Integrated System and Operations Planning

Highlights

- Integrated System and Operations Planning has developed key capabilities that enable Duke Energy to align planning across Generation, Transmission, Distribution and customer programs and understand inter-disciplinary effects of distributed energy resources across the system.
- Those key capabilities enable contributions to the Carolinas Resource Plan from distributed energy resources, and also link resource planning to investments in transmission, distribution and Grid Edge programs.
- Integrated System and Operations Planning will continue developing its key capabilities and build upon them to further facilitate integration of renewable resources, from transmission-connected assets to behind-the-meter resources.
- Stakeholder engagement has helped to shape Integrated System and Operations Planning and given Duke Energy the opportunity to share its work with interested parties, and will continue to do so.

Background on Integrated System and Operations Planning

Integrated System and Operations Planning ("ISOP") is the planning framework that optimizes capacity and energy resource investments across generation, transmission, distribution and customer solutions for Duke Energy Carolinas, LLC ("DEC") and Duke Energy Progress, LLC ("DEP" and, together with DEC, "Duke Energy" or the "Companies"). Development of ISOP is driven by rapid changes in the energy mix in the Carolinas, which requires coordination across utility planning processes to ensure an orderly, executable energy transition that maintains power supply reliability and least-cost planning. Engagement with interested external parties has and will continue to drive

ISOP development as an objective and integrated framework for linking generation, transmission and Grid Edge (distribution and customer) resources.

While this Appendix will focus on the ways that ISOP enables the addition of resources identified in the Carolinas Resource Plan ("the Resource Plan" or "the Plan"), it is also helpful to view ISOP through the lens of how it informs investment planning across the generation, transmission and Grid Edge disciplines. For example, generation investments in solar or wind resources, as discussed in Appendix I (Renewables and Energy Storage), can be geographically focused in preferred development areas using distributed generation guidance maps developed by ISOP. Investments in transmission capacity are screened for non-traditional solutions ("NTS") using bulk system values that are derived from resource planning. ISOP informs distribution investments through continued use of the Advanced Distribution Planning ("ADP") toolset for capacity planning, NTS screening and identification of where to install equipment used in the Companies' self-optimizing grid technology. ISOP's value is manifest in linking resources from the Grid Edge to generation and linking actual investments to the more generic resource plan options for meeting system needs. To that end, development of ISOP capabilities like ADP has been included in grid investment plans.

This Appendix is organized in terms of existing functional capabilities, contributions to the current Plan, future capability developments and stakeholder engagement avenues.

Underlying Integrated System and Operations Planning Capabilities

Before explaining how ISOP contributes to the Plan, it is useful to provide background on the underlying ISOP capabilities that make those contributions possible. Duke Energy has shared more in-depth information about these capabilities through past external engagement activities, but brief summaries are also provided below.

Morecast: 11-year Hourly Distribution Circuit Level Forecasting

In 2021, Duke Energy released Morecast, a new tool that provides 11-year hourly forecasts down to the distribution circuit level. These bottom-up feeder-level forecasts include projections for adoption of distributed energy resources ("DER") such as rooftop solar, electric vehicles ("EV") and energy efficiency programs. Those DER adoption forecasts are related to the jurisdiction-wide projections for rooftop solar and EV penetration described in Appendix D (Electric Load Forecast). Disaggregating the jurisdiction-wide projections down to individual feeders required extensive collaboration between load forecasters and distribution planners to produce informed forecasts tied to geographic information system data for the distribution devices associated with the load. Morecast's granular localized forecast underlies the NTS screening and energy storage evaluations undertaken by ISOP.

Integrated System and Operations Planning Data Systems

ISOP enhanced the usefulness of Duke Energy's grid data by bringing disparate sources and formats together for a holistic picture of the grid. Synthesizing data points from multiple databases enables the Companies to perform analysis across generation, transmission, distribution and customer programs

with common points of reference. Along with supporting development of Morecast, the ISOP data systems serve as the foundation for the ADP toolset, NTS screening and visualization tools like the Distributed Generation ("DG") Guidance Maps. The sophistication of ISOP analysis requires detailed and accurate data from a variety of sources. Duke Energy leverages data analytics and machine learning to improve the quality and robustness of data supporting ISOP.

