

# I Solar

Solar development has benefited from a long history of supportive policies, resulting in significant growth of the industry in the Carolinas. Over the past five years, the State has been among the top 10 states in the country for additions of solar resources[1] and is currently the number four state in the country for solar generation capacity.[2] As of December 31, 2021, approximately 4,350 megawatts ("MW") of utility-scale solar is connected on the Duke Energy Carolinas, LLC ("DEC") and Duke Energy Progress, LLC ("DEP" and, together with DEC, "Duke Energy" or the "Companies") systems. As described in more detail in Chapter 3 (Portfolios), the amount of solar will need to at least double over the next eight years (2022 to 2030), adding approximately 5,980 to 7,930 MW of incremental solar, which will cause the total solar to grow to as much as 10,350 to 12,300 MW. Note that these numbers only reflect utility-scale, or universal, solar projects that are generally greater than 1 MW. While "grid-edge" or customer-connected, distributed solar is important to decarbonizing the grid in the Carolinas, these customer programs are discussed in Appendix G (Grid Edge and Customer Programs).

To meet the $CO_2$ emissions reductions targets set in Session Law 2021-165 ("HB 951"), the Companies will need to "bend the curve" and accelerate interconnection of solar. This will require the Companies to annually connect to the grid in future years approximately 2.5 times the maximum amount of utility-scale solar that the Companies have ever connected in a single year in the Carolinas. This becomes more challenging as the Companies will also need to add significant amounts of other resources, such as energy storage, natural gas generation, nuclear and wind, to the portfolio while also retiring nearly 10 gigawatts ("GW") of coal generation. One of the key barriers to adding resources, particularly solar, to the system is increasing transmission network upgrades required to interconnect new resources, which will be addressed through generator interconnection studies as well as proactive strategic transmission investments that are described further below and in Appendix P (Transmission System Planning and Grid Transformation).

The type of solar resources being added to the system are expected to change in the future. Of the 4,350 MW of solar connected today, over 95% of installed solar projects are smaller, distribution-tied projects that, in sum, make up nearly 60% of connected nameplate solar capacity.

[1] Solar Energy Industries Ass'n & Wood Mackenzie, US Solar Market Insight: 2021 Year-in-Review (Mar. 2022).

[2] Solar Energy Industries Ass'n, Solar State by State, https://www.seia.org/states-map (last visited May 14, 2022).

The majority of solar needed in the Carolinas Carbon Plan (the "Plan" or "Carbon Plan") is expected to be competitively sourced. On March 14, 2022, the Companies petitioned the North Carolina Utilities Commission (the "Commission") for approval of the first competitive procurement of new solar resources, pursuant to HB 951. The solar procured in this first procurement is expected to begin providing energy to the system as early as 2026.

Meeting the $CO_2$ emissions reductions targets of HB 951 will require evolution of the solar landscape in the Carolinas. As is typical with all generation additions, transmission investments will be needed to accommodate increased solar deployment. Interconnection timelines must compress and higher capacity factor solar facilities, sometimes paired with energy storage, will need to join the operating fleet to meet the needs of the Companies' customers.

## Types of Solar in the Plan

As mentioned above, approximately 4,350 MW of solar are providing zero-carbon generation to the Companies' customers today. Most of these facilities are small, distribution-tied projects that generally have lower capacity factors than larger facilities. Larger facilities often include single-axis tracking and bifacial solar panels that increase energy output. On average, based on typical year irradiance, existing solar facility capacity factors are less than 23%, which is lower than what will be expected of new transmission-tied systems.

One of the outcomes of the Carbon Plan stakeholder meetings was confirmation from developers that solar facilities have moved toward bifacial solar panels rather than monofacial panels, as bifacial panels continue to be exempt from Section 201 import tariffs. Based on this feedback, the Companies assumed that all future solar will be bifacial panels, with an estimated annual capacity factor of 28%, when designed with single-axis tracking capability.

Pairing storage with solar can further increase the energy output of solar. Based upon feedback from the Carbon Plan stakeholder process, the Companies included an additional option for solar paired with storage ("SPS"). The two SPS configurations included in the modeling are presented in Table I-1 below.

