**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO**

* * * * *

IN THE MATTER OF THE APPLICATION OF PUBLIC SERVICE COMPANY OF COLORADO FOR APPROVAL OF ITS 2021 ELECTRIC RESOURCE PLAN AND CLEAN ENERGY PLAN	**) PROCEEDING NO. 21A-____E**

DIRECT TESTIMONY AND ATTACHMENTS OF KEVIN D. CARDEN

ON

BEHALF OF

PUBLIC SERVICE COMPANY OF COLORADO

March 31, 2021

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO**

* * * * *

IN THE MATTER OF THE APPLICATION	**)**
OF PUBLIC SERVICE COMPANY OF	**)**
COLORADO FOR APPROVAL OF ITS	**) PROCEEDING NO. 21A-_____E**
2021 ELECTRIC RESOURCE PLAN AND	**)**
CLEAN ENERGY PLAN	**)**

DIRECT TESTIMONY AND ATTACHMENTS OF KEVIN D. CARDEN

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF ATTACHMENTS

Attachment KDC-1	Planning Reserve Margin and Resource Adequacy Study, Final Report, prepared for Public Service Company of Colorado by Astrapé Consulting
Attachment KDC-2	Reserve Margin References Table
Attachment KDC-3	Curriculum Vitae of Kevin D. Carden

GLOSSARY OF ACRONYMS AND DEFINED TERMS

Acronym/Defined Term	**Meaning**
2021 ERP & CEP	2021 Electric Resource Plan and Clean Energy Plan
AESO	Alberta Electric System Operator
Astrapé	Astrapé Consulting
BHEC	Black Hills Energy Corporation
Commission	Colorado Public Utilities Commission
CSU	Colorado Springs Utilities
ELCC	Effective Load Carrying Capability
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
IEEE	Institute of Electrical and Electronics Engineers
JDA	Joint Dispatch Agreement
LOLE	Loss of Load Expectation
LOLH	Loss of Load Hours
MISO	Midwest Independent System Operator
MW	Megawatt
NERC	North American Electric Reliability Council
NYISO	New York Independent System Operator
PACE	PacifiCorp East
PRPA	Platte River Power Authority
Public Service or Company	Public Service Company of Colorado

Acronym/Defined Term	**Meaning**
SCS	Southern Company Services
SERVM	Strategic Energy and Risk Valuation Model
SPP	Southwest Power Pool
The Study	Planning Reserve Margin and Resource Adequacy Study
TVA	Tennessee Valley Authority

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

* * * * *

IN THE MATTER OF THE APPLICATION OF PUBLIC SERVICE COMPANY OF COLORADO FOR APPROVAL OF ITS 2021 ELECTRIC RESOURCE PLAN AND CLEAN ENERGY PLAN	**) PROCEEDING NO. 21A-_____E**

DIRECT TESTIMONY AND ATTACHMENTS OF KEVIN D. CARDEN

I. INTRODUCTION, QUALIFICATIONS, AND PURPOSE OF TESTIMONY

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Kevin D. Carden. My business address is 3000 Riverchase Galleria, Suite 575, Hoover, Alabama 35244.

Q. BY WHOM ARE YOU EMPLOYED AND WHAT IS YOUR POSITION?

A. I am the Director of Astrapé Consulting ("Astrapé").

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THE PROCEEDING?

A. I am testifying on behalf of Public Service Company of Colorado ("Public Service" or the "Company").

Q. **WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY?**

A. The purpose of my Direct Testimony is to introduce and summarize the Planning Reserve Margin and Resource Adequacy Study that Astrapé conducted on behalf of Public Service. More specifically, I discuss the input assumptions, study methodology, and results of the study. I also provide an overview of how the study results compare to similar planning reserve margin and resource adequacy assessments on an industry-wide basis. The Planning Reserve Margin and Resource Adequacy Study ("the Study") is provided as Attachment KDC-1 to my Direct Testimony.