Advanced Distribution Planning

Duke Energy has developed an ADP toolset capable of performing detailed analyses and supporting evaluation of both traditional and NTSs on the system. The ADP toolset, which leverages automation and uses Morecast and the ISOP data systems, was deployed to DEC and DEP distribution planners in 2021. The new functionality of the ADP toolset enables distribution capacity planners to evaluate battery energy storage systems as a potential solution for capacity needs and identify the most likely hourly patterns where potential new batteries would be needed to address local issues. These battery profiles are then used for determining size and duration for NTS options and estimating potential NTS value at the transmission and bulk generation levels. Duke Energy will continue building upon ADP automation. This includes tool improvements, automation of power flow analyses, enhanced awareness of forecasted grid capacity, and reconciliation between transmission and distribution ("T&D") planning.

Bulk System Benefit Quantification

The fourth major ISOP capability underlying the Plan is the valuation of bulk system services that NTS, like battery storage or customer programs, can provide. Using Resource Plan modeling software, the ISOP team has derived proxy values that were developed to be used in screening processes to represent the potential value of ancillary services (i.e., regulation, contingency and balancing), energy arbitrage and firm system capacity that an NTS may provide. Generic bulk system benefits were used in ISOP NTS screening and site-specific adjustments were used in ISOP's evaluation of battery energy storage projects. These values will continue to evolve as their use is extended into more refined Grid Edge program evaluations.

Integrated System and Operations Planning Contributions to the Carolinas Resource Plan

Leveraging the underlying capabilities mentioned above, ISOP contributions to the Plan show up through NTS screening of traditional T&D investments and evaluation of battery energy storage systems included in Appendix I. The DG Guidance Maps and Portfolio Screening Tool developed by ISOP also contribute to the Plan by offering external stakeholders visualization tools to better understand how various resource types contribute in different ways to meet energy demand.

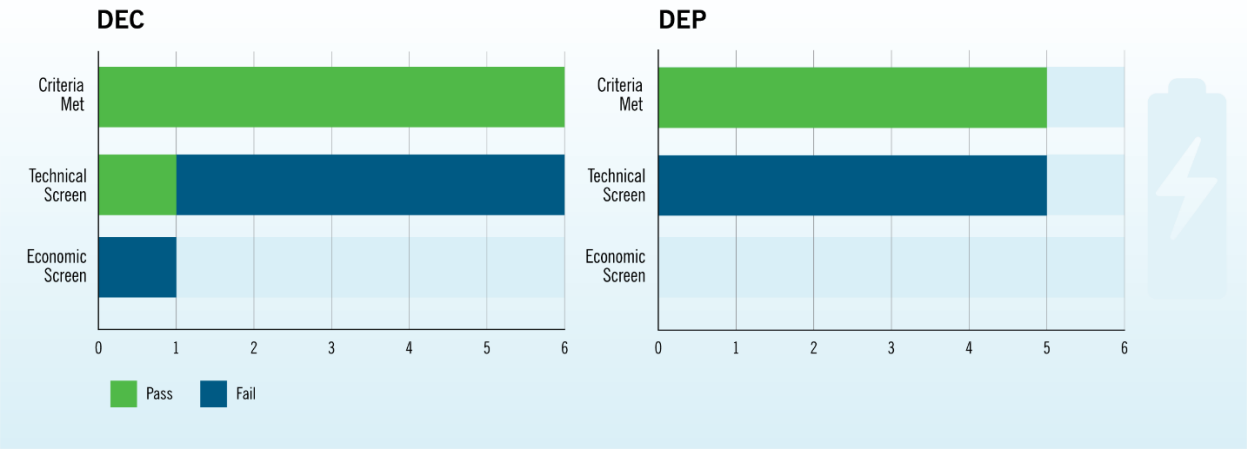
Non-Traditional Solution Screening

NTS screening is a major ISOP function that is unlocked through the underlying ISOP capabilities described above. Duke Energy has used proxy values for bulk system services that batteries could

