- New storage technologies emerge that allow for greater storage capacities to serve transmission needs.
- Higher penetrations of renewables require additional storage on the system.
- Energy management technologies continued to develop to ensure an appropriate balance of generation and load with solely variable energy resources.
- Inverter (grid-forming) technology develops to ensure reliable resource performance under system disturbances.
- While Tri-State is not required to file a CEP with the CPUC, this scenario is consistent with the public policy evidenced by the clean energy targets set forth in Colorado Revised Statute § 40-2-125.5(3)(a)(II).

4. Potential Benefits and Transmission Impacts to Colorado

To achieve 100% renewable energy, geographically diverse resources and significant development of energy storage will be required to ensure transmission system reliability. In this scenario, storage is used as an alternative to some traditional transmission projects, while additional transmission investment is required to ensure adequate transfer capability under extreme import/export conditions due to weather. These developments potentially would reduce the number and/or size of new, local transmission projects and also could potentially reduce associated transmission costs. However, regional transmission projects likely would continue to be necessary to solve import/export congestion issues. Similarly, the increased addition of energy storage also could result in a more robust transmission system that may be better able to accommodate maintenance of transmission lines and ensure continued reliable power delivery during unscheduled transmission line outages.

Appendix C

Public Service Scenarios

Public Service Scenario #1: Accelerated Climate Action

1. Description

The assumptions in this scenario are consistent with the "HB19-1261" scenario identified in the Roadmap paired with Governor Polis' stated goal of moving Colorado to 100% clean energy by 2040. Electric demand approximately doubles in the state by 2040, driven by population growth, EV adoption, and beneficial electrification of fossil fuel end uses such as heating. This scenario also assumes growth of renewable energy, clean firm generation, and energy storage consistent with the Roadmap scenario.

2. Rule 3627 (e) Application

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	**X**
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	**X**
(III)	Emerging generation, transmission and demand limiting	**X**
(IV)	Various load growth projections	**X**
(V)	Requested by Commission	

3. Potential Benefits and Transmission Impacts to Colorado

The transformation of the use and generation of electricity in the state would lead to major additional transmission requirements. The doubling of electric demand in the state would be expected to require similar expansion of transmission to serve that load, and changes to the types of resources that meet this load would require further expansion of the transmission system. It is possible that these transmission expansions would be more local than regional in nature. The Pathway Project is a local transmission project expected to serve as a new backbone transmission loop to collect renewable power from the Eastern Plains and deliver that energy to the Front Range load center. In order to meet new electric demand while remaining compliant with state emissions reductions policies, this scenario dramatically increases the need to generate and deliver additional renewable energy from diverse, resource-rich regions of the state such as southeastern Colorado and the San Luis Valley. Another impact could be changing the traditional peaking of the power system. Public Service's system is summer peaking, but under this scenario increased electrification – especially of heating end uses – would be expected to change the load shape of the Public Service system. While a more even load curve could allow for the more efficient use of existing and new transmission, changes to peak demand could drive further transmission expansion.

Public Service Scenario #2: High Penetration of Distributed Energy Resources

1. *Description*

This scenario addresses a situation that results in customers' energy needs being met in significant part by DERs such as distributed solar, energy storage, and flexible loads. Additional DER deployment would comparatively reduce the need for utility-scale solar and, to a lesser extent, firm resources. Although this scenario potentially could slow the investment of new transmission development, transmission may be necessary to address other drivers and changes in energy delivery and to maximize the value of DERs.

2. *Rule 3627 (e) Application*

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	X
(III)	Emerging generation, transmission and demand limiting	X
(IV)	Various load growth projections	X
(V)	Requested by Commission	

3. *Potential Benefits and Transmission Impacts to Colorado*

Although this scenario potentially could slow the investment of new transmission development by offsetting the need to develop additional solar resources in southern Colorado and the San Luis Valley, transmission expansion within load centers would be necessary to address other drivers and changes in energy delivery, as well as to maximize the value of DERs by enabling them to serve more distant loads with generation in excess of local demand. A high penetration of DER could require changes in generation cost allocation; new distribution reliability issues; increased flexible generation resources that could be different than the current resource mix, potentially resulting in the overbuild of capacity to ensure the appropriate resource flexibility; significant impact to reliability protection schemes on the distribution system; and the need for additional distribution reliability management systems that to date are not widely deployed. These management systems would be analogous to Supervisory Control and Data Acquisition ("SCADA") systems for the real-time operation and management of the transmission system. Extensive communication networks would be required, as well as data handling.

Public Service Scenario #3: Nationwide Infrastructure Initiatives

1. Description

This scenario addresses the creation of a national-scale "super grid" to enable renewable energy to be exported from areas of the country with the most advantageous resource quality (wind energy from the Great Plains and solar power from the Southwest) to population centers primarily along the East and West coasts. This would rely on the integration of the Eastern, Western, and ERCOT Interconnections through enhanced DC ties, as well as a large-scale build-out of multiregional HVDC lines.

