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**Docket No. E-100, Sub 179**

**Public Staff Report**
**Duke Energy "Carolinas Carbon Plan"**
**Stakeholder Meeting 2 (Feb. 23, 2022) and Technical Subgroup Meetings (Feb. 18, 2022)**

## GENERAL OVERVIEW

The second stakeholder meeting was moderated by third-party facilitator Great Plains Institute. In the first portion of the meeting, Duke Energy responded to several key questions raised during the first stakeholder meeting. Next, Duke Energy presented a draft list of what it believed to be the stakeholders' desired outcomes of the Carbon Plan, based on feedback received during the first stakeholder meeting. Stakeholders then provided revisions to the list, which was edited during the meeting. The next two portions of the stakeholder meeting consisted of presentations by Duke Energy on principles for portfolio development and evaluation, and considerations driving different portfolio options. Following each presentation, participants asked questions and gave feedback. In addition to verbal questions and feedback, participants used a chat box to ask questions and make comments.

Duke Energy stated that it is working to get stakeholder engagement on the front end of the process, and that April will be devoted to developing the Carbon Plan. When asked, Duke Energy indicated that it does not plan to distribute a draft of its proposed Carbon Plan before it is filed on May 16. Duke Energy also stated that it would have more information on resource pathways in the March stakeholder meeting. Duke stated that it is not seeking consensus on all aspects of the Carbon Plan, but rather is seeking to understand stakeholder perspectives.

In addition to the second stakeholder meeting held on February 23, three technical subgroup meetings were held on February 18. Those groups focused on the following three topics: (1) Solar Interconnection Forecast, (2) Solar/Wind Cost/Operational Assumptions, and (3) Storage Assumptions. Each technical subgroup included stakeholder panelists, who asked questions and gave feedback during the meetings. Those who did not participate as panelists were able to observe and submit questions and comments using a chat box. A list of stakeholder panelists is located on slides 6, 31, and 53 of the Technical Subgroup Presentation Slides (attached to this report as Attachment 5). A brief summary of stakeholder discussions in each Technical Subgroup is included at the end of this report.

## ATTACHMENTS

Attachment 1 – Stakeholder Meeting Participants
Attachment 2 – Stakeholder Meeting Agenda
Attachment 3 – Stakeholder Meeting Presentation Slides
Attachment 4 – Redlined Version of Stakeholder Desired Outcomes
Attachment 5 – Technical Subgroup Presentation Slides

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## STAKEHOLDER MEETING 2 – FEBRUARY 23, 2022

### STAKEHOLDER FEEDBACK ON PROCESS

- Stakeholders asked to see a draft of the proposed Carbon Plan before it is filed.
- Stakeholders were expecting this meeting to provide information about the scenarios that would be modeled for the Carbon Plan. They expressed concern that if Duke Energy does not provide this information soon, stakeholders will not have an opportunity to comment on the scenarios before the submittal of the proposed Carbon Plan.
- Stakeholders expressed concern that Duke Energy is not sharing inputs, data files, or other information that would allow stakeholders to conduct their own analyses.
- Stakeholders were concerned that Duke Energy was discussing the Carbon Plan delay provisions within HB 951 at this early stage.
- Stakeholders requested a report that would describe how stakeholder input affected Duke Energy's proposed Carbon Plan, in order to demonstrate the effectiveness of these stakeholder meetings.
- Stakeholders recommended that the Carbon Plan tie into other ongoing stakeholder groups, such as the EE/DSM Collaborative, the Comprehensive Rate Review, and the Low Income Affordability Collaborative.
- Stakeholders indicated interest in technical subgroups on the following topics:
  - RTOs.
  - The Encompass modeling software and its abilities, as well as which assumptions and inputs Duke will use.
  - DERs.
  - Demand assumptions related to EE/DSM, DERs, EVs, and electrification.
  - Cost of transmission upgrades and ongoing efforts to relieve transmission and distribution congestion.
  - Carbon reduction efforts of Commercial and Industrial customers.

### ISSUES ON WHICH THERE IS CONSENSUS

- There are potential benefits to consolidating the DEC and DEP balancing authorities to achieve operational efficiencies and more cost-effectively integrate renewables.
- The impact of electrification is an important factor in load projections and should be considered in the Carbon Plan.
- There are concerns about supply chain challenges and inflationary pressures that impact future resource selection and implementation.
- Stakeholders, excluding Duke Energy, shared broad consensus regarding the need to model Duke Energy's system as part of an RTO.

### ISSUES IN DISPUTE

The list below captures broad themes of questions and comments made during the stakeholder meeting. The issues below are not necessarily in dispute at this time, nor is this an exhaustive list of points raised. In addition, the items below are attributable to one or more participants, and do not represent the views of the group as a whole. The Public Staff does not take a position on any of the issues listed below at this time.

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*Carbon Plan, Generally*

- Concerns regarding whether Duke intends to meet HB 951 carbon reduction goals by building gas plants in South Carolina.
- Concerns over whether Duke will acknowledge and consider the cost impacts of South Carolina regulators not accepting the incremental costs of the Carbon Plan (i.e., will the total cost to comply with HB 951 fall solely on North Carolina ratepayers).
- Need to keep the end goal in mind and maintain a long-term view toward achieving a net-zero system.
- Need to include planning for disruptions from growing intense weather patterns, including generator outage risk.
- Concerns regarding where natural gas will be coming from and at what price, given constraints on the Transco pipeline and challenges with the Mountain Valley Pipeline (MVP) and MVP Southgate construction and regulatory approvals. Additional demand on Transco Zone 4 or 5 may cause cost increases to non-utility natural gas customers.
- Questions concerning how Duke Energy is evaluating the regulatory and permitting risk of individual resources, as well as risks around fuel costs and stranded assets.
- Requests for a robust risk analysis (e.g., minimum regrets analysis or stochastic modeling) of portfolios to be included in the Carbon Plan. Stakeholders would like to provide input on the key assumptions to be tested in a risk analysis.
- Question regarding how output from the NC Transmission Planning Collaborative will feed into the Carbon Plan (and vice versa).
- Questions regarding how prior carbon reduction efforts are being incorporated, including outputs from the North Carolina Energy Regulatory Process and DEQ's Clean Energy Plan.

*Emissions Targets, Generally*

- Concerns that Duke Energy was discussing the Carbon Plan delay provisions within HB 951 at this early stage.
- Duke Energy should focus on the long-term 2050 emission target and "work backwards" from there.
- Concerns regarding the urgency of the climate crisis, the potential leakage of emissions across state lines, and the timing of emission reductions – general preference among stakeholders to achieve emission reductions faster while still meeting HB 951 legislative mandates.

*Affordability*

- Some disagreement among stakeholders as to whether there should be more of a focus on rates and less of a focus on total system costs. Stakeholders were also interested in understanding how costs will be allocated among customer classes, and the impact of a multi-year rate plan on costs.
- North Carolina businesses need to be able to operate competitively, retain jobs, and create new jobs.
- Concern around potential for stranded fossil fuel assets and the impact to customer bills.
- Interest in understanding how the Carbon Plan and electrification assumptions would impact total system costs, beyond the electric power system.

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*Environmental Justice and Communities*

- Duke Energy needs to collaborate with environmental justice advocates and affected communities.

*Renewable and Carbon-Free Resources*

- Duke Energy should reassess the timing and commercial availability of certain carbon-free resources, specifically offshore wind and new nuclear, and whether these resources will be available before 2030. Duke Energy should also consider other novel carbon-free or low-carbon resources.
- Would like Duke to model 100% renewable energy.
- Carbon Plan should conduct a load flexibility forecast, taking into account, for example, the ability for rooftop solar and storage to shift load and compete with system resources.
- Concern about a lack of transparency – BOEM wind lease auction will be held on May 15, and the only party who will know at that time whether and to what extent offshore wind will be contained in the proposed Carbon Plan is Duke Energy.

*Modeling and Inputs*

- Question concerning what constraints Duke Energy is imposing in its modeling on the ability to site additional carbon-emitting generation in South Carolina.
- Concerns about how and why Duke Energy is considering different carbon reduction impacts between new natural gas facilities sited in North Carolina vs. South Carolina.
- Whether and how to take into account social and health impacts of each energy type.
- Modeling should consider the life cycle assessment of all system resources.
- Rather than just using data from NOAA that is based on historic weather patterns, the modeling should take into account long-term projections factoring in climate change.
- Planning approach needs to move away from peak/reserve planning and move toward capacity and reserves at every hour.
- Renewable resource curtailment assumptions should be transparent.
- The least cost path could be overbuilding renewable resources with curtailment; could alleviate ramping concerns.
- All-source procurement needs to be modeled.
- The effects of coal plant securitization need to be considered in the Carbon Plan.

**NEXT STEPS**

- The third stakeholder meeting will take place on March 22, 2022.
- Information, feedback, and questions can be sent to DukeCarbonPlan@gpisd.net.
- Meeting materials will be posted on www.duke-energy.com/CarolinasCarbonPlan.

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# TECHNICAL SUBGROUP MEETINGS – FEBRUARY 18, 2022

## SOLAR INTERCONNECTION FORECAST

- This group focused on appropriate modeling assumptions underlying the ability to interconnect new solar resources, including proposed limitations, cost of network upgrades, interconnection timelines, and constrained zones and efforts to alleviate congestion.
- Duke Energy solicited feedback on the appropriate limits in an “Enhanced Transmission Policy” scenario, as well as the appropriate transmission cost adders to apply within the model.
- Stakeholders raised multiple issues and concerns. Major themes included: a request for an unlimited interconnection sensitivity, better integration between the Carbon Plan and the North Carolina Transmission Planning Collaborative (NCTPC), integration with neighboring utilities, more detail as to estimated network upgrade costs for wind and solar, and cost sharing of network upgrades.

## WIND AND SOLAR COST AND OPERATIONAL ASSUMPTIONS

- This group focused on providing information on how Duke Energy builds cost and operational assumptions for the generic solar and wind generators included in the Carbon Plan model. No confidential cost figures were shared with the group.
- Duke solicited stakeholders for additional considerations or data sources that should be considered in building its cost and operational model inputs.
- Stakeholders raised multiple issues and concerns. Major themes included: utility vs. distributed solar, stakeholder access to confidential data and the use of publicly available data, whether non-renewable resources will be subject to interconnection limits or network upgrade costs, and regulatory permitting processes for offshore wind resources.

## STORAGE ASSUMPTIONS

- This group focused on describing the characteristics of storage that will be used in the Carbon Plan, including data sources, use cases, system configuration, and key assumptions. Duke also highlighted other storage technologies considered for meeting system need beyond 2030.
- Stakeholders raised multiple issues and concerns. Major themes included: inclusion of behind-the-meter energy storage in the Carbon Plan, and whether Duke’s assumptions around operational limitations, usable energy, and efficiencies are reasonable.