provide based on where they are located on the grid and compared the net cost of those batteries against traditional investments in transmission or distribution upgrades. As described below, the newly established ISOP NTS screening processes have not yet identified technical, economic opportunities for batteries to defer transmission or distribution capacity projects. However, cost declines in battery energy storage systems over time and potentially higher bulk system benefits derived from the Plan are generally expected to result in more competitive NTS opportunities in the future. Another factor in battery costs that has been suggested during engagement with third parties is the potential opportunity to offset costs through a standalone storage investment tax credit as discussed further in Chapter 2 (Methodology and Key Assumptions). To that end, future NTS screening will assume a reduction in battery costs to account for expected stand-alone storage investment tax credits.

Distribution NTS screening looks for opportunities to defer traditional capacity upgrades by installing battery energy storage systems. As mentioned previously, the ADP toolset rolled out in 2021 to distribution planners automates the sizing — both capacity (kilowatt) and energy (kilowatt hour) — of a battery system that would address the overload. The NTS screening then evaluates the cost of a battery against the bulk system benefits of that battery and the value of deferring the traditional project. For the 2022–2023 distribution planning cycle, Duke Energy screened six NTS candidates in the DEC territory and five candidates in the DEP territory. As illustrated in Figure G-1 below, 10 of those NTS candidates involved overloads too large to be addressed by a battery, and for one DEC candidate the cost of batteries evaluated as NTS candidates was greater than the combined bulk system benefits and traditional project deferral values.

Figure G-1: 2022–2023 Distribution Storage NTS Screening Results

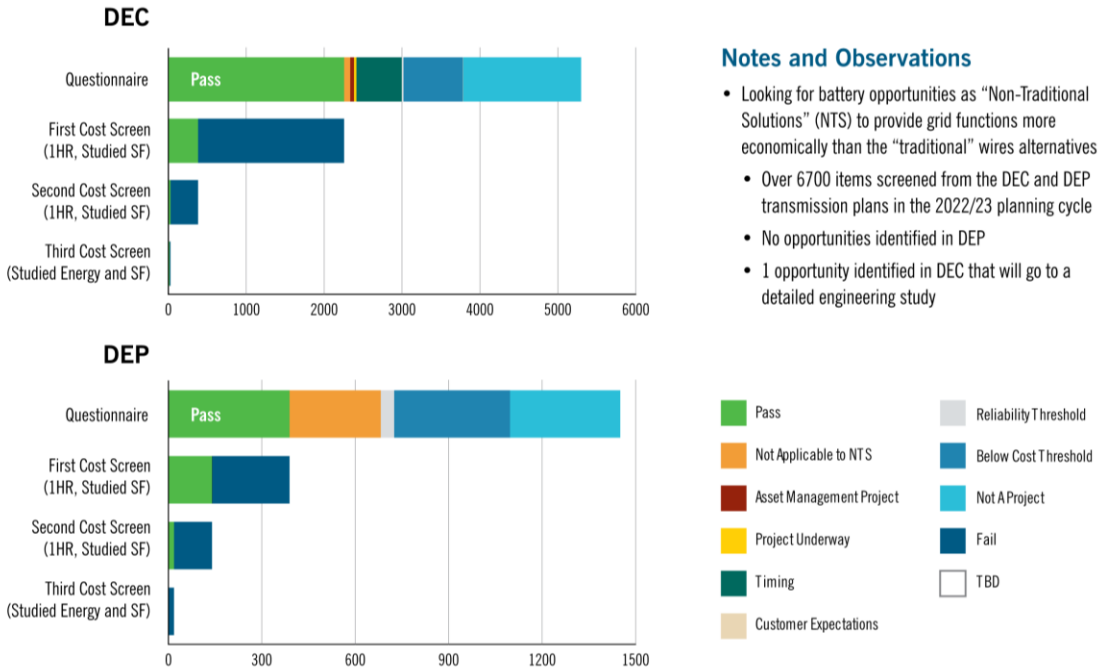


During an engagement session focused on ISOP, participants indicated that they would be interested in seeing customer programs considered as NTS resources for future screening. The Companies are interested in exploring that further, as described in Appendix H (Grid Edge and Customer Programs) under the title “Energy Orchestration.” This would involve considering how customer programs could

serve system needs in addition to local constraints. Duke Energy looks forward to sharing more about this concept as it develops in future resource plans.