Q. WHAT IS ASTRAPÉ AND WHAT WORK DO THEY DO IN THE UTILITY INDUSTRY?

A. Astrapé is a Resource Planning Consulting firm that specializes in generation resource adequacy planning. We were founded in 2005 and have since been providing consulting services using our Strategic Energy and Risk Valuation Model ("SERVM") for utilities, independent system operators, and regulators around the world. We also license SERVM to planning entities. Studies using SERVM have been vetted through public regulatory processes for over 30 years.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND AND WORK EXPERIENCE?

A. I hold a Bachelor of Science Degree in Industrial Engineering from the University of Alabama. Prior to starting Astrapé in 2005, I was employed by Southern Company Services, Inc. ("SCS") as a reliability engineer, where I performed resource adequacy studies for Alabama Power Company, Georgia Power Company, Mississippi Power Company, and Gulf Power Company. I am an active participant in several industry groups concerned with resource adequacy and reliability, including the North American Electric Reliability Council ("NERC") Probabilistic Assessment Working Group and Institute of Electrical and Electronics Engineers ("IEEE") Loss of Load Expectation Working Group.

Q. WHAT ARE YOUR JOB DUTIES AND RESPONSIBILITIES AT ASTRAPÉ?

A. As the Director of Astrapé Consulting, I primarily manage the SERVM software for Astrapé and perform reliability studies, capacity valuation studies, and renewable integration studies using SERVM for clients across North America and internationally. SERVM was originally developed by SCS in the 1980s to assist with system reliability planning needs. Astrapé took over maintenance of the model in 2005 and began marketing the software to other entities across the country. In addition to providing resource adequacy analyses for many of the largest utilities in the nation, Astrapé has performed resource adequacy analyses for many of the organized markets in North America, including Midwest Independent System Operator ("MISO"), Southwest Power Pool ("SPP"), Electric Reliability Council of Texas ("ERCOT"), PJM, and Alberta Electric System Operator ("AESO"). Most of these entities rely on SERVM simulations for their resource adequacy assessments. I have also performed studies for the Federal Energy Regulatory Commission ("FERC") and the United States Department of Energy on the implications of market structure on electric system reliability. My curriculum vitae is provided as Attachment KDC-D-3.

Q. WHAT WORK WAS ASTRAPÉ ASKED TO PERFORM REGARDING PUBLIC SERVICE'S 2021 ELECTRIC RESOURCE PLAN?

A. For the Company's 2021 Electric Resource Plan and Clean Energy Plan ("2021 ERP & CEP"), Astrapé was asked to develop data inputs to be used in a planning reserve margin and resource adequacy study, construct a model of the Public Service system, and identify a planning reserve margin to be applied to the forecasted Public Service peak load to maintain system reliability at industry standards. The development of the data inputs included creating historical weather-based representations of load, wind, and solar hourly profiles, historical performance-based generation unit outages, non-firm gas supply outages, and transmission availability outages. The resulting model was to capture generation, transmission, and load topology, generation resource characteristics, energy-limited resource characteristics, ancillary service requirements, reserve sharing group requirements and response, and market reliance limits of the Public Service system.

Q. PLEASE DESCRIBE THE WORK YOU PERFORMED FOR PUBLIC SERVICE THAT IS THE SUBJECT OF YOUR TESTIMONY AS IT RELATES TO THE PLANNING RESERVE MARGIN AND RESOURCE ADEQUACY STUDY.

A. Astrapé developed the data inputs for the SERVM model outlined in the request for proposal issued by Public Service that sought proposals for performing a planning reserve margin and resource adequacy study. This includes development of hourly load, wind, and solar profiles, generator outages, transmission constraints and system resources for Public Service and its neighboring systems. The SERVM model was then used to identify the planning reserve margin for Public Service that will result in a system LOLE of one day in ten years for the planning years of 2021, 2023, 2026 and, 2030. Astrapé also performed multiple sensitivity analyses to examine the reserve margin impact of varying assumptions.

Q. HAVE YOU PERFORMED SIMILAR WORK FOR OTHER UTILITIES?

A. Yes. Astrapé has performed resource adequacy studies for other utilities including Duke Energy Corporation, Tennessee Valley Authority ("TVA"), Southern Company, Cleco, Louisville Gas and Electric, Santee Cooper, North Carolina Electric Membership Corporation, Georgia System Operations Corporation, and Public Service Company of New Mexico. As noted above, Astrapé has also performed related resource adequacy studies for large independent operators such as ERCOT, SPP, MISO, and AESO.

