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Integrated System and Operations Planning ("ISOP")

Integrated System and Operations Planning ("ISOP") is the planning framework that optimizes capacity and energy resource investments across generation, transmission, customer delivery (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 value non-traditional solutions ("NTS") – like battery energy storage systems or customer programs – for the Companies' energy and grid needs. ISOP development has been informed by large-scale stakeholder engagement efforts dedicated to ISOP, as described herein.

In a settlement agreement approved by the North Carolina Utilities Commission ("Commission") in the Companies' most recent North Carolina rate cases, DEC and DEP agreed to implement the basic elements of the ISOP process in the 2022 Integrated Resource Plans ("IRP"). The Companies also agreed to include details about how both existing and new distributed energy resources ("DER") and non-wires applications will be examined in their ISOP process as means to defer traditional capital investments in the system in their next IRPs. Finally, the Companies agreed to publish Distributed Generation Guidance Maps ("DG Guidance Maps") for North Carolina. The remainder of this Appendix highlights the ways in which Duke Energy is meeting ISOP commitments in the Carolinas Carbon Plan (the "Plan" or "Carbon Plan"), in alignment with stakeholder feedback received during Carbon Plan Stakeholder Meeting 3.

Underlying ISOP Capabilities

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

Morecast: 10-year Hourly Distribution Circuit Level Forecasting

In 2021, Duke Energy released Morecast, a new tool that provides 10-year hourly forecasts down to the distribution circuit level. These bottom-up feeder-level forecasts include projections for adoption of

DERs 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 F (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 ("GIS") 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.

ISOP 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 Advanced Distribution Planning ("ADP") toolset, NTS screening, and visualization tools like the 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 ("ADP")

Duke Energy has developed an ADP toolset capable of performing detailed analyses and supporting evaluation of both traditional and non-traditional solutions 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.

Bulk System Benefit Quantification

The fourth major ISOP capability underlying the Carbon Plan is the valuation of bulk system services that NTS, like battery storage or customer programs, can provide. Using IRP modeling software, the ISOP team has derived proxy values 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. It is important to note that the existing bulk system benefit methodology is based upon assumptions from the Companies' 2020 IRPs. That methodology will likely evolve as the Carbon Plan takes shape, particularly with respect to the value that NTS resources could potentially provide in facilitating CO_2 emissions reductions. Duke Energy's ISOP team will monitor the Carbon Plan development and relevant additional dockets such as energy efficiency with respect to valuing CO_2

emissions reductions and factor such guidance into future ISOP work on NTS screening and battery energy storage system evaluations.

ISOP Contributions to the Carbon Plan

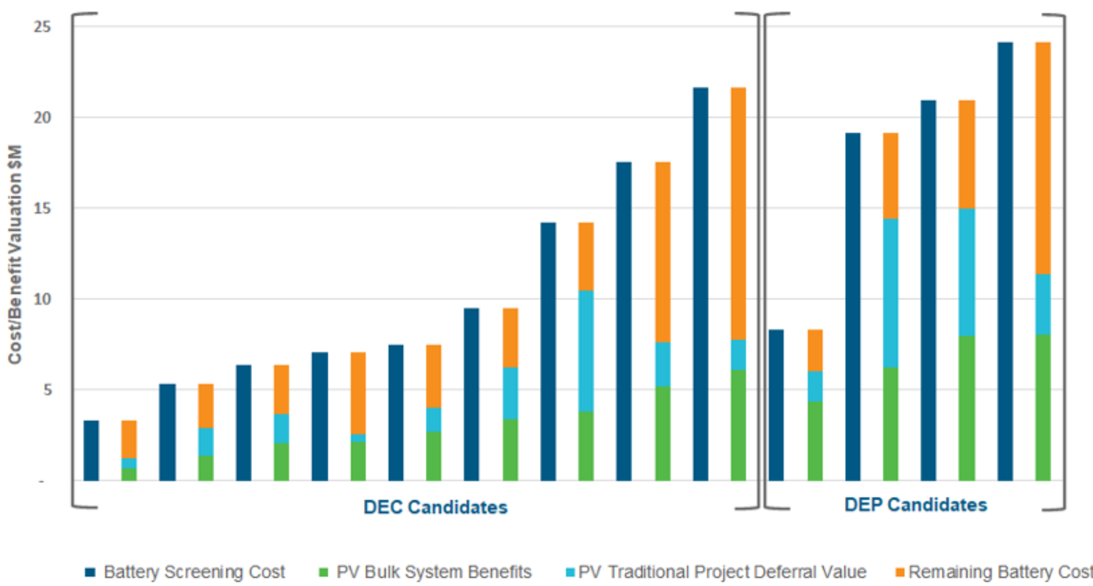
Leveraging the underlying capabilities mentioned above, ISOP contributions to the Carbon Plan show up through NTS screening of traditional transmission and distribution investments and evaluation of battery energy storage systems included in Appendix K (Energy Storage). The DG Guidance Maps and Portfolio Screening Tool developed by ISOP also contribute to the Carbon Plan by offering external stakeholders visualization tools for how they can help Duke Energy achieve its CO_2 emissions reductions targets.