Transmission NTS screening involves identifying transmission needs that could potentially be deferred with NTSs. Over 6,700 items were screened from the DEC and DEP transmission plans in the 2022–2023 planning cycle. Figure G-2 below reflects how those NTS opportunities passed through the screening process steps. One NTS opportunity was identified for DEC that will go to a detailed engineering study, while there were no viable NTS opportunities identified for DEP.

Figure G-2: 2023 Transmission NTS Screening Results



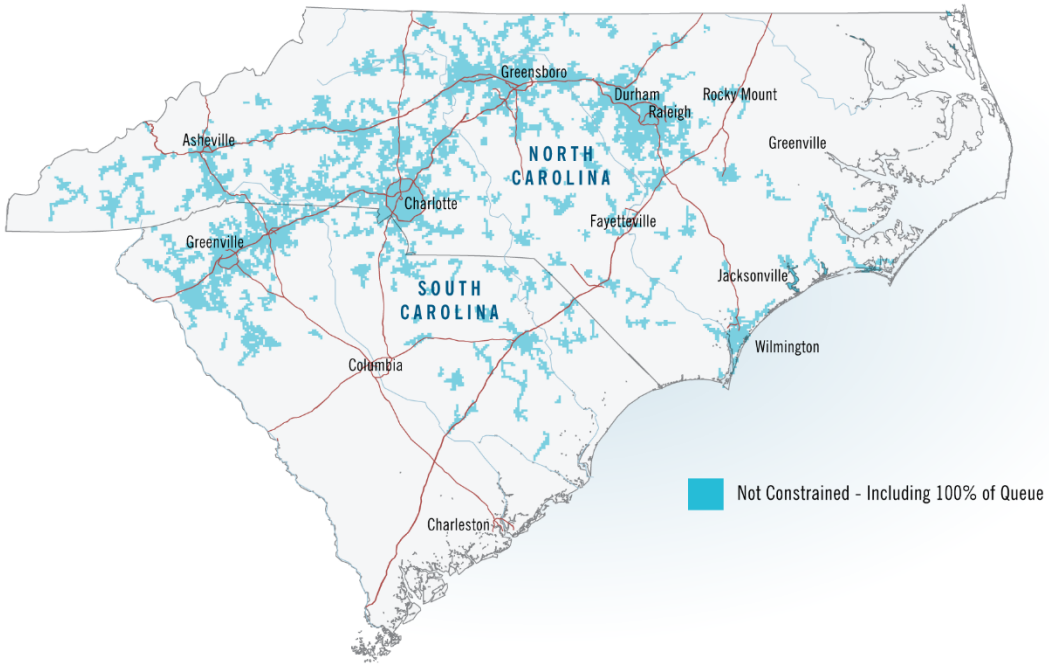
Battery Energy Storage System Evaluation

While NTS screening has not yet resulted in actionable alternatives to T&D capacity investments, ISOP capabilities are being used in technical and economic evaluations of battery projects included in the Plan as described in Appendix I. The ISOP bulk system benefit proxy values help Duke Energy's Energy Storage Development team evaluate projects. When strategic sites are identified to support distribution or bulk system grid needs, ISOP bulk system proxy values can be calibrated to recognize the specific project details and use cases, including interactions between benefits like reliability value with broader bulk system benefits. The Companies are pursuing federal grant applications that include battery energy storage projects with an emphasis on those that support disadvantaged and environmental justice communities as defined by the Department of Energy.