**Table I-1: Solar Paired with Battery Storage, Plan Modeling Options**

| | Option 1 | Option 2 |
|---|---|---|
| **Solar Capacity** | 75 MW | 75 MW |
| **Storage Capacity** | 20 MW | 40 MW |
| **Duration** | 4-hour | 2-hour |
| **Approximate Capacity Factor** | 32% | 32% |

Moving forward, more solar resources will be owned by the Companies compared to the existing grid-tied solar on Duke Energy's system. HB 951 requires that 45% "of any solar energy facilities established pursuant to this section shall be supplied through the execution of power purchase agreements with third parties."[3] The remaining 55% shall be utility-built or purchased from third parties and owned by the Companies.[4] To model the cost of new solar resources maintaining the required ownership split, the Companies applied a weighted average cost of third-party PPA (45%), and utility-owned (55%) solar resources reflecting appropriate financing assumptions for each ownership type and a 10% Investment Tax Credit.

## Solar Interconnections

Interconnection of utility-scale resources is a complex undertaking requiring extensive coordination, substantial technical expertise and collaboration between the Companies and the Interconnection Customer. The Commission has previously received extensive evidence regarding the challenges and opportunities of the interconnection process in other proceedings (e.g.*,* Docket No. E-100, Sub 101, E-100, Sub 165, E-2, Sub 1159 and E-7, Sub 1156). In various proceedings, the Companies have presented unrebutted evidence demonstrating that they have achieved nation-leading quantities of solar interconnections in recent years. The Companies have also discussed the complexity of the interconnection study process, construction timelines and the inherent interdependency of the interconnection process (i.e.*,* the fact the actions or inactions of interconnection customers can impact interconnection timelines not only for a particular interconnection customer, but, in some cases, also for all other interconnection customers "downstream" of such decision).

To further streamline the interconnection process, the Companies, under the direction of the Commission, pursued implementation of new interconnection procedures (commonly referred to as "Queue Reform") and engaged stakeholders to develop a consensus approach to Queue Reform that was ultimately approved by this Commission (along with the Public Service Commission of South Carolina and Federal Energy Regulatory Commission ("FERC")). Queue Reform is now in-flight and, in just over two years, has achieved the intended outcome of eliminating the backlog of interconnection requests, streamlining the interconnection study process and providing a more predictable study process. Undoubtedly, there will be lessons learned and improvements to be made as more experience is gained, but the Companies believe that Queue Reform is a crucial aspect of streamlining the interconnection process.

Queue Reform provides a more efficient interconnection study process, which is the process that takes place from the point of submission of an interconnection request by an Interconnection Customer to an Interconnection Agreement ("IA"). Looking forward, the Companies anticipate that competitive procurement events will, in most cases, need to be aligned with the study process, as has been the case in Competitive Procurement of Renewable Energy ("CPRE") Tranche 3[5] and is being proposed for the requested 2022 Solar Procurement Program ("2022 SP Program").[6]

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[3] Session Law 2021-165, Section 1(2)(b).

[4] *Id*.

[5] CPRE Tranche 3 is the third of three requests for proposals ("RFP") issued by the Companies to comply with the CPRE requirements in HB 589.

[6] *See Docket Nos.* E-2, Sub 1297 and E-7, Sub 1268.

After executing the IA, the timeline for interconnection is influenced by the time required to construct both (1) Interconnection Facilities between the project and the point of interconnection and (2) any system upgrades that have been identified and assigned to the Interconnection Customer needed to ensure safe and reliable service. Looking forward to Plan implementation, Duke Energy will continue to explore all available options to streamline both the timelines needed to complete Interconnection Facilities and system upgrades. Appendix P (Transmission System Planning and Grid Transformation) describes the planned potential pathways to resolve certain of the more substantial system upgrades likely to be required to facilitate least-cost solar resources.