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 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 Carbon Plan are generally expected to result in more competitive NTS opportunities in the future. Another factor in battery costs is the potential opportunity to offset costs through a standalone storage investment tax credit or federal funding from the Infrastructure Investment and Jobs Act ("IIJA"), as discussed further in Appendix K (Energy Storage).

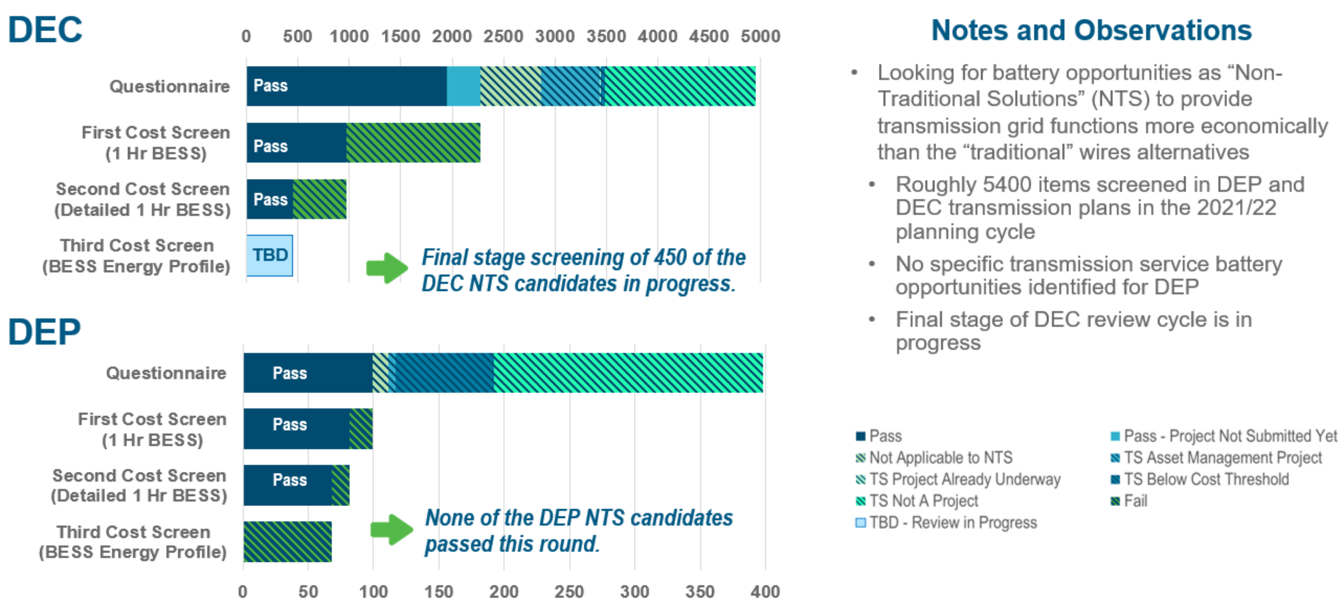
Distribution NTS screening looks for opportunities to defer traditional capacity upgrades by installing battery energy storage systems. As mentioned previously, the ADP toolset rolled out in 2021 to distribution planners automates the sizing – both capacity (kW) and energy (kWh) – of a battery system 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 2021 distribution planning cycle, Duke Energy screened nine NTS candidates in the DEC territory and four candidates in the DEP territory. As illustrated in Figure S-1 below, the cost of batteries evaluated as NTS candidates was greater than the combined bulk system benefits and traditional project deferral values in all cases.