Distributed Generation Guidance Maps

Duke Energy has published DG Guidance Maps for its DEC and DEP service territories, as depicted below in Figure G-3. These DG Guidance Maps, which are available to the public on Duke Energy's website, leverage the ISOP data systems to illustrate areas on the distribution system with cumulative and individual site constraints that could impact interconnection of additional distributed generation.[1] This provides visualization of potential constraints on the system as it exists today and allows developers looking for opportunities to interconnect to have greater awareness of areas with potential constraints ahead of submitting interconnection requests. Duke Energy is building on the DG Guidance Maps through its grid hosting capacity ("GHC") effort, which is described later in this Appendix. Providing such guidance will enable adoption of more DERs to support the energy transition in the Carolinas.

Figure G-3: 2023 DG Guidance Map



System Reliability Requirements

One of the objectives of the ISOP initiative has been to ensure operational feasibility of the resource mixes being considered as the Companies execute the ongoing energy transition. Regulating and balancing reserve requirements account for potential uncertainty in both supply and demand. As

[1] Duke Energy, Fast Track Interconnection Process, See "Distribution" section under "System Constraints and Locational Guidance", available at https://www.duke-energy.com/business/products/renewables/generate-your-own/fast-track-interconnection-process.

weather-dependent generation resources such as solar and wind become more prominent in the energy supply, it is important to capture the associated effects of uncertainty in balancing supply and demand to maintain reliability. These reserve requirements are a function of the level of renewable resources in the generation fleet at each point in time throughout the modeling horizon for each individual Portfolio modeled within the Plan. The need to address supply and demand uncertainty is illustrated further in Chapter 2 and Appendix M (Reliability and Operational Resilience).

Portfolio Screening Tool

Duke Energy developed the Portfolio Screening Tool to provide stakeholders with a way to illustrate how a user-defined resource mix may serve load over several challenging seasonal seven-day periods. This simple, clear and transparent tool provides an intuitive illustration of how a given resource mix could support a seasonal generation profile since it does not analyze economics or incorporate the operational constraints or historic data that make a full planning model more complicated and time intensive. The Portfolio Screening Tool was debuted with stakeholders during the Companies' 2020 Integrated Resource Plan proceedings and could be leveraged for back of the envelope stakeholder assessments of the Plan.

Integrated System and Operations Planning Developments Beyond the 2023 Carolinas Resource Plan

Duke Energy anticipates further developments in its ISOP processes beyond the current Plan, including supporting the assessment of future transmission needs, incorporation of climate risks into T&D planning, further development of visualization tools like the hosting capacity analyses, and exploration of customer programs as NTS to traditional T&D investment.

Strategic Transmission Planning

As discussed in Appendix L (Transmission System Planning and Grid Transformation), there are proposed revisions to the Carolinas Transmission Planning Collaborative[2] local transmission planning process under development that will help identify and develop future transmission projects that align with future iterations of the Resource Plan. To enable this proposed strategic planning process, Duke Energy's ISOP and transmission planning teams will continue to work together to develop the new data sources, processes and tools that build on the existing modeling practices. In the past year, Duke Energy has worked on developing the tools and processes to assist with identifying likely locations for future power supply resources. This effort will effectively support planning for transmission projects that will facilitate and sustain the significant increase in the pace of interconnecting renewables called for in this Plan. During this process, transmission constraints are identified that will need to be addressed to help reach targeted levels of renewable interconnections. As the strategic transmission work evolves, the Companies are focusing on developing the ability to perform transmission studies