Q. ARE YOU SPONSORING ANY ATTACHMENTS AS PART OF YOUR DIRECT TESTIMONY?

A. Yes. I am sponsoring the following three attachments:

- Attachment KDC-1 is the Planning Reserve Margin and Resource Adequacy Study, prepared for Public Service by Astrapé;
- Attachment KDC-2 is a summary table of planning reserve margin references across multiple entities; and
- Attachment KDC-3 is a copy of my curriculum vitae.

Q. BEFORE DISCUSSING THE DETAILS OF THE STUDY, WHAT IS PUBLIC SERVICE'S CURRENT RESERVE MARGIN AND WHAT IS THE RECOMMENDED TARGET RESERVE MARGIN BASED ON ASTRAPÉ'S ANALYSIS?

A. Public Service's current planning reserve margin is 16.3 percent. This planning reserve margin has been used for ERP and resource adequacy purposes since 2008. As a result of the Study, Astrapé recommends a target reserve margin range of 18 to 20 percent to adequately ensure compliance with a 0.1 Loss of Load

Expectation ("LOLE") standard. Table KDC-D-1 below is a reproduction of Table ES1. 0.1 LOLE Results from the Study.

Table KDC-D-1: LOLE Results

Year	**2021**	**2023**	**2026**	**2030**
0.1 LOLE Reserve Margin	17.4%	19.3%	19.1%	18.0%

II. PLANNING RESERVE MARGIN & RESOURCE ADEQUACY STUDY OVERVIEW

Q. PLEASE GENERALLY DESCRIBE THE PLANNING RESERVE MARGIN AND RESOURCE ADEQUACY STUDY THAT ASTRAPÉ PERFORMED FOR PUBLIC SERVICE.

A. The Study evaluated the amount of generation capacity in excess of the firm peak load that would be needed to meet the industry standard for reliability in years 2021, 2023, 2026, and 2030 and also other resource adequacy risks. The Company has a carbon dioxide reduction requirement by 2030 as part of its Clean Energy Plan. The Company has also taken significant actions in the nearer term generation transition through the Colorado Energy Plan, approved by the Colorado Public Utilities Commission ("Commission") in 2018. Because these plans will create significant changes to the Public Service system, both near term changes associated with the recently approved Colorado Energy Plan and longer-term changes associated with the Clean Energy Plan, the reliability assessment focused on multiple years throughout the coming decade.

Q. WHAT IS THE PURPOSE OF THE STUDY?

A. Public Service had not performed a planning reserve margin and resource adequacy study since 2008. One of the purposes of the Study prepared by Astrapé was to assess the resource adequacy implications of the Public Service system with much different characteristics from that studied in 2008. In addition, Public Service commissioned the Study to achieve better alignment with current resource adequacy assessment best practices from the industry.

Q. PLEASE EXPLAIN RESERVE MARGIN AND HOW IT IS DEFINED FOR PURPOSES OF THE STUDY.

A. Reserve margin represents the megawatt ("MW") amount of generation capacity that a utility maintains on its system *above* its forecast of peak load, in order to accommodate for example, events such as unexpected outages of generating units or higher than expected customer load due to extreme weather. Reserve margin on a percent basis is defined by the formula:

reserve margin = (resources – firm peak demand) / (firm peak demand).

The resources component of the formula represents the capacity in MW of generation resources available on-peak. The nameplate MW rating of energy limited or non-dispatchable resources such as renewables is not used when calculating the reserve margin since their output is highly variable. Rather, an accounting mechanism such as effective load carrying capability ("ELCC") must be employed to those resources that gives credit for their expected contributions to reliability. Accurate quantification of a resource's reliability contribution will result in a relatively stable reserve margin over time that meets reliability standards. Firm peak demand in the reserve margin formula represents the median annual peak demand forecast. Half of all weather scenarios would be expected to produce an annual peak lower than the forecast and half would be expected to produce an annual peak higher than the forecast.