Figure S-1: Selected 2021 Distribution Storage NTS Screening Results ($M)



Transmission NTS screening involves identifying transmission needs that could potentially be deferred with non-traditional solutions. ISOP is performing its first full transmission NTS screening in 2022, with DEP screening of 400 items completed and DEC screening of nearly 5,000 items currently in progress. Figure S-2 below reflects how those NTS opportunities have passed through the screening process steps, but ultimately have not yet resulted in viable NTS opportunities.

Figure S-2: NTS Screening Process



Battery Energy Storage System Evaluation

While NTS screening has not yet resulted in actionable alternatives to transmission and distribution capacity investments, ISOP capabilities are being used in technical and economic evaluations of battery projects included in the Carbon Plan as described in Appendix K (Energy Storage). 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.

Quantification of Regulating and Balancing Reserve Requirements

One of the objectives of the ISOP initiative has been to ensure operational feasibility of the resource mixes being considered as the Companies prepare for a fleet transition to significantly more renewable resources. Regulating and balancing reserve requirements account for potential uncertainty in both supply and demand. As 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 (Methodology and Key Assumptions) and Appendix Q (Reliability and Operational Resilience Considerations).

Distributed Generation Guidance Maps

Duke Energy has published DG Guidance Maps for its DEC and DEP service territories. These DG Guidance Maps, which are available to the public on Duke Energy's website,[1] 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. 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. While this is an indirect contribution to the Carbon Plan, it is an important example of ISOP providing stakeholders with a view of how they can support CO_2 emissions reductions efforts in Duke Energy's service areas. An updated version of the DG Guidance Maps and Methodology Guide for the Companies was published March 1, 2022, to incorporate the latest interconnection queue status.

Portfolio Screening Tool

Duke Energy developed the Portfolio Screening Tool[2] 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 IRP proceedings and could be leveraged for back of the envelope stakeholder assessments of the Carbon Plan.

As an illustrative example, Figure S-3 below represents an approximation of resources from Portfolio P1 under spring season conditions in the 2036 timeframe, after coal is projected to be eliminated from the generation mix. Note that the dashed line indicates the net demand, or load minus renewable energy, that the dispatchable resources must follow. A simplified illustration like this can help stakeholders understand why significant energy storage is required to help balance the system with high levels of renewable adoption and that curtailment of renewables should be anticipated as a natural economic outcome at certain times of the year.

[1] https://www.duke-energy.com/business/products/renewables/generate-your-own/interconnection-more-than-20kw.
[2] https://screeningtool.duke-energy.com.