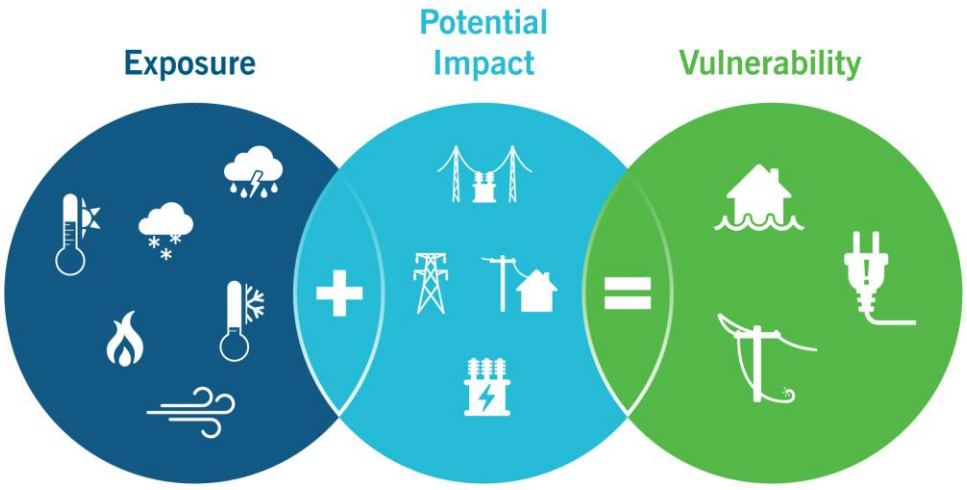
[2] As explained in Appendix L, the Companies have proposed to change the name of the North Carolina Transmission Planning Collaborative to the Carolinas Transmission Planning Collaborative or CTPC to more accurately reflect the scope of transmission planning conducted by that organization.

across multiple scenarios, prioritize which long-term solutions are most likely to be needed, and create a multi-value framework, which leverages stacked value methodologies applied to other technologies to demonstrate the business case of the projects identified.

Carolinas Transmission & Distribution Climate Risk & Resilience Study

Duke Energy has been increasing the resilience of its energy system for the last decade through storm hardening, smart grid technologies, capacity and reliability projects. To build on this work, Duke Energy initiated a Climate Risk and Resilience Study ("CRRS") of the North Carolina and South Carolina T&D systems in 2021 to 1) systematically assess the vulnerability of its T&D assets and operations to the projected physical impacts of climate change as illustrated below in Figure G-4 and 2) develop a flexible framework to inform continued investments in North Carolina and South Carolina's T&D system's resilience. The consulting firm ICF led the research and analysis, and throughout the process, Duke Energy subject matter experts from across the Companies provided detailed input and feedback through ongoing discussions, interviews, workshops and comments and supplemented with input from stakeholders as described further below. The final CRRS report, with recommendations regarding adaptive actions, is being released in the third quarter of 2023 and will be filed in the appropriate commission dockets and posted on the public-facing website where the interim report and other materials related to the study are already available.[3] Duke Energy's ISOP team will work with its peers in T&D to ensure that appropriate steps are taken to address resilience measures identified through the CRRS.

Figure G-4: Climate Study Process



[3] Duke Energy, Climate Resilience and Adaptation, available at https://www.duke-energy.com/our-company/environment/climate-resilience-and-adaptation.

Grid Hosting Capacity Analyses

Building upon ISOP capabilities and experience creating DG Guidance Maps, the Companies are developing a GHC map that will provide third parties with guidance about which parts of the Duke Energy electric distribution system in North Carolina and South Carolina may be most suitable to site new utility-scale DERs without adversely impacting power quality or reliability under existing control configurations and with reduced potential for requiring infrastructure upgrades. This type of analysis is computationally intensive and, like the ADP toolset, will leverage various automation and data analytics techniques. In order to perform this type of analysis efficiently and accurately, it is important for the future hosting capacity process to be synchronized with the distribution planning inputs and process cycle as well as the interconnection process and method of service guidelines.

Customer Programs as Non-Traditional Solutions

As stated previously in this Appendix, the Companies anticipate future work with stakeholders to address complex challenges as they undertake development work on new programs that would rely on customer behaviors and long-term program participation to defer a traditional solution that performs grid reliability functions. These programs have very different metrics and characteristics that will need to be considered as they are compared with the traditional solutions. Engaging with stakeholders on such multi-faceted issues will provide opportunities for constructive dialogue and feedback to support ongoing ISOP development efforts.