**Docket No. E-100, Sub 179** **ATTACHMENT 1**

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**Public Staff Report**
**Duke Energy "Carolinas Carbon Plan"**
**Stakeholder Meeting 2 (February 23, 2022)**
**9:30 am – 4:30 pm**

**Participating Stakeholders**

350 Triangle
AARP SC
Alder Energy Systems, LLC
Ameresco
American Petroleum Institute
APCO
Apex Clean Energy
Appalachian Voices
Atrium Health
Audubon SC
Bailey & Dixon, LLP
Baldwin Consulting Group
Birdseye Renewable Energy
Black Voters Matter
Blue Horizons Project
BP
Bright Blue Door, LLC
Brooks Pierce
Brooksform, LLC
Capital Group of the Sierra Club
Carolina Utility Customers Association
Carolinas Clean Energy Business Association
Carolinas Friends School
Cary Chamber of Commerce
Central Electric Power Cooperative
Charles River Associates
Chatham County
Chatham County Climate Change Advisory Committee
CIGFUR
Citizens Climate Lobby
City of Asheville
City of Charlotte
City of Henderson
City of Wilmington
Clean Energy Buyers Association
CleanAIRE NC
Clemson University
Climate Action NC
Conservation Voters of South Carolina
Continental Tires
Cypress Creek Renewables

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Dominion Energy
Draughon Farms, LLC
Durham County Government
East Point Energy
Eckel & Vaughan
Ed Ablard Law Firm
ElectriCities of North Carolina
Elon University
Energy and Policy Institute
EnerWealth Solutions, LLC
Enterprise Strategy & Planning
Environmental Defense Fund
EPRI
Fayetteville Public Works Commission
Fox Rothschild LLP
Furman University
Gaia Herbs
GE
Geenex Solar LLC
GMC Consulting Engineers
Google LLC
Granville-Vance District Health Department
Great Plains Institute
Green Built Alliance
Guidehouse
Hitachi Energy USA Inc.
Interfaith Creation Care of the Triangle
KinderMorgan Inc.
Lockhart Power
Longroad Energy
McGuireWoods LLP
Mecklenburg County
Members of the Public
Meridian Renewable Energy
Messer North America
Meta
Mitsubishi Power
MountainTrue
NAACP
National Audubon Society (NC Office)
NC Alliance to Protect Our People and the Places We Live
NC Attorney General's Office
NC Clean Energy Technology Center
NC Conservation Network
NC Department of Commerce
NC Department of Environmental Quality
NC Department of Justice
NC Dept. of Transportation
NC Division of Air Quality
NC Governor's Office
NC Interfaith Power & Light

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NC League of Conservation Voters
NC Sierra Club
NC State Energy Office
NC Sustainable Energy Association
NCUC Public Staff
New Belgium Brewing
North Carolina Climate Solutions Coalition
North Carolina Electric Membership Corporation
North Carolina Justice Center
North Carolina Manufacturers Alliance, CIGFUR
North Carolina State University
Nova Energy Consultants, Inc.
NPCIA, Inc.
NRDC
Nuclear Energy Institute
Orsted
Palladium Energy
Parkdale Mills
Parker Poe
Person County Chamber of Commerce, Roxboro N.C.
Person County Economic Development Commission
Piedmont Community College
Pine Gate Renewables, LLC
PJM Interconnection LLC
Plus Power
Polk County Local Government - Planning
Regional activist in the Blue Horizons Project in Asheville, Net Zero Foundation
RES
Research Triangle Cleantech Cluster
RMI
Robinson Consulting Group
Rutherford Electric Member
RWE
Santee Cooper
Savion Energy
SC Department of Consumer Affairs
SC DHEC
SC NAACP
SC Office of Regulatory Staff
SC Senate
SC State Conference NAACP
Sepa Power
Siemens Energy
Sierra Club
Solar Operations Solutions, LLC
Soltage
South Carolina Coastal Conservation League
Southeast Sustainability Directors Network
Southeastern Wind Coalition
Southern Alliance for Clean Energy
Southern Current

Southern Environmental Law Center
Southern Renewable Energy Association
Spilman Thomas & Battle (outside counsel to Walmart Inc.)
Strategen Consulting
StratGen
Sunnova
Sunrun Inc.
Sustain South Carolina
Synapse Energy Economics
TerraPower LLC
The Glarus Group LLC
Tierra Resource Consultants
Town of Apex
Town of Cary
Town of Davidson - Parks and Rec
Town of Polkville
UNC Greensboro
University of North Carolina at Chapel Hill
University of North Carolina - Charlotte
Upstate Forever
UtiliCom
Wake County Government
Wake Forest University
WFAE



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# Carbon Plan Stakeholder Meeting 2 Agenda
**February 23, 2022**
**9:30am – 4:30pm**

**9:30am:** **Welcome and Introductions**

*Review agenda, ground rules, and overall plan for stakeholder engagement; participant introductions via chat; welcome from Duke.*

**9:45am:** **Presentation and Q&A: Respond to key questions from Meeting 1**

*This session will provide an opportunity for Duke to respond to questions from stakeholders in Meeting 1.*

**10:45am** **BREAK**

**11:00am:** **Discussion: Stakeholder Desired Outcomes**

*This session will provide an opportunity for stakeholders to review, discuss, and refine a draft list of their desired outcomes for the Carolinas Carbon Plan, based on input from Meeting 1. These are things that stakeholders would like Duke to keep in mind as they develop the Carbon Plan.*

**12:00pm:** **Lunch**

**1:00pm:** **Presentation and Discussion: Principles for portfolio development and evaluation**

*This session will provide an opportunity for stakeholders to discuss principles for developing and evaluating potential carbon reduction pathways.*

**2:15pm** **BREAK**

**2:45pm** **Presentation and Discussion: Considerations driving different portfolio options**

*This session will provide an opportunity for stakeholders to discuss considerations that will inform the development of potential carbon reduction pathways, such as timing and availability of advanced technologies and contributions to carbon reduction by resource type.*

**4:15pm** **Next Steps**

*Facilitators will summarize next steps. Please save the date for Meeting 3 on March 22, 2022.*

**4:30pm** **Adjourn**

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# Duke Energy Carolinas Carbon Plan Stakeholder Meeting 2

## Virtual Meeting – February 23, 2022

**Please note, this meeting is being recorded. Presentations will be posted on the Carolinas Carbon Plan website, and discussion portions will be kept for internal purposes only to ensure accuracy of meeting notes.*

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## Welcome!

**Please introduce yourself (name and organization) in the chat.**

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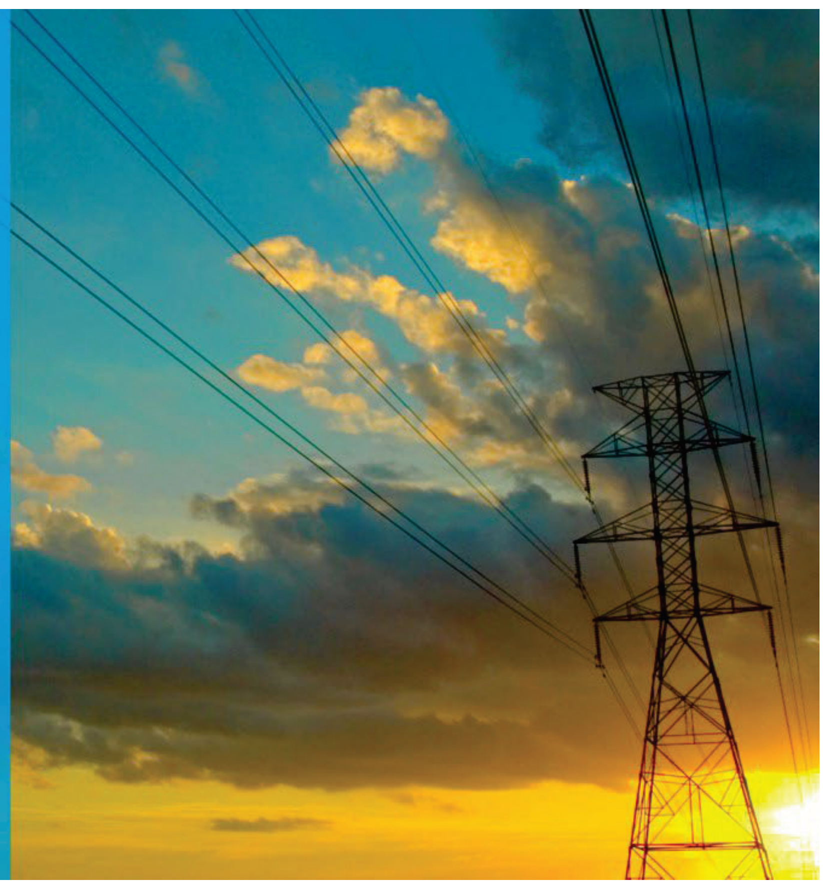

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# Today's Agenda

| | |
|---|---|
| 9:30am: | Welcome and Introductions |
| 9:45am: | Presentation and Q&A: Respond to stakeholder questions from Meeting 1 |
| 10:45am: | BREAK |
| 11:00am: | Discussion: Stakeholder Desired Outcomes |
| 12:00pm: | LUNCH BREAK |
| 1:00pm: | Presentation and Discussion: Principles for portfolio development and evaluation |
| 2:15pm: | Break |
| 2:45pm: | Presentation and Discussion: Considerations driving different portfolio options |
| 4:15pm: | Next Steps |
| 4:30pm: | Adjourn |

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# Duke Welcome

**Julie Janson**

Executive Vice President & CEO

Duke Energy – Carolinas Region

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# Meeting Ground Rules

- **Respect each other:** Help us to collectively uphold respect for each other's experiences and opinions, even in difficult conversations. We need everyone's wisdom to achieve better understanding and develop robust solutions.
- **Focus on values and outcomes:** Today's discussion is about what stakeholders value in the energy future, and how the Carolinas Carbon Plan can align with those values. Pending legal issues are outside the scope of this conversation.
- **Chatham House Rule**: Empower others to voice their perspective by respecting the "Chatham House Rule;" you are welcome to share information discussed, but not a participant's identity or affiliation (including unapproved recording of this session).

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# Meeting Ground Rules

- **Respect the time:** Our time together is limited and valuable, and we have a large group, so please be mindful of the time and of others' opportunity to participate.
- **Use the chat:** Please submit your comments and questions in the chat. GPI staff will monitor the chat to pull out questions for Q&A portions. Please be respectful and focus on issues, not people.
- **Raise your hand:** During dedicated Q&A portions of the meeting, use the "Raise Hand" feature to indicate you would like to voice a question or comment.