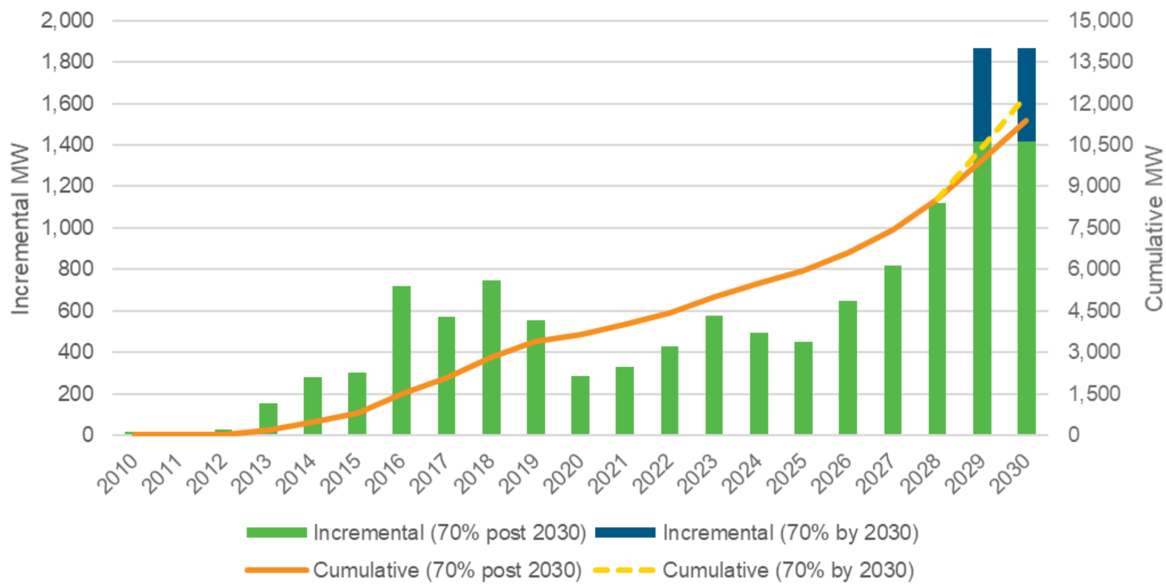
There will always be “real-world” limitations on the ability of Duke Energy (or any utility or transmission operator) to interconnect projects. Therefore, the Companies have appropriately included such real-world limitations in its Plan modeling analysis, with two potential annual interconnection scenarios assumed in the Companies’ modeling as discussed further below. In response to stakeholder feedback and because of internal initiatives, the Companies have increased the annual interconnection target included in the Plan modeling. It is important to note that there are several factors that are unknown or outside of utility control that will ultimately impact the actual amount of the annual interconnections achievable. One of the most significant unknowns is the size of an individual project that will ultimately be procured as part of the Plan. The total amount of annual MW for projects that can be completed will be highly dependent on the size of the projects that are procured. If the size of the projects procured trends higher than in the past (e.g., 200 to 300 MW projects or larger), then the Companies will be more likely to exceed the annual targeted amounts. The Companies will continue to monitor this issue in future Plan updates and will “check and adjust” such assumptions based on changing facts and lessons learned.

It should be noted that the finite interconnection resources available to the Companies must also be allocated to non-solar resources as well. That is, at the same time as the Companies will likely be seeking to substantially increase the quantity of solar resources interconnected on an annual basis, substantial additional interconnection study and work will be needed for other resources selected by the Commission as part of the Plan (*e.g.,* new storage, gas or wind resources).

## Background on Historic Interconnections

Beyond the solar generation that is already interconnected, a substantial number of solar generation projects are in various stages of the interconnection process and will come online between 2022 and 2025, including North Carolina House Bill 589 (“HB 589”) Green Source Advantage and CPRE Tranches 1 and 2 projects. The Companies anticipate that current uncontracted projects under CPRE Tranche 3 would also be connected prior to 2026 and remaining uncontracted HB 589 Green Source Advantage MW would connect throughout the remainder of the decade. The total amount of solar expected to connect from 2022 through 2025 is approximately 2,250 MW, which means approximately 6,600 MW of utility-scale solar is projected to be in service in the Carolinas by 2026. Figure I-1 below illustrates the historic and potential interconnected solar generation serving the Companies’ customers in the Carolinas. The potential amounts from 2026 to 2030 are consistent with the solar interconnection assumptions in the Plan modeling, as discussed in Chapter 2 (Methodology and Key Assumptions).