2. Rule 3627 (e) Application

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	X
(III)	Emerging generation, transmission and demand limiting	X
(IV)	Various load growth projections	X
(V)	Requested by Commission	

3. Potential Benefits and Transmission Impacts to Colorado

Colorado is well-situated to serve as an exporter of renewable electricity due to its high-quality wind and solar resources. In addition to the development of additional DC ties between the Eastern and Western Interconnects that potentially could be located in eastern Colorado as well as HVDC transmission lines that would link Colorado to more distant load centers, the increased ability to integrate renewable energy created by higher export capacity would drive substantial renewable energy generation in Colorado. This increase in renewable generation would require additional development of local traditional transmission facilities to serve as a collector system for these new wind and solar resources.

Public Service Scenario #4: Technological Advancements

1. Description

Under this scenario, Public Service anticipates that rapid advancement of various technologies could create additional tools that advance the decarbonization of the power sector. These tools could include resources such as new dispatchable zero-carbon generating technologies, like advanced nuclear reactors, hydrogen, or fossil fuels with carbon capture, energy storage solutions with the ability to meet demand over longer periods or to bridge seasonal variability in renewable output, new flexible load resources, or new transmission technologies that enhance the reliability and efficiency of the power grid.

2. Rule 3627 (e) Application

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	**X**
(III)	Emerging generation, transmission and demand limiting	**X**
(IV)	Various load growth projections	**X**
(V)	Requested by Commission	

3. Potential Benefits and Transmission Impacts to Colorado

Rapid advancement of carbon-free technologies such as those identified in this scenario would enable meeting state policy goals while prioritizing affordability and reliability for customers. While renewable energy will meet substantial proportions of energy demand in Colorado, centralized power stations or energy storage resources located closer to loads could reduce the need for additional transmission development. Advanced transmission technologies that enhance the reliability and efficiency of the transmission system also could allow for greater utilization of existing transmission facilities and delay or offset the need for the development of new transmission capacity needed to reduce or eliminate congestion.

Appendix D

20-Year Base Case Scenario

20-Year Base Case Scenario

1. ***Description***

This scenario contemplates that the requirements for utilities to serve demand with renewable energy will be modeled at thirty percent (30%) for IOUs such as Public Service and Black Hills, twenty percent (20%) for Tri-State, and ten percent (10%) for all other utilities. Furthermore, Public Service and Black Hills resources through Self-Builds and Power Purchase Agreements are modeled in compliance with Senate Bill 19-236.

Two (2) power flow models are developed under this scenario that illustrate a typical 2042 summer peak load and 2042 summer off-peak load. The power flow models are created using Siemens PTI PSS/E software and available upon request made to the CCPG Chair. Due to WECC policy governing all derivations of WECC base cases and their classification as CEII, a non-disclosure agreement is required between WECC and the requester to access these models.

2. ***Rule 3627 (e)***

Rule	Credible alternatives	Apply
(I)	Reasonably foreseeable future policy initiatives	X
(II)	Possible retirement of existing generation due to age, environmental regulations or economic considerations	X
(III)	Emerging generation, transmission and demand limiting	
(IV)	Various load growth projections	
(V)	Requested by Commission	X

3. ***Assumptions and Drivers***

- RES of thirty percent (30%) for Public Service and Black Hills, twenty percent (20%) for Tri-State, and ten percent (10%) for other utilities.

- Clean Energy Plan under Senate 19-236 that requires Public Service and Black Hills to develop a resource plan that reduces carbon dioxide emissions associated with electricity sales by eighty percent (80%) from 2005 levels by 2030 and one hundred percent (100%) by 2050.

- Forecasted loads, resources and topology updates were contributed by Black Hills, Tri-State and Public Service.

- Renewable and conventional generation MWs and locations were contributed by Black Hills, Tri-State and Public Service.

- Peak case, wind generators may be dispatched slightly greater than 20% of nameplate for load and resource balance; solar generators are dispatched at 65% of nameplate.

- Off-peak case with light loads and high wind outputs

- Foreseeable transmission plans were added to the power flow models

- Publicly announced generator retirement plans were added to the power flow models.

4. Indicators

- Transmission plans include the Public Service Colorado Senate Bill 07-100 ("SB07-100") facilities, Senate Bill 19-236 Pathway project, and any additional transmission lines to accommodate the RES assumptions.

- Transmission lines added from the resources to load center based on engineering judgment and empirical knowledge.

- Generator retirement plans that have been publicly announced for Black Hills, Tri-State and Public Service.

5. Potential Impacts to Colorado

If load continues to increase as modeled, significant transmission may need to be developed in the state to deliver renewable energy to load centers.