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# Stakeholder Process Update

Rebecca Dulin, Duke Energy

Director, Stakeholder Engagement

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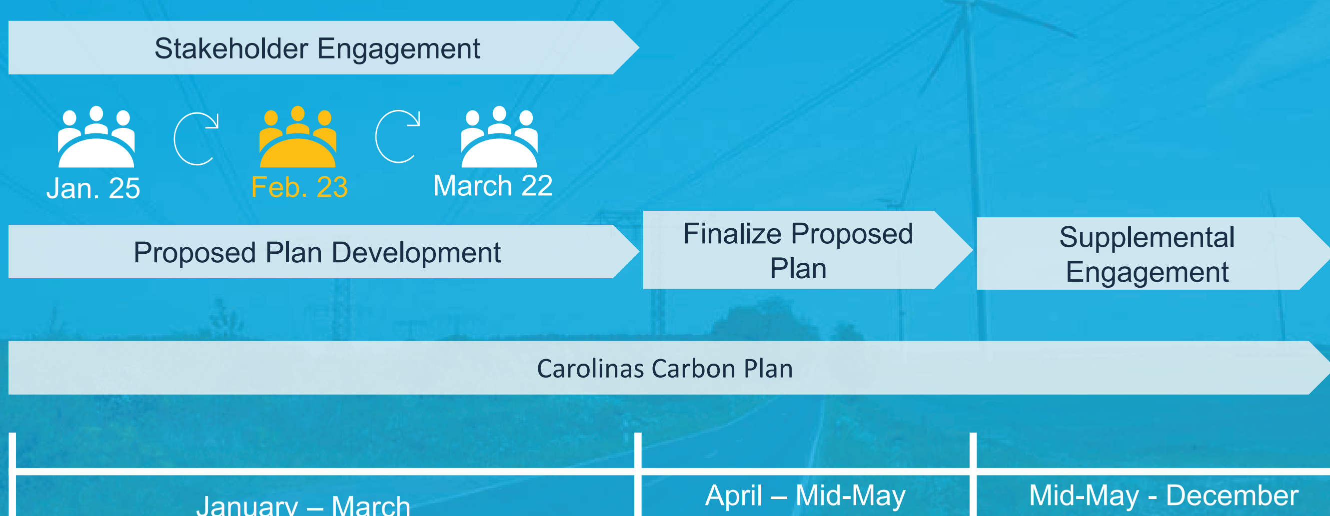
## Stakeholder Process Timeline

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# Stakeholder Process Timeline


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# Technical Subgroup Meetings

- Panel 1: Solar Interconnection Forecast
- Panel 2: Solar and Wind Cost/Operational Assumptions
- Panel 3: Storage Cost and Operational Assumptions

**Stakeholder Panelists:**

Mark Johnson, Clemson University
Zander Bischof, Cypress Creek Renewables
Neil Kern, Electric Power Research Institute
John Lemire, NC Electric Membership Corporation
Jeff Thomas, NCUC Public Staff
Dustin Metz, NCUC Public Staff
Amanda Levin, National Resource Defense Fund
Steve Levitas, Pinegate Renewables
Kirsten Millar, Rocky Mountain Institute
Katharine Kollins, Southeast Wind Coalition
Tyler Fitch, Synapse Energy Economics
Ed Burgess, Strategen Consulting
Tyler Norris, Cypress Creek Renewables
Steve Levitas, Pinegate Renewables
Maggie Shober, Southern Alliance for Clean Energy
Daniel Brookshire, North Carolina Sustainable Energy Assoc.
Nathan Adams, Longroad Energy
Brad Slocum, East Point Energy
Raafe Khan, Pinegate Renewables
Ron DiFelice, Southern Current

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# Presentation and Q&A:

## Respond to stakeholder questions from Meeting 1

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# Initial Selection of Technologies

Can you share how the regulatory uncertainty and maturity of technologies plays into your modeling process? Is there an earlier "qualification" stage by which you make decisions about which technologies proceed to your modeling process, or do you run all technologies in the model and later subtract those you don't believe will meet regulatory or technology readiness requirements?

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## Modeling Coal Securitization

Will coal retirement analysis take into account the reduced revenue requirements available through securitization of remaining coal plant costs?



## Combining Balancing Areas

Does Duke plan to pursue consolidating its balancing areas as a part of its strategy to achieve the carbon reductions contemplated under the Carbon Plan? And if there is no plan to do so, why not?

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# Consolidating Future IRPs

Does Duke plan to combine future Integrated Resource Plans for DEC and DEP?



# Electric Vehicles and Decarbonization

Are you modeling the shift from internal combustion vehicles to electric in your demand projections?

Can you discuss the tension between pursuing vehicle electrification (which increases load) with the need to decarbonize (which is served by a reduction in load)?

# Carbon Plan Cost Impacts

Can you please describe how the Carbon Plan will account for costs to customers?

What steps are being taken to consider cost impacts to low income customers?

When will stakeholders have more information about the costs of the Carbon Plan to customers?

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# Break

## Please return at 11:00AM.

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# Discussion: Stakeholder Desired Outcomes

# Lunch Break

## Please return at 1:00PM.

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# Presentation and Discussion:

## Principles for portfolio development and evaluation

# Portfolio Development Objectives & Evaluation Criteria

**Nate Gagnon**, Principal Planning Analyst, Carolinas Integrated Resource Planning

FEBRUARY 23, 2022

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# Objectives for an Energy Transition Pathway

## $CO_2$ Reduction

- 70% by 2030
- Net-zero by 2050

## Reliability

- Maintain adequate system capacity to meet customer needs during peak demand periods
- Maintain adequate system flexibility to respond to changing real-time operating conditions

## Affordability

- Aggregated capital, land, operations, maintenance, and fuel costs associated with alternative pathways
- Cumulative costs over time
- Forecasted customer bill impacts at points in time

## Executability

- Deliverability of expected carbon reduction
- Ability to bring projects online according to plan timeline and cost estimates
- Ability to obtain necessary regulatory approvals for new projects and programs



# Types of Portfolio Evaluation & Comparison

## Minimum Standards

- Basic requirements for any potential resource portfolio
- Built into quantitative analysis as constraints
- Include environmental standards, $CO_2$ targets, and reliability requirements

## Quantitative Comparison

- Measurable (forecasted) characteristics of potential resource portfolios
- Specific comparison with respect to a single criterion
- Include costs, operating metrics, etc.

## Descriptive Comparison

- Complex concepts that cannot be distilled to a single number
- Trends over time
- Includes balancing multiple priorities

# Proposed Metrics for Evaluation & Comparison

## Minimum Standards

- Maintain adequate planning reserves
- Maintain adequate balancing and regulating reserves
- Maintain environmental standards
- 70% $CO_2$ reduction and net-zero targets

## Descriptive Comparison

**Reliability**

- Portfolio diversity
- Extreme weather performance

**Plan Executability**

- Pace of new interconnections
- Reliance on new-to-the-Carolinas resource types
- Reliance on regulatory changes / approvals

## Quantitative Comparison

**Affordability**

- Present value of revenue requirements
- Average bill impact at points in time

**System Operations / Reliability**

- Forecasted curtailment
- Forecasted flexibility requirements




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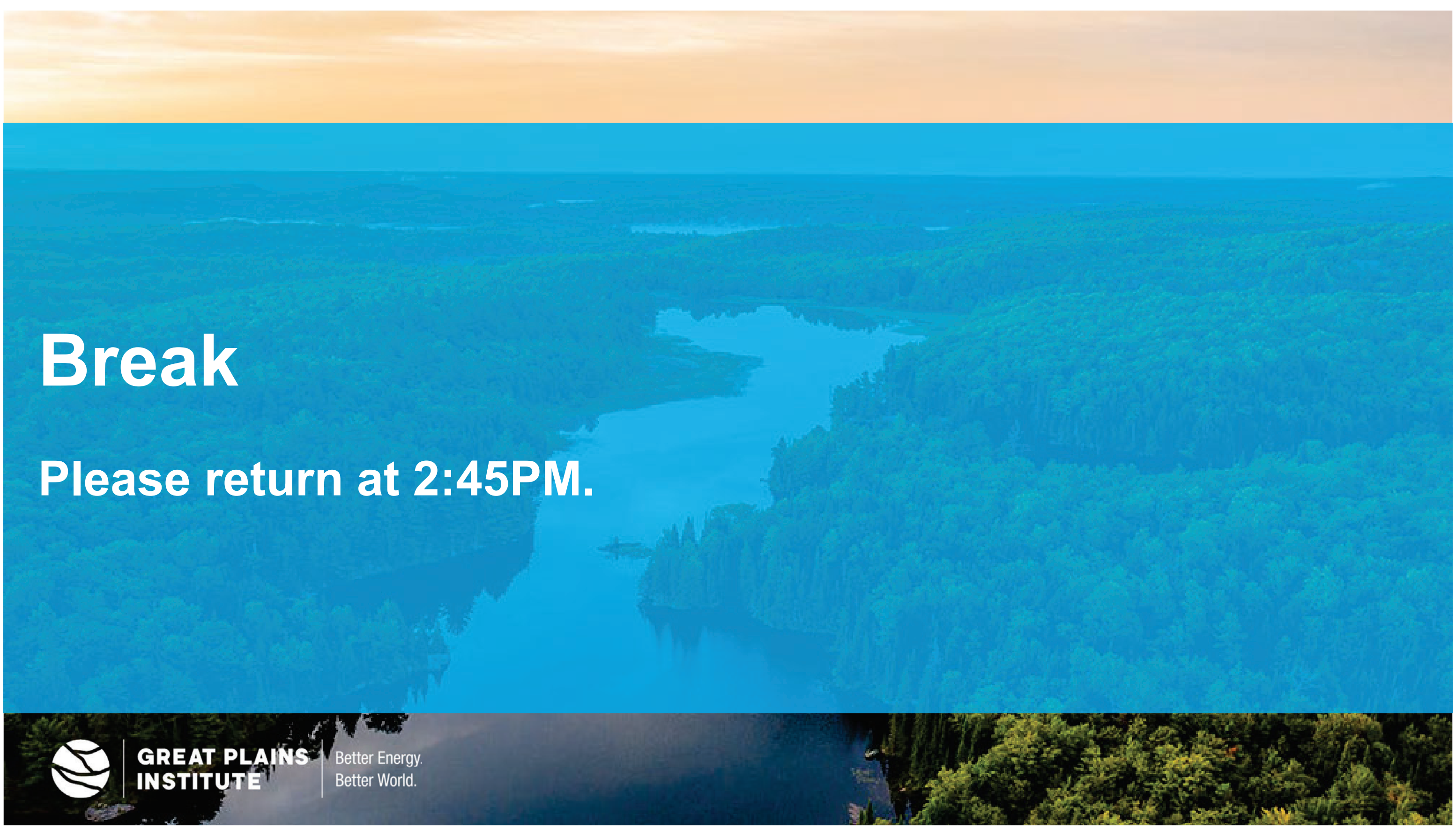

# Presentation and Discussion:

## Considerations driving different portfolio options

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# Factors Differentiating Alternative Pathways

**Glen Snider**, Managing Director, Carolinas Integrated Resource Planning

FEBRUARY 23, 2022

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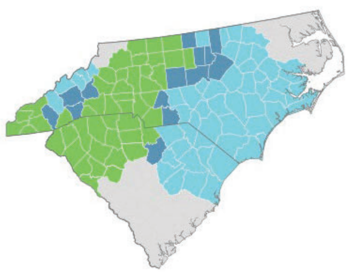
# Details of Legislation Will Shape Portfolio Analysis