Q. WHY IS IT IMPORTANT THAT UTILITIES ESTABLISH AN ADEQUATE RESERVE MARGIN?

A. It is important to establish an adequate reserve margin because firm load customers expect to have electricity at all times of the year, especially during extreme weather conditions like hot summer days when there can be increased resource adequacy risk for Public Service. To avoid firm load shed events and ensure reliability during these peak periods, Public Service should maintain an adequate reserve margin to manage variable conditions like extreme weather, load growth, and forced outages of generating units. It is particularly important to ensure adequate reserve margin is available to maintain reliability as Public Service retires conventional fossil fuel resources and adds increasing levels of intermittent and energy limited resources. It is important to note, however, that an adequate reserve margin does not imply zero firm load shed events. Constructing a system with zero probability of firm load shed would be prohibitively expensive.

Q. HOW IS RESOURCE ADEQUACY RISK GENERALLY ADDRESSED IN THE RESOURCE PLANNING PROCESS?

A. Most entities perform simulations which incorporate distributions of weather uncertainty, load forecast uncertainty, and generation performance uncertainty and identify the frequency with which load plus ancillary service requirements are greater than the available generating capacity. The frequency of shortfalls (i.e., firm load shed events) is measured in LOLE. Simulations are performed at varying reserve margin levels. The reserve margin which produces LOLE equal to the industry standard is set as the target reserve margin.

Q. WHAT IS THE INDUSTRY STANDARD FOR RESOURCE ADEQUACY PLANNING?

A. The standard for resource adequacy planning in the United States is to procure sufficient resources to expect to shed firm load less than one day every 10 years (0.1 LOLE).

Q. IS THE TARGET RESERVE MARGIN RECOMMENDATION FROM THE STUDY PREPARED BY ASTRAPÉ BASED ON THE SAME INDUSTRY STANDARD AS PUBLIC SERVICE'S MOST RECENT RESERVE MARGIN STUDY PERFORMED IN 2008?

A. No. In Public Service's most recent reserve margin study performed in 2008, the target reserve margin of 16.3 percent was based on an alternate interpretation of the one day in 10-year loss of load reliability standard. Namely, the prior Public Service study planned to 24 hours of load shed in 10 years which could have occurred over multiple days. The 0.1 LOLE interpretation is defined as a single day with one or more hours of firm load shed in 10 years. The planning target of 24 hours of load loss in 10 years is commonly referred to as 2.4 Loss of Load Hours ("LOLH"). The updated Study prepared by Astrapé is based on the interpretation that the one day in 10-year standard is properly represented by 0.1 LOLE.

Q. WHY DOES ASTRAPÉ RECOMMEND CHANGING THE BASIS OF THE TARGET RESERVE MARGIN TO THE INDUSTRY STANDARD 0.1 LOLE FROM THE 2.4 LOLH THAT WAS USED IN THE COMPANY'S PRIOR PLANNING RESERVE MARGIN STUDY?

A. While the industry standard reliability metric in North America of one day of firm load shed in 10 years has very high adoption, some latitude has been taken on its interpretation. The two primary interpretations have been 0.1 LOLE and 2.4 LOLH. The 0.1 LOLE interpretation results in a higher reserve margin and produces a significantly higher level of reliability than those associated with the 2.4 LOLH interpretation. In most systems, firm load shed events have a duration of 2-3 hours which would correspond to 0.2 to 0.3 LOLH per year when using the 0.1 LOLE interpretation. This means 2.4 LOLH interpretation corresponds to an order of magnitude higher frequency of expected firm load shed – shedding firm load every year rather than once in 10 years. Given the reduced reliability associated with the 2.4 LOLH interpretation, we do not believe it to be consistent with the intent of the original one day in 10-year reliability standard. The origins of the 1-in-10 standard were from the 1940s and 1950s when probabilistic analysis only considered reliability in the peak hour.[1] Shedding load in the peak hour on one day in 10 years simply cannot be equated with shedding firm load 24 hours in 10 years. To further support the utilization of 0.1 LOLE, a partial list of entities that

[1] Source: Calabrese, Giuseppe, "Generating Reserve Capacity Determined by the Probability Method," American Institute of Electrical Engineers, Transactions of the IEEE, vol.66, no.1, pp.1439-1450, Jan. 1947

use that interpretation is included in Table KDC-D-2. Attachment KDC-2 to my Direct Testimony includes a table of planning reserve margin references across multiple entities.