Integrated System and Operations Planning Stakeholder Engagement

Stakeholder engagement has and will continue to be integral to the development of ISOP as an objective and integrated framework. Duke Energy receives and has received stakeholder feedback through its ISOP engagement sessions, the Carolinas T&D CRRS and through coordination with wholesale customers. Below are some highlights of those engagement activities.

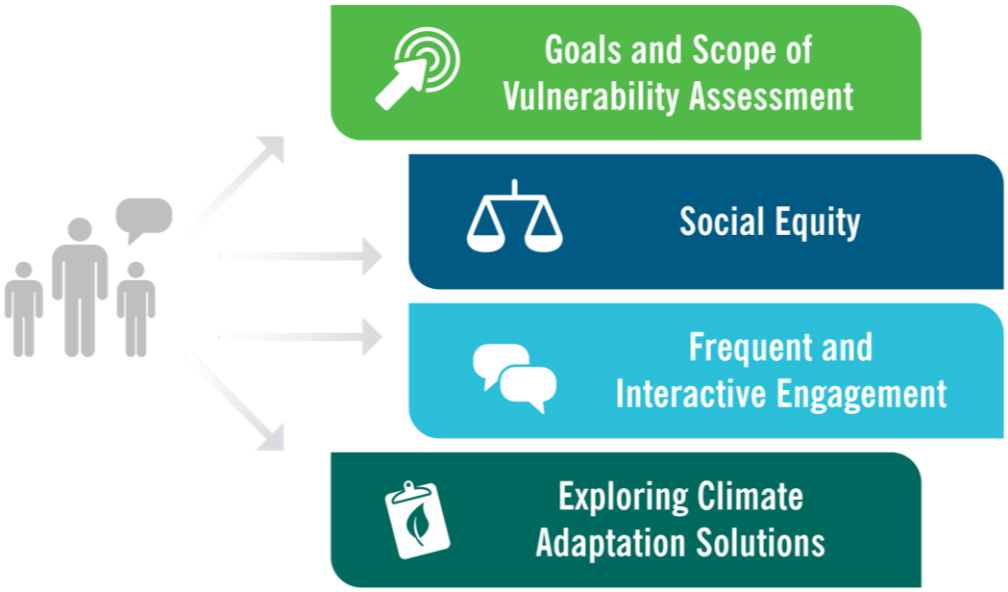
Integrated System and Operations Planning Engagement Sessions

ISOP development has been informed, in part, by interested individuals and organizations through a robust and thorough stakeholder engagement effort. This process began in late 2019 with the goal of educating and soliciting feedback from interested stakeholders and has continued into 2023 with a number of workshops focused on an open dialogue about the various initiatives under the ISOP umbrella. The Companies plan to continue this engagement and encourage participation from external individuals and organizations. In addition to the broader ISOP stakeholder sessions, Duke Energy is holding deep dive stakeholder engagement sessions on GHC. Those stakeholder sessions are being held as the company develops GHC capabilities, which will help Duke Energy deliver a product that will be useful to third parties outside of the Company.

Carolinas Transmission & Distribution Climate Risk & Resilience Study Technical Working Group

Stakeholders have been an integral component of the DEC/DEP T&D CRRS discussed previously. Duke Energy engaged the consulting firm ICF to convene a Technical Working Group, consisting of key subject matter experts from stakeholders across the Carolinas participating extensively for two years. Members of the CRRS Technical Working Group, representing dozens of governmental, academic, customer and advocacy groups, have made recommendations as reflected below in Figure G-5, such as the inclusion of environmental justice and social vulnerability considerations in the CRRS analysis. This recommendation is in line with Duke Energy's pursuit of Infrastructure Investment and Jobs Act ("IIJA") funding with projects that have a focus on disadvantaged communities as defined by the DOE's Energy Justice Dashboard and the White House's Climate & Economic Justice Screening Tool. Not only will the Companies leverage insights from CRRS as applicable, but the Companies will also continue to share IIJA funding opportunities available to their community members to help them meet resilience needs they may identify through the CRRS process.