### HB951 Focus is $CO_2$ Emitted in North Carolina

- The Utilities Commission shall take all reasonable steps to achieve a seventy percent (70%) reduction in emissions of carbon dioxide (CO2) emitted in the State from electric generating facilities owned or operated by electric public utilities from 2005 levels by the year 2030



### Timing Dependent Upon Technologies Approved by NC Utilities Commission

- In achieving the authorized carbon reduction goals, the Utilities Commission shall:
  - …Retain discretion to determine optimal timing and generation and resource-mix to achieve the least cost path to compliance
  - …provided, however, the Commission shall not exceed the dates specified to achieve the authorized carbon reduction goals by more than two years, except in the event the Commission authorizes construction of a nuclear facility or wind energy facility that would require additional time…

PSCSC will evaluate proposed resource portfolios in future dockets



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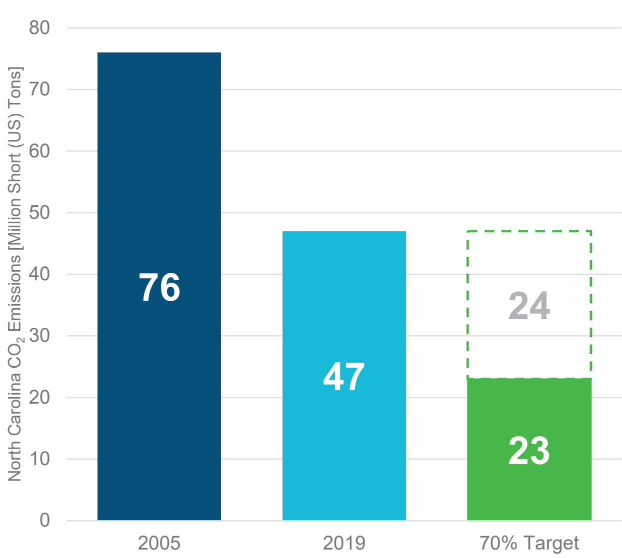
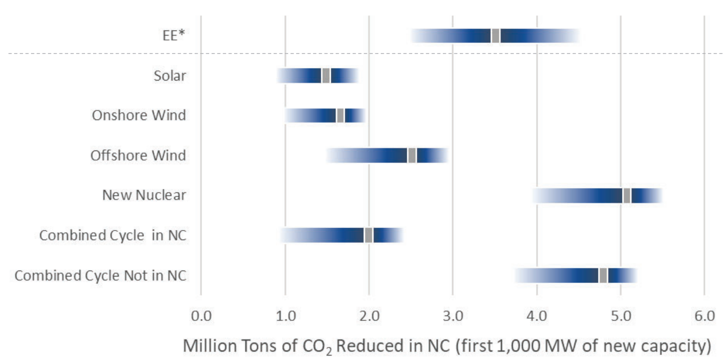
# Carbon Reduction Target and Toolbox

### Recall: 24 Million Ton Reduction Required in North Carolina to Achieve 70% Target




### Estimated Potential NC $CO_2$ Reduction (first 1,000 MW)




*EE range reflects estimated impact by 2030 across low through high deployment cases

### Consider:

- $CO_2$ reduction varies according to annual energy production and carbon intensity of generation being displaced
- As emissions decrease, additional tranches of carbon-free resources displace lower-carbon generation, resulting in ever-decreasing $CO_2$ reduction impact

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# Two Main Paths on the Way to Carbon Neutrality

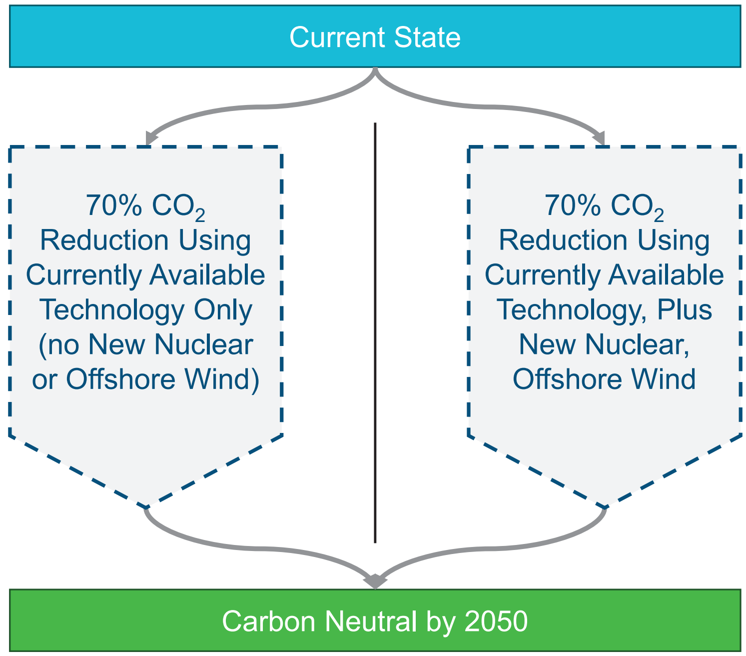
## There are tradeoffs to consider

- Pace of $CO_2$ reduction
- Plan affordability
- Implementation feasibility
- Technology risk
- Portfolio diversity

## Additional factors will further differentiate potential portfolios

- Degree of reliance on advanced technologies
- Pace of solar interconnection
- Fuel supply and pace technological development

## All paths lead to carbon neutrality by 2050






# Next steps:

- Information/feedback can be sent to DukeCarbonPlan@gpisd.net
- The next meeting will take place on Tuesday, March 22. GPI will be sending out an email with the link to register.

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Meeting materials/recordings will be uploaded to the website:

www.duke-energy.com/CarolinasCarbonPlan


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# Duke Energy Carolinas Carbon Plan Stakeholder Engagement Process

## Stakeholders' Desired Outcomes: Version 2 (revised 2/23/2022)

### BACKGROUND

**This document is intended to describe, at a high level, what stakeholders would like to see reflected in Duke Energy's Carolinas Carbon Plan and included in the process to develop the plan. This was originally drafted in response to feedback received at the first meeting on January 25, 2022, and subsequently revised by stakeholders during the second meeting on February 23, 2022.**

*Importantly, these criteria are:*

- *intended to represent the collection of different stakeholder desired outcomes for the Carbon Plan;*
- *numbered for reference purposes only (the numbers do not represent a ranking or prioritization); and*
- *assumed to be in addition to the expectation that the Carbon Plan will comply with North Carolina Session Law 2021-165 and all relevant regulatory requirements.*

### STAKEHOLDERS' DESIRED OUTCOMES OF THE CARBON PLAN

1. **Engagement:**
    a. Consider input from stakeholders and recognize where input changed assumptions, and what those changes were.
    ~~a.~~b. Identify areas of consensus on as many issues as possible prior to filing.
    ~~b.~~c. Incorporate recommendations from related stakeholder engagement processes, including but not limited to the Clean Energy Plan stakeholder process, the Low Income Affordability Collaborative, and the Working Group on Climate Risk and Resilience.
    d. Consider the carbon reduction goals and plans of cities and businesses in Duke's service territories.
    ~~c.~~
2. **Emissions:**
    a. Reflect the critical role that the electric system has in solving the economy-wide emissions problem by considering the electrification of sectors and end uses served by fuels other than electricity. Recognize the benefits in terms of customer total cost (not just electric) of electrification of end-uses.
    b. Address all greenhouse gas emissions beyond carbon dioxide, including upstream methane leakage from natural gas being delivered to electric power plants.
    c. Address the urgency of the climate problem by reducing emissions as soon as possible and by considering options that will achieve greenhouse gas emissions reductions more rapidly than the required targets. Avoid exporting emissions/pollution.
    d. Maintain a long-term view towards achieving a net-zero system (keep the end goal in mind).
    ~~c.~~e. Consider life cycle assessment of all system resources, including but not limited to construction of infrastructure, etc., to get to net zero.
3. **Customer and community impacts:**
    a. Take a holistic and intentional approach to the siting of new facilities, avoiding areas already disproportionately impacted by energy generation or other industrial facilities.
    b. Provide support for coal plant host communities to address the economic and community impacts of plant retirements.
    ~~b.~~c. Support the ability of businesses and industries to operate competitively, preserve existing jobs, and/or to create new jobs.
    ~~c.~~d. ~~Maintain~~ Strive to achieve fair and affordable rates and total costs for all customers, including at-risk/low- and moderate-income households and communities.
    e. Center environmental justice communities in the development of the carbon plan.

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~~d.~~f. ~~Design the plan with environmental justice communities in mind.~~Consider new or expanded customer-facing programs for energy efficiency, DSM, and renewables.

4. **Transparency:**
   a. Clarify the approach to siting facilities between North Carolina and South Carolina.
   b. Transparently present modeling and measurement assumptions, inputs, and tools to the extent possible while protecting trade secret and copyrighted information. Ensure no inherent bias. Include analysis of improvements to the transmission grid.
   c. Transparently present metrics and principles being used to develop pathways and make modeling decisions.
   d. Transparently present the impacts of the plan, including costs.
   e. Clarify policy and regulatory interdependencies with the other components of HB 951.
   f. Consider a modeling approach that begins with a few alternative end states that meet the goal.
   g. Clarify consideration of carbon costs and carbon policies in the selected scenarios.
   h. Clarify definition of net zero.
5. **Grid Impacts**
   ~~d.~~a. Enhance resilience and grid hardening through changes over time.

## STAKEHOLDERS' SUGGESTED ENERGY RESOURCE CONSIDERATIONS

**In addition to the desired outcomes, several stakeholders suggested resources, resource scenarios, and resource deployment principles that they would like to see taken into account in developing the Carbon Plan. This list summarizes those suggestions from the meeting on January 25, 2022.**

*NOTE: The technical advisory meetings on February 18, 2022 and the afternoon sessions of Meeting 2 on February 23, 2022 provided an opportunity to discuss modeling and resource considerations, however this specific list was not discussed in either meeting.*

1. Consider resource options with the long-term goal in mind; avoid locking-in resources today that may not be the most effective options down the road.
2. Consider regional coordination, including with respect to transmission.
3. Consider perceived regulatory risk for proposed resources.
4. Consider centering efficiency and demand-side management as first choice resources.
5. Consider an aggressive storage scenario that projects storage will be low cost and high duration, in order to send a signal to the market that research and development is needed.
6. Consider emerging technologies and investments in research and development.
7. Consider on-bill financing as an enabler for energy efficiency/DSM.
8. Consider early action to maximize distributed resources and acknowledge the unique benefits of different scales of generation resources.
9. Consider an option included with a very high level of distributed resources, and all currently available mechanisms for those resources to shift load out of peak periods.
10. Consider the offshore wind development goals in NC Executive Order 218 (2.8GW by 2030 and 8GW by 2040).
11. Consider solar and storage together as a resource.
12. Consider a "no new gas" scenario.
13. When discussing renewables in the context of reliability, distinguish between predictable and unpredictable variability.