Table KDC-D-2: Entities Utilizing 0.1 LOLE

New York Independent System Operator ("NYISO")	Florida Power and Light
ISO-New England	MISO
PJM	Louisville Gas and Electric
SPP	Southern Company
Duke Energy Carolinas	TVA
Duke Energy Progress	Public Service Company of New Mexico
Duke Energy Florida	California Public Utilities Commission

Q. HOW DID ASTRAPÉ CALCULATE PHYSICAL RELIABILITY FOR A RANGE OF TARGET RESERVE MARGINS FOR THE PUBLIC SERVICE SYSTEM?

A. To calculate the necessary reserve margin for the Public Service system, Astrapé utilized its reliability model, SERVM, to perform over 9,500 yearly simulations with one-hour granularity at various reserve margin levels. With each simulation, SERVM calculates multiple physical reliability metrics in order to provide a holistic perspective on the reliability of the Public Service system. Each of the 9,500 yearly simulations was developed through stochastic modeling of the uncertainty of load, renewable generation, economic growth, unit availability, and transmission availability. In addition to the Base Case analysis of study years 2021, 2023, 2026, and 2030, sensitivity analyses were performed to understand the importance of varying assumptions.

Q. PLEASE EXPLAIN THE ELECTRIC MARKET REPRESENTATION OF THE STUDY.

A. The Study includes all neighboring utilities that are one transmission connection away from Public Service and have historically delivered power to Public Service during normal operations. This includes the current Joint Dispatch Agreement ("JDA") neighbors and other neighbors inside and outside the Public Service Balancing Authority Area. The reliability benefits provided by the electrically interconnected neighboring systems were captured in the Study. The market was calibrated in SERVM using historical data to reflect a reasonable representation of the reliability benefits from neighbors due to weather and generator outage diversity.

Q. PLEASE SUMMARIZE THE RECOMMENDED TARGET RESERVE MARGIN BASED ON ASTRAPÉ'S ANALYSIS IN THE STUDY.

A. Astrapé recommends a target reserve margin range of 18 percent to 20 percent to adequately ensure compliance with a 0.1 LOLE standard. As initially referenced above in Section I of my Direct Testimony, Table KDC-D-1 is a reproduction of Table ES1. 0.1 LOLE Results from the Study.

Table KDC-D-1: LOLE Results

Year	**2021**	**2023**	**2026**	**2030**
0.1 LOLE Reserve Margin	17.4%	19.3%	19.1%	18.0%

Q. PLEASE EXPLAIN WHY ASTRAPÉ HAS RECOMMENDED A TARGET RESERVE MARGIN *RANGE* FOR YEARS 2021, 2023, 2026, AND 2030.

A. Absent changes to the Public Service load shape and conventional portfolio outage rate, the reserve margin that meets the 0.1 LOLE standard could remain static even as the renewable profile changes. However, given the uncertainties in reliability contributions of renewable resources and in the reliability contributions of neighboring systems, the target reserve margin that achieves 0.1 LOLE cannot be known with precision. Rather than make conservative assumptions and set the target reserve margin at the high end of the range, Astrapé recognizes the reliability outcomes are only marginally different within the range of 18-20 percent and portfolios that achieve reserve margins in this range can be considered compliant with industry standard reliability targets.