Figure G-5: Climate Study Stakeholder Interests



Coordination with Wholesale Customers

As part of the broader ISOP stakeholder engagement effort, Duke Energy has collaborated with the North Carolina Electric Membership Corporation ("NCEMC") — due to their Distribution Operator implementation — to exchange ideas related to ISOP. The scope of this stakeholder engagement with

NCEMC continues to expand to new topics and Duke Energy sees value in having this same engagement with other wholesale customers. A summary of the coordination with wholesale customers is provided below along with a discussion of how wholesale resources impact the resource planning process.

Summary of Discussions between Duke Energy and other Load-Serving Entities

- **Load Forecasting** – Duke Energy has initiated or plans to initiate discussions with all wholesale customers regarding the load forecasts that they provide for planning purposes. The goal of these conversations is to better understand and to align load forecast assumptions, where feasible, and to understand what Grid Edge resources may already be included in these load forecasts along with the capability and the usage of these Grid Edge resources.

- **Grid Edge Resources** – In addition to understanding what Grid Edge resources are contained in the load forecasts, Duke Energy is also classifying the types of wholesale resources that are installed, how they are controlled, and what operational constraints apply to each technology. In the past, Duke Energy and NCEMC have shared updates on their respective lessons learned from integrating Grid Edge resources related to NCEMC's Distribution Operator implementation. Sharing and implementing utility best practices will ensure that both parties are able to maintain a reliable grid, including improving the joint capability to manage reliability and contingency events with Grid Edge resources that are under dispatch control of the Duke Energy system operator.

- **Non-Traditional Solutions** – As shared in this appendix, Duke Energy screens its T&D plans to identify potential opportunities for NTS. NCEMC has requested additional information on this process and opportunities for its members to contribute to an NTS. As a result of these discussions, Duke Energy developed and shared proposed criteria that would need to be met to qualify as an NTS. Duke Energy discussed a draft of the proposed criteria with NCEMC and is willing to hold similar discussions with other interested wholesale customers. The Companies continue discussions on the results and lessons learned from the NTS screens.

- **Demand Response Best Practices** – Duke Energy and its wholesale customers manage a number of demand response ("DR") programs and agree that it is beneficial to both parties to share operational information on DR programs. Duke Energy has incorporated communications into its load reduction plans for requesting the NCEMC Distribution Operator to deploy its DR programs if Duke Energy is deploying its own programs due to an energy emergency. The Companies plan to continue to meet with NCEMC to discuss best practices for these programs.

Resources Already Included in the Carolinas Resource Plan

Duke Energy already includes several wholesale resources in its models for developing resource plans. These resources include generation facilities and DR programs that have contracts with the Companies that allow Duke Energy to dispatch. In addition, the Companies have agreements with

several wholesale customers to dispatch behind-the-meter diesel generators and additional DR programs during emergency situations.

Future Potential of Coordinated DER Resources

Duke Energy is working with wholesale customers to quantify the capacity of Grid Edge resources that exist behind the wholesale delivery points and whether or how each type of resource could be dispatched to provide additional benefits that allow the Companies to reliably meet the Plan goals. The Companies are aware of some DR programs and storage that are owned and operated by wholesale customers to which the Companies do not currently have contractual rights to call for dispatch or directly dispatch. Coordination between transmission operators and distribution operators may provide the Companies with an opportunity to call on some of these Grid Edge resources when additional capacity is needed.

Progress and Impediments of Coordinated DER Resources Contributing to Low Cost, Reliable Electric Service and Resource Plan Implementation

Although Duke Energy is coordinating or will coordinate with wholesale customers on finding additional potential opportunities to utilize any current or future Grid Edge resources, there are some impediments that prevent these resources from being included in the resource plan. As mentioned above, one major planning challenge is that many of these resources are under the control of the wholesale customer, not Duke Energy, and wholesale customers dispatch to minimize their costs under their wholesale power supply contracts, not necessarily aligning with other hours in which Duke Energy may have a need. Despite the identified challenges, the Companies are continuing to collaborate with wholesale customers to investigate ways that coordination could add operational value in support of reliability, and possibly carbon reductions.