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# Duke Energy Carolinas Carbon Plan Technical Subgroup Meeting

## Virtual Meeting – February 18, 2022

**Please note, this meeting is being recorded for internal purposes only, to ensure accuracy of meeting notes.*

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## Participant Roles:

- **Observers:**
  - Not able to participate in meeting discussions
  - Can submit questions/comments to panelists using the chat function
  - Invited to send feedback via email (DukeCarbonPlan@gpisd.net) after the meeting

- **Panelists:**
  - Able to participate in meeting discussions
  - Can submit questions/answers using the chat function
  - Invited to send feedback via email (DukeCarbonPlan@gpisd.net) after the meeting

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# Today’s Approach

- **Subgroup 1:**
  **Solar Interconnection Forecast**
  **(10:00am-12:00pm)**
- **Subgroup 2:**
  **Solar/Wind Technology Operational/Cost Assumptions**
  **(1:00pm-3:00pm)**
- **Subgroup 3:**
  **Storage Operational/Cost Assumptions and System Configurations**
  **(3:30pm-5:00pm)**

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- **Respect each other:** Help us to collectively uphold respect for each other's experiences and opinions, even in difficult conversations. We need everyone’s wisdom to achieve better understanding and develop robust solutions.
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# Solar Interconnection Forecast for Carbon Plan Modeling

Carolinas Carbon Plan Technical Subgroup Stakeholder Meeting

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FEBRUARY 18, 2022

# Introductions

**Duke Presenters and Panelists:**

- Bailey McGalliard
  - Lead Strategy & Analytics Consultant
- Sammy Roberts
  - General Manager, Transmission Planning and Operations
- Matt Kalemba
  - Director, Distributed Energy Technologies Planning and Forecasting
- Support Panelists:
  - Kerry Powell
    - VP Transmission and Fuels Strategy and Planning
  - Maura Farver
    - Director, Distributed Energy Technologies Strategy and Policy
  - Ken Jennings
    - General Manager, Renewable Integration and Operations

**Stakeholder Panelists:**

- Tyler Norris, Cypress Creek Renewables
- Jeff Thomas, NCUC Public Staff
- Dustin Metz, NCUC Public Staff
- Steve Levitas, Pinegate Renewables
- Kirsten Millar, Rocky Mountain Institute
- Maggie Shober, Southern Alliance for Clean Energy
- Tyler Fitch, Synapse Energy Economics
- Ed Burgess, Strategen Consulting
- Daniel Brookshire, North Carolina Sustainable Energy Association

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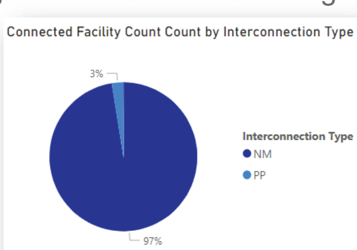
# Agenda and Level Set

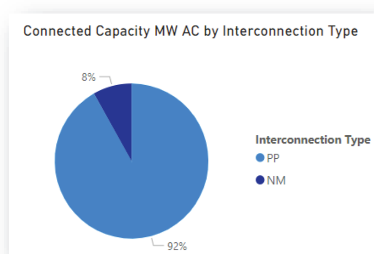
- Goal: Discuss the model inputs to be used to forecast how much new solar Duke can safely interconnect each year.
  - A forecast is an **estimate** of future conditions, using **the best information available today**
- Topics to cover today:
  - ***Historic*** pace of interconnection and increasing complexity of interconnection on DEC/DEP systems → *how to translate this into future predictions*
  - Describe factors impacting ***future*** pace of interconnection:
    - Length of time from Interconnection Agreement to In-Service Date
    - Volume of transmission network upgrades that can be completed each year
- Topics that are out of scope:
  - Policy debates as to the "merits" of solar as a resource
  - Cost or operational assumptions of solar included in the model (separate session on this)
  - Transmission investments that could be identified and evaluated through the FERC-jurisdictional local transmission planning process
  - Affected systems generator interconnection studies/policies
- ***Intent*** is to discuss appropriate modeling assumptions, not to solve the policy debates around transmission planning and generator interconnection



# Defining Scope of this Historic Look

- Two most prominent configurations in our service territory can be categorized as follows:
  - **Net Metering** (customer offsets utility usage)
  - **Purchased Power** (customer sends generation to the grid)
- **Purchased Power** represents **3%** of the **count** of interconnections and **92%** of the **Installed Capacity** connected to our grid in the Carolinas through 2021.




- For the purposes of this historical interconnection recap, we will focus on **Purchased Power** configured solar

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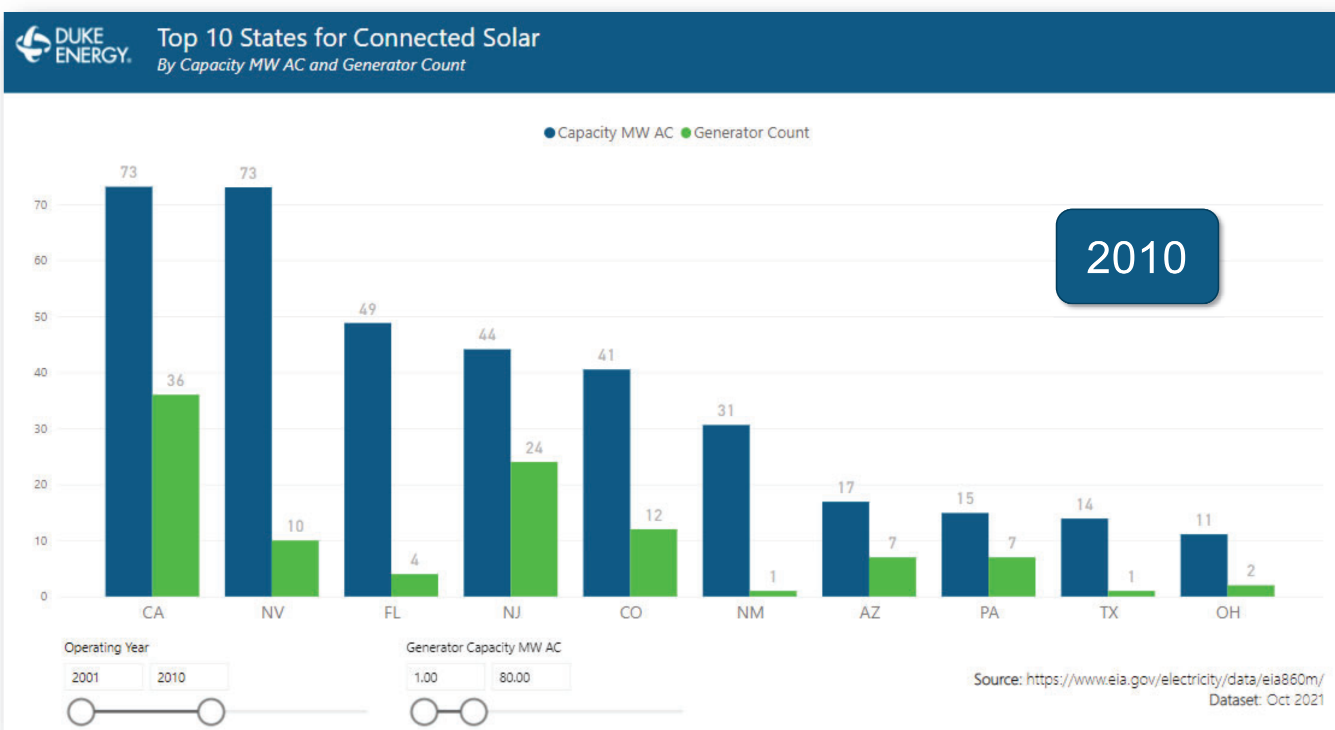
# A Quick Look at US Solar Interconnection Trends

- Data Source: EIA 860 M, October 31
- Data Context: Qualified Facility generators (purchased power intent, 80 MW or less)