**Figure I-1: Historic and Potential Solar Growth in DEC and DEP (2010-2030)**




## Modeling Assumptions and Expanding Interconnection Capacity

To achieve the energy transition and HB 951 $CO_2$ emissions reductions targets, transmission investments are needed to accommodate increased solar deployment, interconnection timelines must compress and higher capacity factor solar facilities, sometimes paired with storage, will need to be added to meet the needs of the Companies' customers. The portfolios presented in Chapter 3 (Portfolios) indicate the need to interconnect between 3,730 MW and 5,680 MW of incremental solar between 2026 and the start of 2030. These total incremental quantities of solar achievable by 2030 were, in part, defined by the assumptions regarding the quantities of solar that can be interconnected each year.

Currently, the approximate interconnection timeline for a transmission-connected solar project is 26-32 months from a signed IA, assuming minimal system upgrades. If a project is dependent on any substantial system upgrades, the interconnection cannot be completed until such system upgrades are completed. System upgrades are more complex than direct interconnection construction, requiring more labor and technical resources, often involving upgrading many miles of major transmission lines and in many cases, are limited to implementation during non-peak periods on the system (i.e., shoulder periods) to maintain adequate customer and system reliability. The standard interconnection timeline will be extended when system upgrades are required. While other resources in the Plan portfolios (i.e., natural gas combined cycles, new nuclear facilities and wind) will also require transmission expansion, solar is unique in that the transmission interconnection and system upgrade timeline is often the critical path for commercial operation because the actual construction timeline for solar is much shorter than other resources.

Most projects bidding into the 2022 SP Program will be studied as part of the 2022 Definitive Interconnection System Impact Study ("DISIS") Cluster commencing in July 2022. Winners of the Request for Proposals ("RFP") will be announced in May 2023, with IAs executed in the second half of 2023. This puts those projects on a path to begin to be interconnected beginning in 2026, with the specific in-service date for each project to vary based on the extent of interdependency with any needed major system upgrades. Any other solar projects wishing to connect to Duke Energy's system would be studied as part of annual DISIS clusters beyond 2022, placing those projects on pace to be interconnected after 2026.

Table I-2 below illustrates the two discrete annual maximum solar interconnection rates, the first are the rates assumed in the portfolio that achieves 70% $CO_2$ emissions reductions after 2030 with wind or nuclear, and the second are the rates assumed in the portfolio that achieves 70% $CO_2$ emissions reductions by 2030.

**Table I-2: Maximum Solar (MW) Allowed to Connect Annually (by Jan. 1 of year shown)**

| Beginning of Year | 2027 | 2028 | 2029 | 2030+ |
|---|---|---|---|---|
| 70% by 2034 with Wind or Nuclear | 750 | 1,050 | 1,350 | 1,350 |
| 70% by 2030 | 750 | 1,050 | 1,800 | 1,800 |

These two unique solar interconnection scenarios were modeled in the Plan, as discussed further in Appendix E (Quantitative Analysis). The first solar interconnection scenario used in the 70% after 2030 portfolios represents the capacity of solar that the Companies believe can be reasonably interconnected through 2030 as enabled through process improvements and transmission expansion plan upgrades described below and in greater detail in Appendix P (Transmission System Planning and Grid Transformation). The second solar interconnection scenario used in the 70% by 2030 portfolio represents an aggressive case that enables the Companies to meet the 70% interim target by 2030. Additional transmission expansion planning studies and associated upgrades will be needed to enable the incremental 450 MW/year of solar beginning in 2029 in the 70% by 2030 scenario over the 70% by 2034 with Wind or Nuclear scenario. Input on solar facility locations and projected MW sizes will be needed for these transmission expansion planning studies. Also, it is worth noting that as the volume of annual interconnections increases beyond the volumes assumed in the 70% after 2030 scenario, the costs of the actual system upgrades required may increase as well.