Figure S-3: Approximation of Resources from Portfolio P1

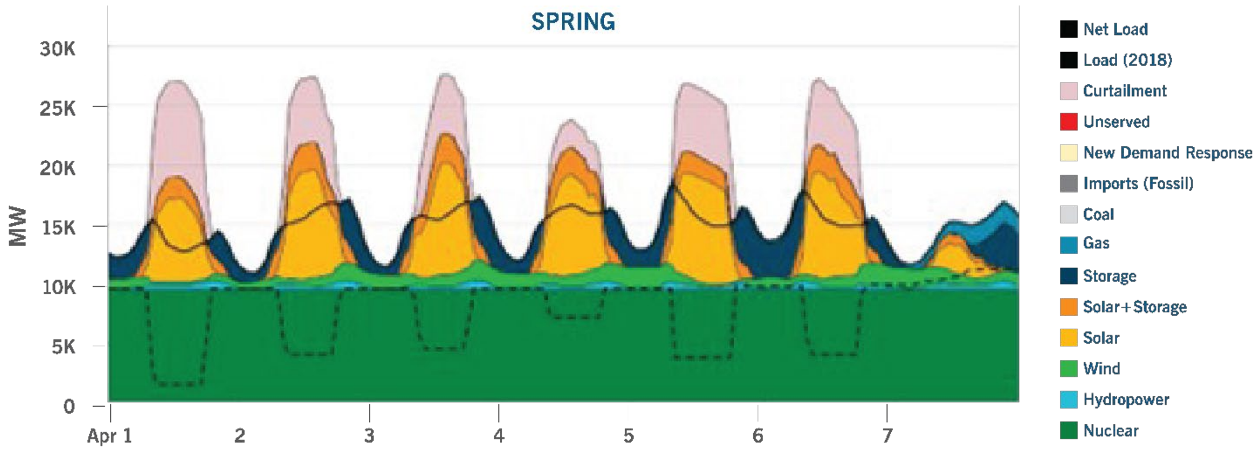
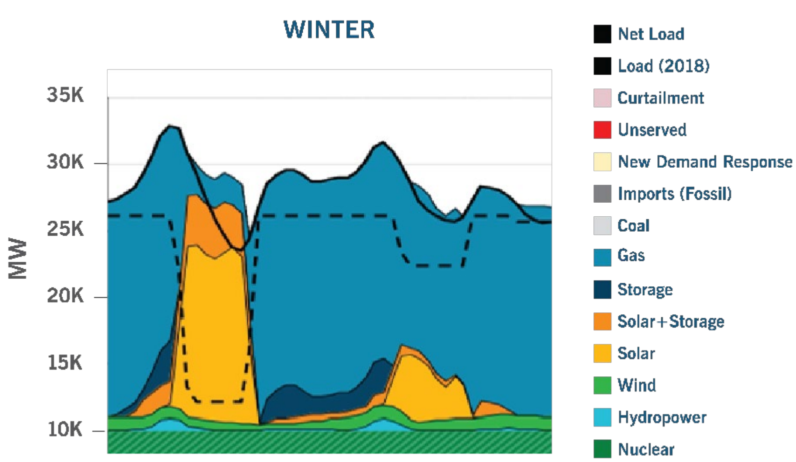


Figure S-4 below helps to illustrate the effects of high levels of renewable adoption on system ramping requirements. Note that the net demand curve climbs approximately 15,000 megawatts ("MW") in a short window of time to cover the evening load pickup as solar generation drops rapidly. This reinforces the need for a significant volume of fast ramping flexible resources to help balance the system. The Companies encourage stakeholders to utilize the Portfolio Screening Tool to consider implications of various portfolios to achieve the CO_2 emissions reductions targets.

Figure S-4: Effects of Renewable Adoption on System Ramping Requirements



ISOP Developments Beyond the Carbon Plan

Duke Energy anticipates further developments in its ISOP processes beyond the current Carbon Plan, including supporting the assessment of future transmission needs, further development of visualization tools like the hosting capacity analyses, and continued stakeholder engagement to share information about ISOP capabilities and development opportunities.

ISOP Development Efforts to Inform Future Transmission Needs

To successfully examine pathways to meet clean energy objectives in the manner envisioned in ISOP and achieve the levels of renewable adoption projected in the Carbon Plan, it will become increasingly important in future years to consider the mix of both centralized and distributed energy supply resources in use over the planning period and examine the interactions of the energy resources with the delivery systems to ensure that energy can be efficiently managed and reliably delivered on the grid. Additionally, the effect of the changing resource mix must also be factored into future evaluations of transmission needs to enable a more efficient and rapid pace of interconnection for renewable resources than historically observed under traditional planning processes that were geared toward smaller, incremental additions. Duke Energy's ISOP and transmission planning teams will work together to develop tools and processes that build on the existing modeling practices to help answer important questions about how the utilities will integrate diverse energy resources to reliably serve their customers in the future.

Hosting Capacity Analyses

Building upon ISOP capabilities and experience creating DG Guidance Maps, the Companies have begun engaging stakeholders to develop hosting capacity analyses for a representative sample of distribution circuits. 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.