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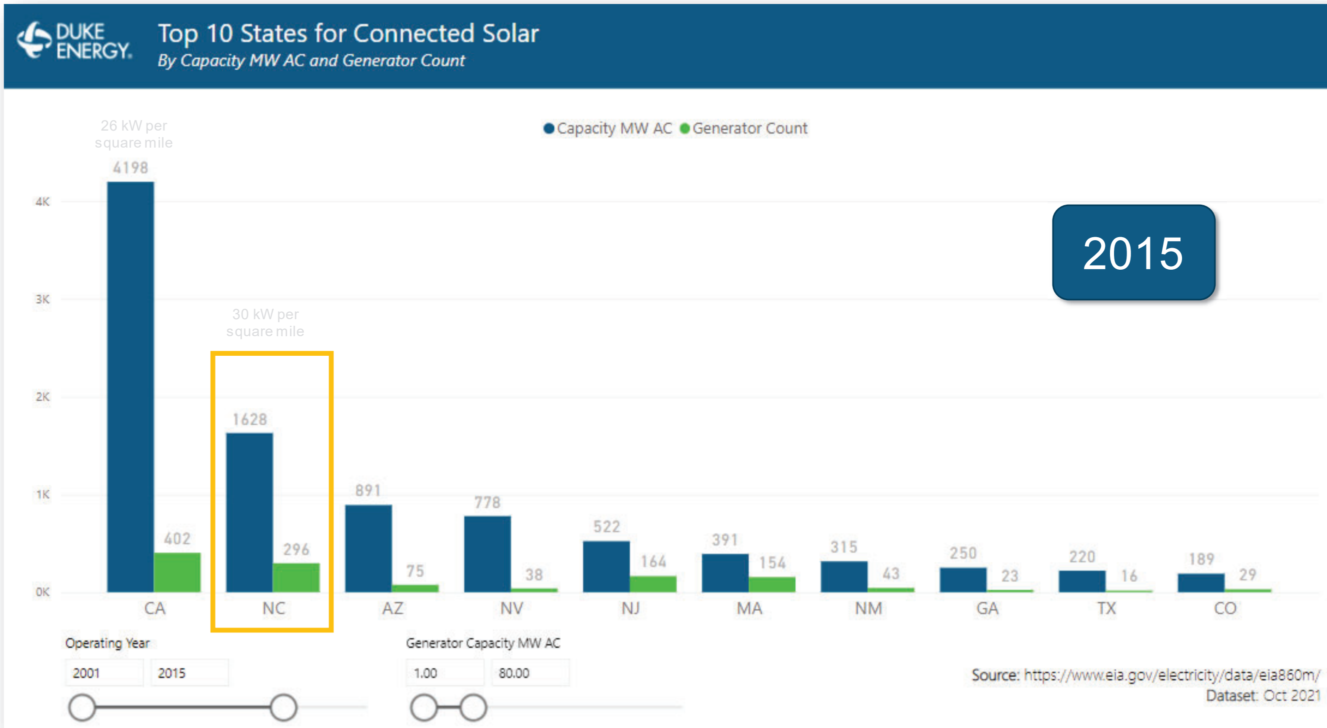
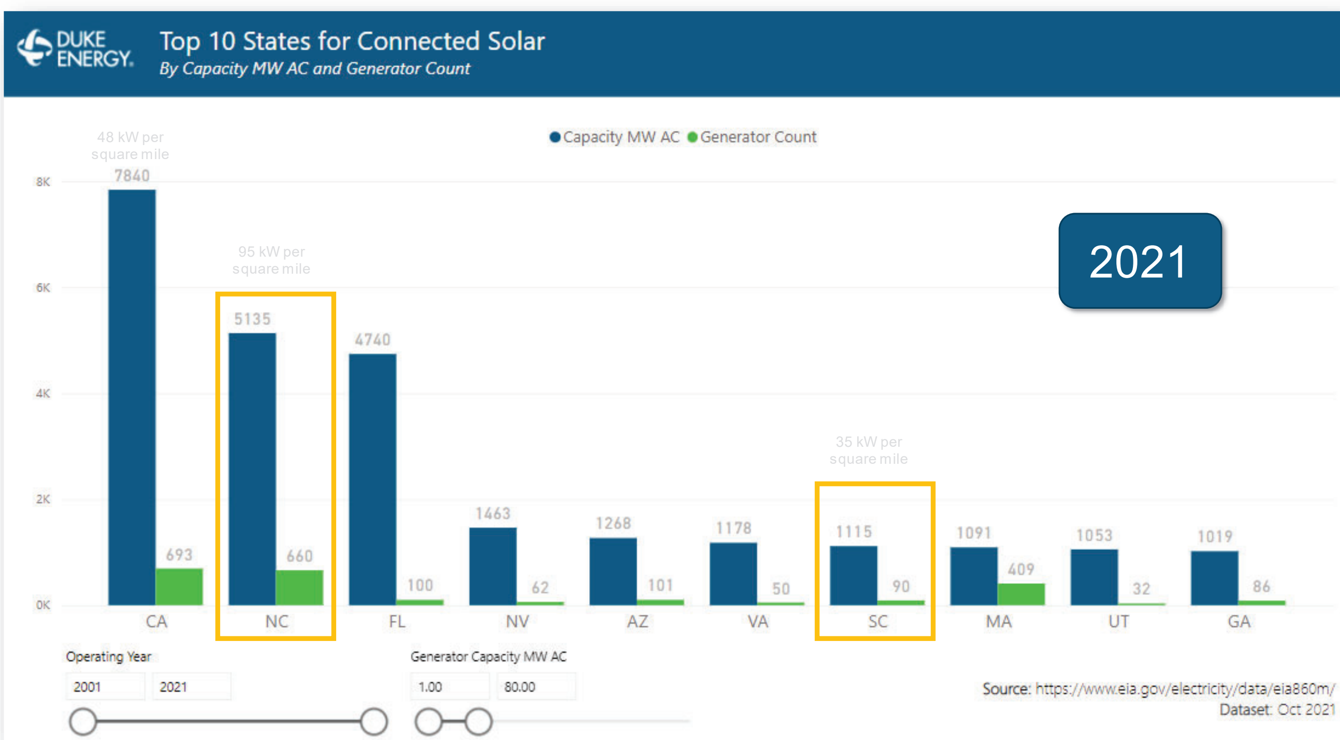
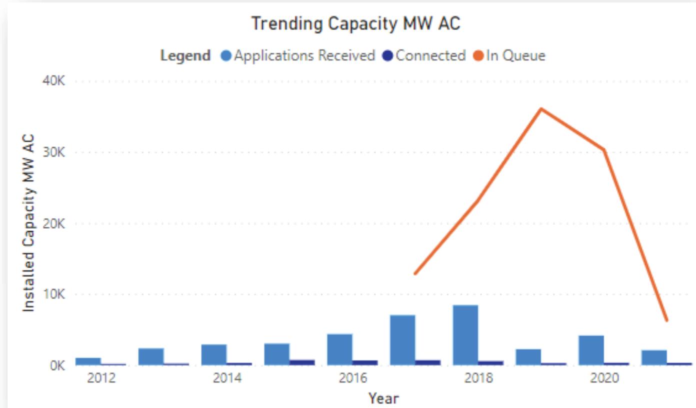


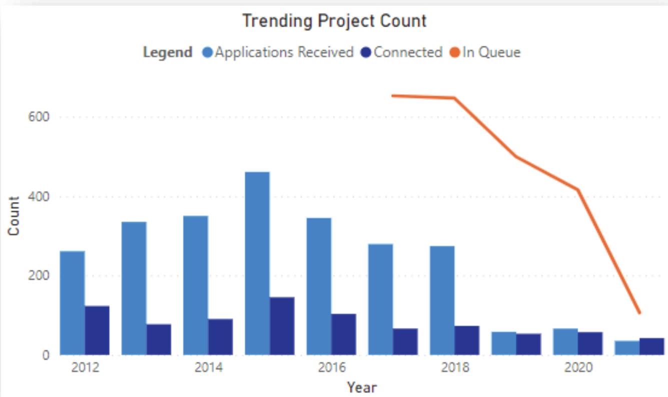


# Duke Energy Service Area

Duke Energy has cumulatively connected approximately **4,300** MW universal scale solar in the Carolinas to-date.




**Two key takeaways:**

1. Highlight movement of projects In Queue
2. Visible movement in the **application count and capacity**, while the **connected count and capacity remains relatively consistent**.

**Let's discuss.**



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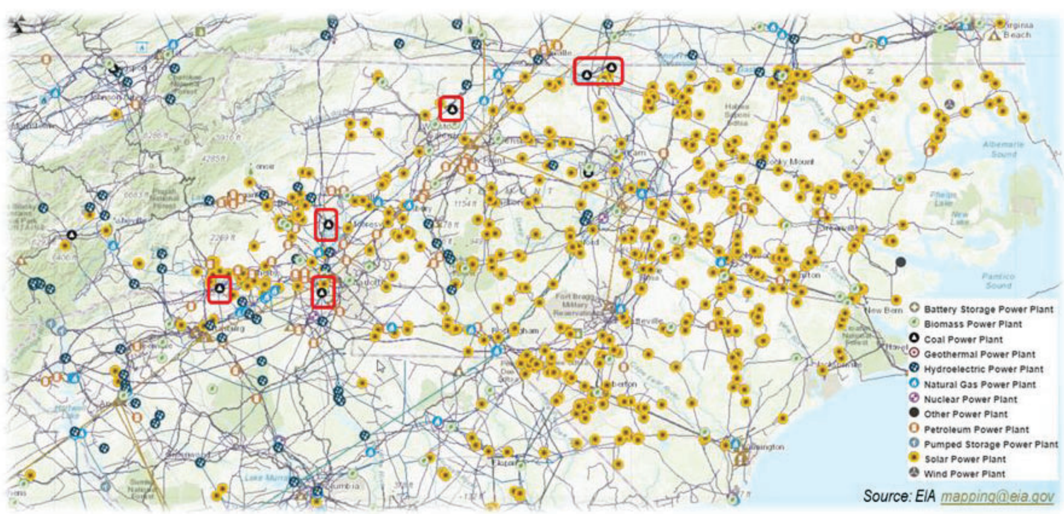
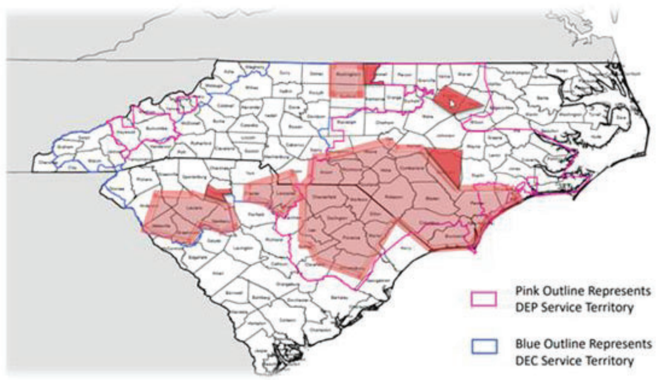
# Distributed Generation and Transmission Transformation

- Distributed Generation is requiring a transformation of the grid
- Coal retirements could be impactful
- Pace of transformation will quicken
- Reliability will not be sacrificed



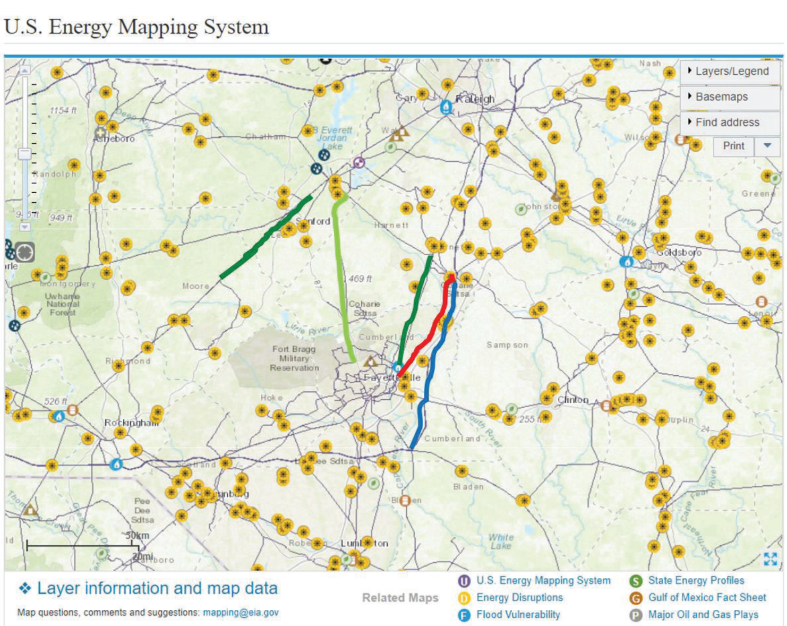
# Unlocking the Red Zone

- Generator location in red zone areas will likely require significant upgrades
- Network upgrades required to unlock red zone areas
- Network upgrades require coordinating transmission outages
- Working to make process more efficient
- Reliability will not be sacrificed