The Companies' assumed annual interconnection levels were informed by the following key factors and data points:

- **Expected Project Size:** One of the major evolving factors that will influence the achievable amount of MW of interconnections is the size of the solar projects procured under HB 951. As the Commission is aware, the State incented a truly unparalleled amount of 5 MW and smaller utility-scale solar generation that required interconnection to the distribution system. As explained in prior proceedings, the Companies' nation-leading solar historic interconnection success is even more remarkable given that such outcomes required interconnection of hundreds of distribution-connected utility-scale projects. Looking forward, the Companies will primarily procure substantially larger, transmission-connected projects. Third-party owned projects are expected to be 50-80 MW and utility-owned projects could be substantially larger. Since 2015, the Companies have averaged five transmission-connected solar projects each year, with a maximum of nine projects in 2017. Based partially on the historic maximum of nine solar transmission interconnections in a year and an assumption of an average solar facility size of 80 MW, the Companies targeted 750 MW to be connected in 2026, more than double the average capacity connected in the last three years.

- **Need for Transmission Upgrades:** As mentioned previously, the Companies have already connected approximately 4,350 MW of solar in the Carolinas. As discussed in Appendix P (Transmission System Planning and Grid Transformation) and consistent with adding any generation type, the influx of solar into the eastern Carolinas has created a need for significant transmission system upgrades to allow for additional resource interconnections. These areas have been communicated as “red zones” to developers and are generally flat open spaces, ideal for solar development. These areas will become more attractive for solar development as the Plan implementation moves forward. Network upgrades required to enable solar growth can take three to five (or more) years to construct. Based on the timeline to complete these projects, the Companies project that interconnected solar increases over time as network upgrades are completed.

- **Increasingly Complex Interconnections:** Not only will more complex system upgrades be required to interconnect solar, but the average cost for direct interconnection facilities will also increase in the future. This cost increase results from the fact that most prime real estate close to existing transmission infrastructure has been, or is already, being developed. Solar facilities seeking to interconnect will on average be built further from existing infrastructure than historical developments. Building further from existing infrastructure requires larger direct interconnection facilities, further consuming available resources and limiting the maximum achievable annual interconnections.

- **Historic Annual Interconnection Data:** While not dispositive, it is instructive to assess what the Companies have accomplished historically in terms of annual solar interconnections. Duke Energy is a national leader in terms of solar interconnections; however, as presented in Figure I-1 above, the average annual new solar capacity added to the grid since 2015 is approximately 520 MW. In fact, the annual interconnection capacity only exceeded 700 MW in two years (2015 and 2017). The projected annual interconnections required to deliver on the Plan portfolios discussed in Chapter 2 (Methodology and Key Assumptions) represent an order of magnitude increase over what has been accomplished historically in the Carolinas and is notably higher than the historic interconnection levels in many other states. For context, the 1,800 MW of solar projected be interconnected in 2028 in the 70% by 2030 case would surpass the total amount of solar interconnected since records began in the states of Louisiana, Mississippi, Alabama and Tennessee combined.[7]

The solar interconnection projections utilized in the Plan models are intended to reflect realistic estimates of the maximum solar the Companies can interconnect annually. The projections are based on a range of factors, some of which are unknown at this time or outside of the Companies' control. The Companies will continue to evaluate the accuracy of these assumptions and will adjust them as appropriate in future Plan updates.

The Companies have sought to better align hand-offs, perform certain activities in parallel and streamline design practices to reduce the duration of the interconnection process. Queue Reform has substantially improved the efficiency of the interconnection study process (i.e., the time from interconnection request to IA) and, as detailed in Appendix P (Transmission System Planning and Grid Transformation), the Companies have identified a reasonable approach to accomplish the more substantial networks upgrades needed to support higher levels of solar generation. The Companies are actively working to identify new practices to advance interconnection timelines. Accordingly, the Companies formed a team to review options and actions to accelerate the interconnection timeline and have targeted being able to complete interconnection activity in 20 months from a signed IA for facilities that can connect with a standard design. The team included multi-function SMEs, stakeholders, and process element owners for the interconnection queue, customer interface, interconnection study work, project planning and management, engineering, construction and facility commissioning. To date, those efforts have identified the following enhancements:

- Development of standard interconnection engineering designs
- Options for early ordering of equipment with long lead times
- Ability to parallel certain engineering design activities
- Steps to accelerate timing for certain construction activities
- Definition of more visible performance measurement and tracking

These efforts and initiatives will continue to reduce interconnection timelines, thereby enabling interconnection of more solar going forward to support the energy transition and achievement of HB 951 $CO_2$ emissions reductions targets.