Q. WHY ARE THE 2023-2030 TARGET RESERVE MARGINS HIGHER THAN THE TARGET RESERVE MARGIN IN 2021?

A. The reason that 2023 through 2030 are higher than 2021 is that on an incremental portfolio basis, the Company's capacity credit (i.e., ELCC) for certain resources is slightly higher than the reliability contributions for those same resources reflected within SERVM. The most significant change in the reserve margin percentage occurs in 2023, when within the Study, one of the Comanche coal units is retired and approximately 1,000 MW of utility scale solar and 300 MW of battery storage are added in the modeling. Between 2023 and 2030, the differences between SERVM's reliability contribution and the Company's ELCC values become smaller and the 0.1 LOLE compliant reserve margin moves closer to the 2021 result. Astrapé reviewed the ELCC analysis performed by Public Service and found the technical approach to be sound. Small differences in renewable profiles and utilization assumptions of energy limited resources contribute to the minor differences in reliability contributions within SERVM simulations, but Astrapé believes both the Public Service analysis and SERVM analysis to be equally plausible outcomes. This means that the reserve margin that meets 0.1 LOLE varies between 17.4-19.3 percent.

Q. DO YOU KNOW HOW PUBLIC SERVICE PLANS TO IMPLEMENT THE TARGET RESERVE MARGIN RANGE AND DOES IT MEET THE 0.1 LOLE RELIABILITY STANDARD?

A. Public Service has indicated that it intends to acquire long-term generation resources for years 2023-2030 to meet an 18 percent reserve margin through the ERP process. Company witness Mr. James F. Hill discusses the long-term planning reserve margin and Company witness Mr. Jon T. Landrum discusses how the 18 percent long-term planning reserve modeling has been incorporated into the modeling in this proceeding.

To the extent additional capacity is needed in years 2023 through 2026 above any capacity resources acquired and brought online through the ERP process to meet the 19.3 percent and 19.1 percent levels, for those years, my understanding is Public Service intends to procure that capacity through normal course of business short-term market purchases. Company witness Mr. John T. Welch discusses these short-term reserve margin considerations in more detail in his Direct Testimony.

Q. WHAT ARE THE KEY DRIVERS OF ASTRAPÉ'S RECOMMENDED TARGET RESERVE MARGIN?

A. The key drivers of Astrapé's recommended target reserve margin include weather-related load uncertainty, generator outages, operating reserve requirements, market purchase availability, economic load forecast uncertainty, energy limited resource performance uncertainty, and non-dispatchable resource reliability contribution uncertainty.

Q. DOES THE RISK OF BEING UNABLE TO SERVE FIRM LOAD CUSTOMERS EXIST ONLY DURING SUMMER PEAK LOAD PERIODS?

A. No. While seasonal peak load forecasts are higher for the summer than winter, load variability is higher in winter, solar and wind capacity provides less reliability value in the winter, and generator performance for these resources is more volatile in the winter. Thus, as the penetration of renewable resources increases, the proportion of modeled winter reliability events rises.

Q. IN ADDITION TO THE BASE CASE, WERE OTHER CASES OR SCENARIOS MODELED IN THE STUDY?

A. Yes.

Q. PLEASE DESCRIBE THE SENSITIVITIES THAT WERE SIMULATED IN THE STUDY.

A. In addition to the base case scenarios which simulated expected conditions for 2021, 2023, 2026, and 2030, sensitivities were run to examine the reserve margin impact of various modeling assumptions. This included a 2021 island sensitivity where Public Service was modeled with no access to external assistance from its neighbors, a 2030 "No Economic Load Forecast Error" sensitivity where the economic load forecast error distribution was removed, a 2030 "No SPP Import" sensitivity where the SPP import across the Lamar DC tie was removed, a 2030 "No Four Corners Transmission Import Path" sensitivity where the Four Corners transmission path was removed, a 2030 "Increased Transmission" sensitivity where the Public Service and PacifiCorp East ("PACE") transmission capability was increased bi-directionally by 200 MW, a second 2030 "Increased Transmission" sensitivity where the Public Service and PACE transmission capability was increased bi-directionally by a further 200 MW to 400 MW, a 2030 "Non-Firm Fuel Supply" sensitivity where Plains End I and Plains End II were modeled on forced outage when the temperature was -5°F or below due to an assumed lack of natural gas supply, a 2030 "JDA Market Reliance" sensitivity where Black Hills Energy Corporation ("BHEC"), Colorado Springs Utilities ("CSU"), and Platte River Power Authority ("PRPA") were removed, and a 2023 "Firm Energy Purchase" sensitivity where 250 MW of the JDA assistance was modeled as a firm purchase as opposed to a non-firm purchase. A summary of the impact on the target reserve margin is shown in Table KDC-D-3.