# Constructing Network Upgrades



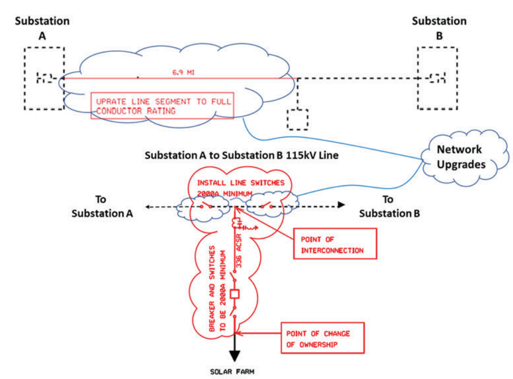




Figure 1 – Network Upgrades Associated with Interconnecting 75MW Solar Facility



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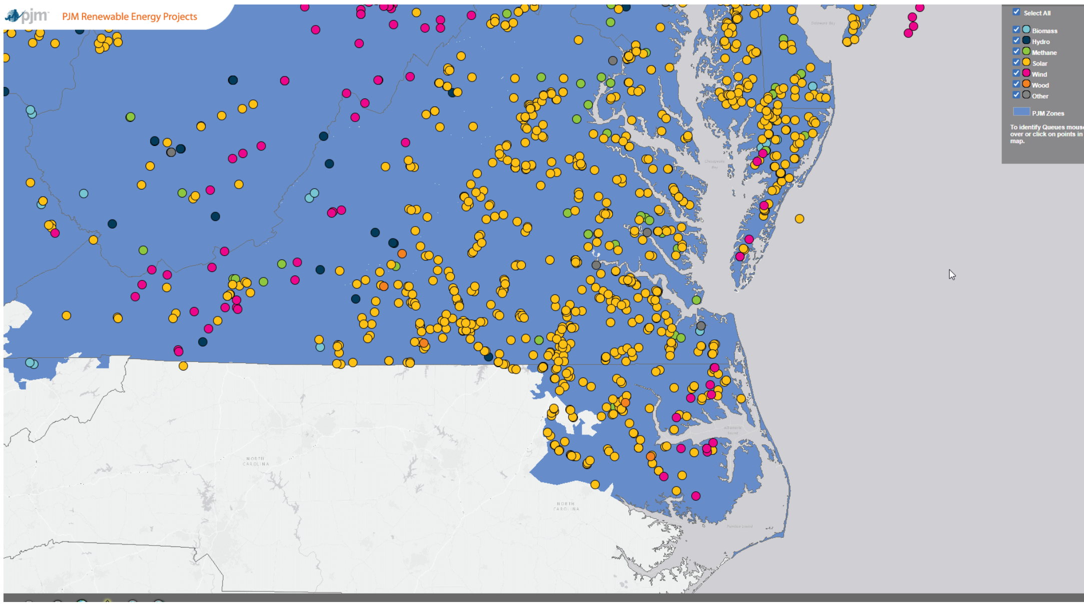
# Challenges are not unique to Duke

**PJM** recently proposed two-year delay on approximately 1,250 projects in the queue

- New projects not eligible for review until 4Q 2025





"A piecemeal approach to expanding the transmission system is not going to get the job done. We must take steps today to build the transmission that tomorrow's new generation resources will require."
FERC Chairman Glick
(July 15, 2021)

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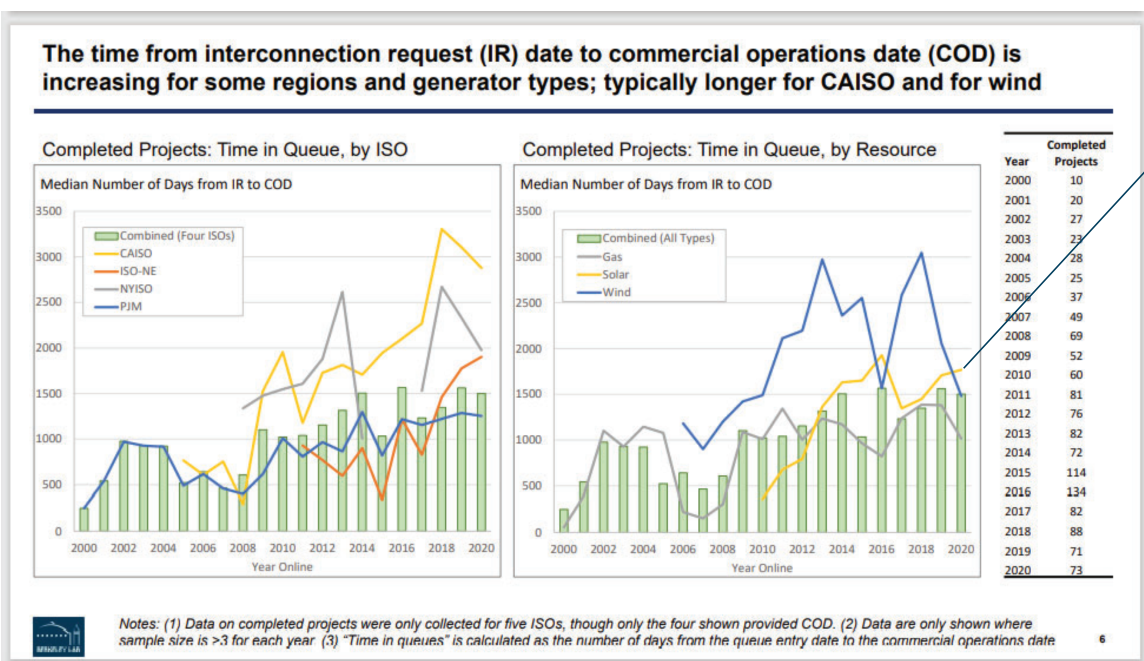
# 2021 LBNL Report Shows Lengthy Interconnection Timelines




| Year | Completed Projects |
|---|---|
| 2000 | 10 |
| 2001 | 20 |
| 2002 | 27 |
| 2003 | 23 |
| 2004 | 28 |
| 2005 | 25 |
| 2006 | 37 |
| 2007 | 49 |
| 2008 | 69 |
| 2009 | 52 |
| 2010 | 60 |
| 2011 | 81 |
| 2012 | 76 |
| 2013 | 82 |
| 2014 | 72 |
| 2015 | 114 |
| 2016 | 134 |
| 2017 | 82 |
| 2018 | 88 |
| 2019 | 71 |
| 2020 | 73 |

2020 = ~1750 days
~4.8 years



Lawrence Berkeley National Laboratory, May 2021 Report, https://emp.lbl.gov/publications/queued-characteristics-power-plants

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# Solutions to Explore

- Revised interconnection process ✓
  - Cluster studies with cost sharing mechanism for network upgrades

- Create efficiencies to reduce timeframe from Interconnection Agreement to COD

- Follow local transmission planning process to explore and facilitate transmission upgrades for public policy needs



# OATT Attachment N-1 – Local Transmission Planning

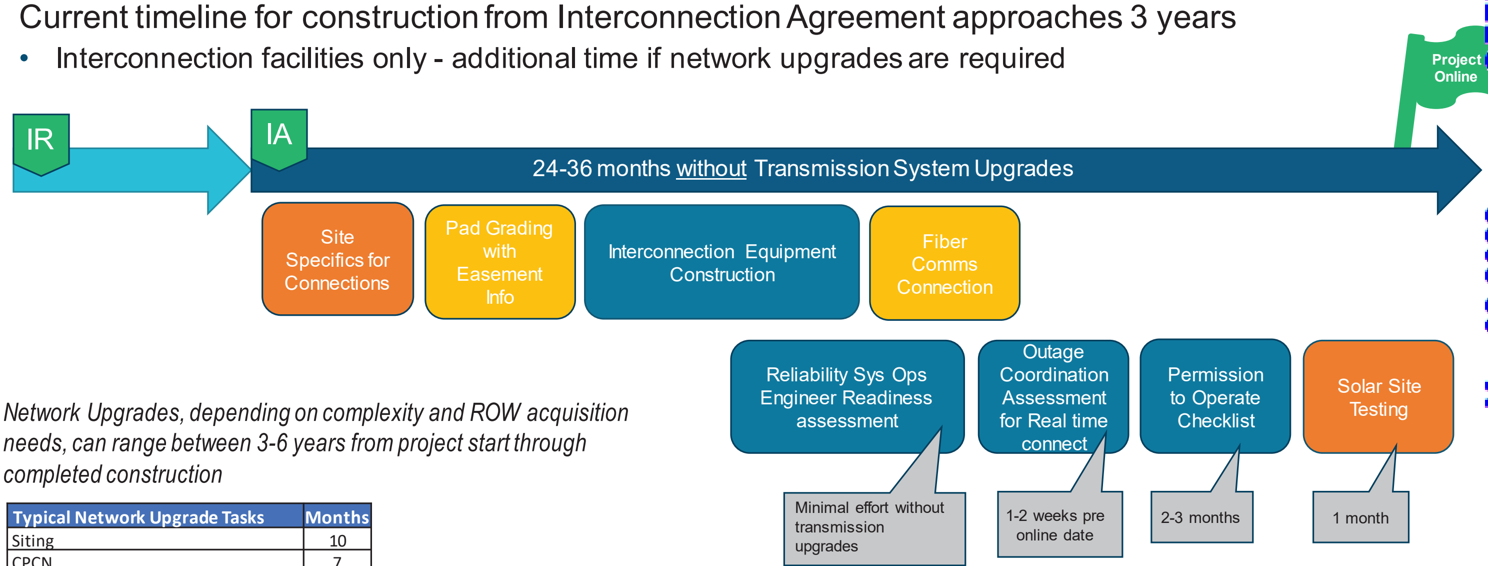
- FERC has exclusive federal jurisdiction over transmission planning
- Follow the FERC approved Orders 890 and 1000 Local Transmission Planning process in the OATT
  - North Carolina Transmission Planning Collaborative covers DEC and DEP transmission systems in NC and SC
    - OSC – Oversight Steering Committee
    - PWG – Planning Working Group
    - TAG – Transmission Advisory Group
  - Process must consider all transmission customer stakeholders that wish to provide input
  - Annual Local Transmission Planning cycle
  - Considers Reliability Projects, Economic Projects, and Public Policy Need

# Current Carolinas Interconnection Timeline

## *Signed IA through Construction*

Current timeline for construction from Interconnection Agreement approaches 3 years

- Interconnection facilities only - additional time if network upgrades are required




*Network Upgrades, depending on complexity and ROW acquisition needs, can range between 3-6 years from project start through completed construction*

| Typical Network Upgrade Tasks | Months |
|---|---|
| Siting | 10 |
| CPCN | 7 |
| Line Design | 24 |
| Prepare Permits | 6 |
| Obtain Permits/Construction Planning | 12 |
| Construction per mile per crew | 2 |



# Solar Interconnections in Model

- The Carbon Plan must be an executable plan that achieves the Carbon reductions under HB951 and that maintains or enhances reliability
- The timing and ability to interconnect resources should be reflected in the model
- Solar is unique
  - One of the few carbon free resources readily available pre-2030
  - Most optimal areas for solar development are in the most transmission constrained areas
  - Timing to interconnect solar will primarily be driven by timing of transmission system upgrades
- The timing, number, and volume of solar interconnections, and the costs required to increase the pace of solar deployment on the system should be modeled
  - Model solves based on capacity (i.e. MW), but limitation is a combination of number of projects and capacity



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# Annual Solar Interconnection Capability – Model Sensitivities

### Range of Interconnection Capability Sensitivities

| Nameplate MW | 2026 | 2027 | 2028 | 2029 | 2030 | Potential Connected Solar by 2030* |
|---|---|---|---|---|---|---|
| Progressive | *About* 10 projects @ 75 MW Average = 750 MW | 750 | 750 | 750 | 750 | ~10,250 |
| Enhanced Transmission Policy (Base) | About 10 projects @ 75 MW Average = 750 MW | 1,000 | 1,360 | 1,360 | 1,360 | ~12,300 |

- *Progressive* – Land availability less constraining than expected, cluster study process leads to more efficient interconnections as upgrade costs are shared among more participants, and / or shift to larger solar facilities leads to steady solar interconnections at historically high levels
- *Enhanced Transmission Policy* – Proactive strategic transmission investments lead to more efficient solar interconnections and increased possibility of larger solar projects

**Assumes 6,500 MW connected by 2025 including CPRE Tr3 and NC GSA*

### Transmission Cost Adder
***(Illustrative DRAFT)***

| Incremental Solar MW | Transmission Cost Adder, $/kw |
|---|---|
| < 2,000 | $X |
| 2,000 – 3,000 | $X+ |
| 3,001 – 5,000 | $X++ |



# Stakeholder Questions and Discussion

Questions
Feedback
Comments



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# Next Steps:

- Meeting materials will be uploaded to the website:

  **www.duke-energy.com/CarolinasCarbonPlan**

- Information/feedback can be sent to:

  **DukeCarbonPlan@gpisd.net**

- The next stakeholder meeting is next Wednesday, February 23rd.
  Please send an email if you need the registration link for this meeting.