## 2022 Solar Procurement Volume

The 2022 SP Program for DEC and DEP is scheduled to open an RFP bid window May 31, 2022, seeking new solar assets to acquire for utility ownership and new solar assets for power purchase agreements. To align the RFP timeline with the 2022 DISIS interconnection process, the procurement

[7] Solar Energy Industries Ass'n, Solar State by State, https://www.seia.org/states-map (last visited May 14, 2022).

was initiated before the Carbon Plan was filed. The proposed RFP sets the target amount based on the capacity of solar selected in the Carbon Plan with operational dates in 2026 as most projects in the 2022 DISIS cluster are anticipated to start coming online in 2026.

Most carbon plan portfolios select 750 MW of new solar to be added in 2026 for DEC and DEP combined, and as such, the 2022 SP Program will target 412.5 MW of utility-owned solar and 337.5 MW of solar power purchase agreements ("PPA") for the RFP Target Volume, assuming that amount is approved by the Commission in the final Carbon Plan.

An RFP Target Volume of 750 MW balances the need to continue to add large amounts of solar energy to the Duke Energy system to reduce carbon emissions against the significant headwinds that solar generation currently faces that put upward pressure on solar energy costs. These factors, detailed further below, leave customers at risk of paying higher prices in a 2022 RFP than in a future RFP, but to meet the targets of the Carbon Plan, the Companies cannot simply wait until market conditions stabilize and expect to hit the 70% interim target. For these reasons, 750 MW is an appropriate 2022 RFP Target Volume to both advance carbon reduction and protect customers from significant overpayment risk.

As a risk mitigant, the RFP Target Volume may also be subject to limited adjustment either up or down depending on how actual bid prices compare to the assumed prices of solar resources in the Carolinas Carbon Plan ("Carbon Plan Solar Reference Cost"). Before selecting the portfolio of winning proposals, the Companies will calculate the weighted average cost of the total portfolio of Utility Ownership Track and PPA Track resources along with their assigned System Upgrade costs. If the weighted average cost is greater than or equal to 110% of the Carbon Plan Solar Reference Cost (the assumed cost of solar capacity, energy, and related System Upgrades that is being used to develop the Carbon Plan), the target volume may be decreased by as much as 20% (subject to 700 MW minimum target), effectively eliminating the highest cost proposals from selection in the 2022 SP Program and deferring some of the modeled procurement volume to the future. If the weighted average cost is less than or equal to 90% of the Carbon Plan Solar Reference Price, the target volume may be increased by up to 20% above the RFP Target Volume, thereby capturing more competitively priced, low-cost solar resources for customers through the 2022 SP Program because they are less expensive than assumed in the Plan. This volume adjustment minimum will not reduce the volume of new solar resources to be procured below the Minimum Target Volume.

## Execution and Risk Management

Significant expansion of utility-scale solar will be required to achieve all four portfolios described in Chapter 3 (Portfolios). The detailed near-term actions that will be required to ensure appropriate expansion of utility-scale solar to deliver on the aggressive interconnection targets set out in the Carbon Plan are discussed in Chapter 4 (Execution Plan).

Though solar is a mature zero-carbon energy generation technology, developing and interconnecting the amount of solar needed to deliver on the energy transition and the HB 951 $CO_2$ emissions reductions target is not without risk. Execution risks are discussed in detail in the remainder of this section, as well as mitigation strategies to address these risks.

**Interconnection:** As discussed throughout this Appendix and Appendix P (Transmission System Planning and Grid Transformation), the ability to construct needed system upgrades and complete interconnections of solar and other resources at the speed and scale required is the most significant challenge to meeting the $CO_2$ emissions reductions targets of HB 951. Adding to this challenge are concerns around the rapidly increasing competition for materials and labor to interconnect solar and expand the distribution and transmission grids. Drivers such as Virginia's Clean Economy Act, the rapid growth of renewables in Georgia, Florida and other southeastern states, grid improvement projects and the federal Infrastructure Investment and Jobs Act, which was signed into law in November 2021 will all contribute to increased demand for these resources.

Duke Energy is devoting significant attention to accelerating the timelines for interconnection projects and will continue to identify opportunities to continue to enhance the interconnection process. As progress is made on this front, the improvements will be reflected in the assumptions around maximum annual solar interconnection limits in Plan updates.