Table KDC-D-3: Sensitivity Impact on Target Reserve Margin

Sensitivity	Reserve Margin Impact
Island	+9.0%
Remove Economic Forecast Error	-0.5%
Remove Access to SPP Market	+1.6%
Remove Access to Four Corners Market	+1.3%
Plus 200 MW Transmission	-2.5%
Plus 400 MW Transmission	-4.0%
Reduce Firm Fuel Supply	+0.5%
Remove JDA Assistance	+1.3%
Add 250 MW Firm Market Purchase	+4-6%

Q. IS IT INSTRUCTIVE TO COMPARE THE TARGET RESERVE MARGIN RANGE RECOMMENDED BY ASTRAPÈ TO RESERVE MARGINS CURRENTLY USED IN OTHER REGIONS ACROSS THE INDUSTRY?

A. No. There are several reasons why one must be cautious when attempting to compare reserve margin targets across different regions. Comparing reserve margin targets alone often does not provide significant insight into the expected reliability differences among various regions. The benefits of participating in a market vary significantly. Some regions face reliability risks in different seasons with different load variability implications. Entities have varying forced outage rates. There is also variation in the methods used to calculate reserve margin. The capacity accounting of non-dispatchable resources varies drastically. Some entities include expected non-firm purchases as a resource. Some include emergency actions such as voltage reduction as resources. Some utilize a load forecast that does not represent median peak load conditions. Some back out non-firm loads from loads and resources. Notwithstanding all those caveats, the reserve margin target recommendation by Astrapé is comparable to the reserve margin targets in other regions in North America. For example, Florida utilities utilize a 20 percent reserve margin target;[2] Southern Company utilities utilize a 25 percent reserve margin target;[3] TVA uses an 18 percent summer and 25 percent winter reserve margin target;[4] California is in the process of moving to a 20 percent reserve margin target;[5] and NYISO ("NYISO") uses a 20.7 percent reserve margin target.[6]

Q. IN YOUR OPINION, WAS THE STUDY PERFORMED ACCORDING TO INDUSTRY BEST PRACTICES?

A. Yes. The Study was performed according to industry best practices. By adopting the recommendations of the Study including determining the reserve margin target using 0.1 LOLE, Public Service's approach to resource adequacy is in line with industry best practices. The Study performed by Astrapé includes rigorous consideration of the drivers of reliability typically considered in resource adequacy studies including weather-related load uncertainty, economic-related load

---

[2]Source: *Duke Energy Florida, LLC Ten-Year Site Plan,* Pages 92-93 http://www.psc.state.fl.us/Files/PDF/Utilities/Electricgas/TenYearSitePlans/2020/Duke%20Energy%20Florida.pdf

[3] Source: *Alabama Power 2019 Integrated Resource Plan Summary Report Public Version,* Page 3 https://www.alabamapower.com/content/dam/alabamapower/Our%20Company/How%20We%20Operate/Regulations/Integrated%20Resource%20Plan/IRP.pdf

[4]Source: *TVA 2019 Integrated Resource Plan Volume I-Final Resource Plan,* Page 36 https://tva-azr-eastus-cdn-ep-tvawcm-prd.azureedge.net/cdn-tvawcma/docs/default-source/default-document-library/site-content/environment/environmental-stewardship/irp/2019-documents/tva-2019-integrated-resource-plan-volume-i-final-resource-plan.pdf?sfvrsn=44251e0a_4

[5] Source: *Comments of the California Independent System Operator Corporation on Order Instituting Rulemaking Emergency Reliability,* Page 6 https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M353/K226/353226841.PDF

[6]Source: *New York Control Area Installed Capacity Requirement,* Page 4 http://www.nysrc.org/PDF/Reports/2021%20IRM%20Study%20Report%20Body%20Final.pdf

uncertainty, planned and forced generator outages, market assistance, operating reserve requirements, and renewable output uncertainty.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.