Ongoing ISOP Stakeholder Engagement

ISOP development has benefited from a robust and thorough stakeholder engagement effort dedicated specifically to ISOP. Duke Energy initiated a series of stakeholder meetings in late 2019 with the goal of educating and soliciting feedback from interested stakeholders. This stakeholder engagement effort was supported by ICF, an industry-leading consultant in advanced integrated planning and regulatory engagement. As part of the broader ISOP stakeholder engagement effort, Duke Energy has collaborated with North Carolina Electric Membership Corporation ("NCEMC") to exchange ideas related to ISOP. As an extension of this collaboration, NCEMC has been working with Duke Energy to improve coordination between the customer's (NCEMC's) Distribution Operator and Duke Energy's Transmission Operator. The parties have agreed to continue this collaboration beyond these initial steps as the ISOP process evolves to ensure that planning and operations are aligned. The Companies will pursue additional ISOP-related interactions with other Distribution Operators within the balancing areas as future opportunities are identified through the normal course of outreach to these stakeholders. The Companies plan to provide future updates to stakeholders regarding the ISOP initiative and integrate ISOP stakeholder engagement into future IRP stakeholder engagement as appropriate.

As described in more detail in Appendix G (Grid Edge and Customer Programs), further work is needed within the related dockets to provide guidance on how the value of CO_2 emissions reductions and resilience should be factored into the cost-benefit framework that ISOP is developing. Duke Energy will work with stakeholders in the appropriate forums to advance these issues. The Companies also anticipate future work with stakeholders to address complex challenges as they undertake development work on new programs which would rely on customer behaviors and long-term program participation to defer a traditional solution that performs grid reliability functions. Traditional solutions have a much higher degree of certainty of performance and typically have very long asset lives, which makes it difficult to compare them to the value proposition for a customer program or rate design that relies heavily on customer participation. Additionally, traditional solutions may have a finite window of opportunity where land acquisition and permitting are required. Once these windows close due to development or other reasons, alternative solutions may be much more costly. This presents a risk in situations where customer adoption or retention does not meet the original expectations of the program. Engaging with stakeholders on such multi-faceted issues will provide opportunities for constructive dialogue and feedback to support ongoing ISOP development efforts.

As addressed in more detail in Appendix B (Stakeholder Engagement), Duke Energy is working with ICF on the DEC/DEP Transmission and Distribution Climate Risk and Resiliency Study ("CRRS") to assess long-term risks to transmission and distribution assets related to climate change and develop an adaptive framework. The CRRS process includes a Technical Working Group, consisting of key subject matter experts from stakeholders across the Carolinas. The significant level of grid investments required to support the fleet transition associated with Session Law 2021-165 ("HB 951") combined with the long life of those assets reinforce the need to consider the potential range of effects related to climate change and how that could affect design criteria, siting and potential for adaptive measures. Members of the CRRS Technical Working Group have also expressed interest in including the climate resilience value of customer-sited solar plus storage and microgrids within the Carbon Plan cost-benefit framework, as noted in the stakeholder discussion above. Not only will the Companies leverage insights from CRRS as applicable, but the Companies are also interested in sharing IIJA funding opportunities available to their community members to help them meet resilience needs they may identify through the CRRS process.

Conclusion

Through ISOP, Duke Energy can better optimize and coordinate capacity and energy resource investments across utility planning processes to value NTS for the Companies' energy and grid needs. The Companies are meeting their ISOP commitments through the Carbon Plan in multiple ways. Underlying ISOP capabilities such as Morecast and ADP enable ISOP to contribute to the Carbon Plan by permitting NTS screening of traditional transmission and distribution investments and evaluation of battery energy storage systems and, through the DG Guidance Maps and Portfolio Screening Tool, offering external stakeholders visualization tools for how they can help Duke Energy achieve its CO_2 emissions reductions targets. Going forward, ISOP will continue to be a critical resource to the Companies' implementation and further refinement of the Carbon Plan and transmission needs assessments more generally.