Beyond the physical challenges of interconnecting the volume of solar identified in the Chapter 3 (Portfolios), timely regulatory approvals from all required authorities and jurisdictions will be needed on an annual basis to ensure projects meet their development and construction timelines.

**Supply Chain and Resource Constraints:** Constraints persist in the supply chain for solar panels, steel, electronics and transmission resources for interconnection, among others. Events like COVID-19 and current socio-political and economic drivers are creating challenging market conditions impacting the entire industry. For example, the recent U.S. Department of Commerce-initiated anti-circumvention inquiry into solar panel cells from four southeast Asian countries has influenced world supply of panels and market prices impacting everyone in the industry. Duke Energy will continue to gather information on the potential impacts of supply chain constraints and will receive specific information related to the impact to the solar industry from the solar procurement processes scheduled for 2022 and 2023.

**Labor Constraints:** While the Carolinas have a strong foundation of local solar installation resources, the scope and scale of solar development needed to achieve the Carbon Plan targets is substantial. Even with continued growth of the local installation workforce, there will continue to be constraints under certain circumstances. For example, the spring and fall months are the periods when planned transmission outages for system upgrades and interconnections typically occur. These months, particularly during the fall, are when most major storms such as hurricanes occur, which can divert resources from performing planned upgrades and resource interconnections. All these factors increase the timeline risk associated with being able to interconnect the amount of solar identified in the Plan.

**Uncertain Future of Solar Tax Credit:** In the short term, the Companies and the industry are monitoring if the federal solar investment tax credit ("ITC"), which is currently scheduled to phase down from the current 26% to 22% for projects placed in service in 2023, and to 10% for projects placed in service in 2024, will be extended and/or increased in the coming months. Absent any other Federal tax action, the market will likely assume a 10% ITC for projects that come into service in 2026. The Companies are evaluating how the 2022 SP Program may be impacted by potential solar ITC actions and how actions could benefit customers.

**Importance of Storage:** As discussed in Chapter 3 (Portfolios) and Appendix K (Energy Storage), energy storage investments are critical to achievement of each of the four pathways. In terms of solar, energy storage is just as important, to ensure that supply can better match demand.

Today, the Companies, particularly DEP, experience periods where the installed solar energy causes the system to reach its Lowest Reliability Operating Limit (“LROL”). The LROL is the point at which the system reaches the minimum level of regulating resources required for system reliability. In other words, all dispatchable resources on the system have been reduced to their minimum safe operating limits, and further reduction would jeopardize the safety and reliability of the equipment and the system. The only options at the point of LROL are to move the excess energy off-system or curtail solar energy production.

As the Plan is executed and greater capacities of solar are connected on the DEC and DEP systems, there will be an increased likelihood of curtailment needed to avoid reaching the LROL. Energy storage can help minimize curtailment in these situations and enable the excess zero-carbon energy to be utilized when there are limitations to the supply of zero- or low-carbon energy. Therefore, the full effectiveness of solar is tied to the installation of appropriate levels of stand-alone storage, solar plus storage, and longer-term electrolysis to support the production of low-carbon hydrogen as discussed further in Appendix O (Low-Carbon Fuels and Hydrogen).

## Conclusion

The energy transition will not be achieved without significant expansion of solar on the Companies’ system in the Carolinas. As of December 31, 2021, approximately 4,350 MW of utility-scale solar is connected on the Companies’ systems, and this amount will need to at least double over the next 8 years (2022 to 2030) to as much as 10,350 to 12,300 MW of solar to deliver on any of the portfolios presented in Chapter 3 (Portfolios). The most significant challenge that the Companies face in the development of this quantity of new solar is the ability to construct needed system upgrades and complete interconnection. This is discussed in detail throughout this Appendix, and the Companies believe that aggressive but realistic annual maximum levels for solar interconnection have informed the modeling and represent a technically feasible pathway for the achievement of the Plan portfolios. If additional progress can be made to improve solar interconnection volumes, the Companies will reflect those changes in the maximum allowable annual solar levels utilized in future Plan updates to ensure that they continue to stay at the forefront of the development of solar projects into the future.