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# Break

## Subgroup 2 will begin at 1:00pm

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# Today's Approach

- ~~**Subgroup 1: Solar Interconnection Forecast (10:00am-12:00pm)**~~
- **Subgroup 2: Solar/Wind Technology Operational/Cost Assumptions (1:00pm-3:00pm)**
- **Subgroup 3: Storage Operational/Cost Assumptions and System Configurations (3:30pm-5:00pm)**

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# Solar and Wind Technology and Cost Assumptions

Carolinas Carbon Plan Technical Subgroup Stakeholder Meeting

FEBRUARY 18, 2022

# Introductions

**Duke Energy Presenters and Panelists:**

- Matt Kalemba
  - Director, Distributed Energy Technologies Planning and Forecasting
- Adam Reichenbach
  - Lead Engineer, Generation Technology
- Clift Pompée
  - Managing Director, Generation Technology
- Support:
  - Glen Snider
    - Managing Director, Carolinas Integrated Resource Planning

**Stakeholder Panelists:**

- Mark Johnson, Clemson University
- Zander Bischof, Cypress Creek Renewables
- Neil Kern, Electric Power Research Institute
- John Lemire, NC Electric Membership Corporation
- Jeff Thomas, NCUC Public Staff
- Dustin Metz, NCUC Public Staff
- Amanda Levin, National Resource Defense Council
- Steve Levitas, Pinegate Renewables
- Kirsten Millar, Rocky Mountain Institute
- Katharine Kollins, Southeast Wind Coalition
- Tyler Fitch, Synapse Energy Economics
- Ed Burgess, Strategen Consulting
- Moji Abiola, Apex Clean Energy



# Agenda and Level-Setting

**Agenda Overview:**

- Utility Scale Solar Profile Development, Operational Assumptions
- Utility Scale Solar Cost Development Process
- Onshore Wind Profile Development; Operational Assumptions
- Onshore Wind Cost Development Process
- Offshore Wind Operational Assumptions
- Offshore Wind Cost Development Process

**Out of Scope:**

- Confidential specific cost information

## INTENT

Provide information and allow for discussion regarding how Duke builds cost and operational assumptions for the generic solar and wind generators included in the model

We may see many different technology configurations and costs in real life.

In Carbon Plan modeling, we include a specific generation/unit type that is representative of future installations on the system



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# Modeled Solar vs Selected Solar

- As of Jan. 1, 2022, there were approximately 4,300 MW of utility scale solar on the DEC and DEP systems
- An additional 2,200 MW of utility scale solar is expected to connect by 2025 based on existing contracts and interconnection agreements for projects that have not yet reached operation along with completion of CPRE Tranche 3
- The Carbon Plan will include these facilities as "modeled" solar*
- Additional solar will be available as "selected solar" beginning in 2026
- ***Today's discussion will focus on the characteristics of "selected solar"***
- ***There is a difference between "selected solar" in the model and optimal solar configurations at the execution phase of the plan. Solar configurations used in the model are best estimates of representative solar facilities that are likely to be available at the time of connection***

** An additional 325 MW of solar will be input into the model from 2026 – 2030 which represents NC GSA solar that has yet to be contracted*



# Utility Scale Profile Development

**Historical Irradiance**
- 20 years of historic data
- 22 representative locations across the Carolinas

**Best Fit Year**
- Mimics a TMY ("Typical Meteorological Year")
- Identify best fit year for each month that most closely matches the average historical irradiance for that month

**Generate Best Fit Profiles**
- PVSyst used to model solar configurations based on DC/AC ratios and Tracking capability
- Creates hourly profiles using only Best Fit Year irradiance

**Load Match Profiles**
- Match historical load and solar production to future load forecasts
- Combine best fit and load match data to create final hourly profiles

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# Solar Technology Key Variables

- Panel mount
  - Fixed Tilt – Arrays of solar panels placed at fixed angle which is usually the optimum tilt
  - Single Axis Tracking – Arrays of solar panels mounted with trackers that move along one axis (usually east-west direction)
    - Over 90% of connected facilities are fixed tilt configuration
    - Majority of facilities connecting over next 3 years are single axis tracking
- DC / AC Ratio or "Overpaneling"
  - The ratio of PV power to inverter power
  - In most cases, targeting high ratio with minimal clipping losses
- Panel type
  - Monofacial – One side of solar cells collecting light
  - Bifacial – Two sides of solar cells collecting light



# Solar PV Technology Assumptions

- **Standalone Solar**
  - 75 MW facility
  - Single-Axis Tracking
  - 1.4 DC/AC panel ratio
  - Monofacial modules
  - Carolina's region
  - 26-28% capacity factor
- **Solar Plus Storage**
  - 75 MW facility
  - Single-Axis Tracking
  - 1.6 DC/AC panel ratio
  - Monofacial modules
  - Carolina's region
  - 30-32% capacity factor

| Adjustable Parameters | *Unit* | Input |
|---|---|---|
| Size (MW-AC) | *MW-AC* | 75 |
| Case Overbuild Ratio[b] | % | 1.4 |
| Forecast Basis | *n/a* | Carolinas |
| Tilt Orientation | *n/a* | Single Axis Tracker |
| Module Face | *n/a* | Monofacial |
| Region | *n/a* | Southeast |

# Solar PV Data Sources and Process

## Data Sources

- Capital cost data from Guidehouse modeling tools
  - Updated Fall 2021
- O&M cost data from solar development team's internal model
  - Updated January 2022
- Additional data sources considered:
  - Internal solar development team and supply chain department
  - Burns & McDonnell engineering study
  - EPRI annual solar cost and performance data
  - NREL ATB 2021
  - Lazard Levelized Cost of Energy 2021
  - EIA AEO 2021

## Process

Cost reports based on market data for solar installations in US

Information is tailored to account for specific NC and SC cost adjustment factors at generic location

EPC estimate generated from input data

Duke-specific owner's cost adder and transmission adder included with cost (this is the "overnight" cost)

Overnight cost information is converted to "all-in" cost including financing, inflation, and disposal/recycling



# Stakeholder Questions and Discussion

Alignment with stakeholders' experiences and industry norms?

Questions
Feedback
Comments

Other cost or data sources Duke should be considering?



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# Onshore Wind Resource

- As of 1/1/2022, no utility scale wind resources in DEP and DEC territories
- Wind viewed as a complimentary resource at high solar build outs
- Carolinas onshore wind assumed to be available as a selected resource beginning in 2028
- Considering including wheeled wind from PJM or other neighbors as a potential resource to meet goal
- ***Today's discussion will primarily focus on the characteristics of onshore Carolinas wind as a resource***
- ***There is a difference between "selected wind" in the model and optimal wind configurations at the execution phase of the plan. Wind configurations used in the model are best estimates of representative wind facilities that may be available at the time of connection***



# Utility Scale Onshore Wind Profile Development

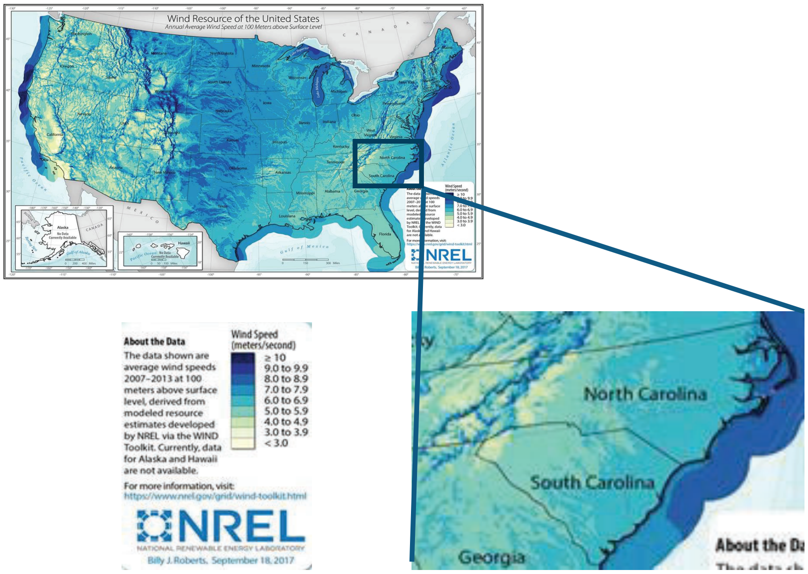
**Historical Wind Speeds**
- 20 years of historic data
- 6 representative locations across eastern NC

**Best Fit Year**
- Mimics a typical year of wind speed using historical data
- Identify best fit year, month, and location that closely matches the average historical wind speed for that month

**Generate Best Fit Profile**
- From the best fit year a single 8760 wind speed profile is created
- Using wind turbine power curves and heights, a best fit capacity factor profile is created

**Forecast**
- Best Fit Profile is used to develop a 30-year forecast

# Locations for Modeled Wind




- When evaluating options for wind resource, mainly followed NREL's exclusions
  - Urban areas
  - Bodies of water
  - Protected lands
  - Distance from structures
  - Ridgetop lands (above 4,000 ft)
  - Military bases and radar line-of-site



# Onshore Wind Technology Assumptions

- 150 MW facility
- 4 MW turbines
- 100-meter hub height
  - Evaluating higher hub heights, but insufficient data exists to include in modeling
- Carolina's region
- 20-30% capacity factor



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# Onshore Wind Data Sources and Process

## Data Sources

- Capital cost data from Burns & McDonnell engineering study
  - Updated January 2022
- O&M cost data from Burns & McDonnell engineering study
- Additional data sources considered:
  - EPRI annual wind cost and performance data
  - NREL ATB 2021
  - Lazard Levelized Cost of Energy 2021
  - EIA AEO 2021

## Process

Costs are based on current EPC estimates to construct on onshore wind facility in Duke Carolinas territory

↓

EPC and Owner's cost estimates prepared by Burns & McDonnell for generic site

↓

Duke-specific transmission adder included with cost (this is the "overnight" cost)

↓

Overnight cost information is converted to "all-in" cost including financing, inflation, and disposal/recycling



# Offshore Wind Technology Assumptions

- 1600 MW of wind generation
- 12/15 MW turbines
- Carolina's region
- 40-45% capacity factor

**Cost Forecast Parameters**

| Parameter | Units |
|---|---|
| Region | |
| Region Cost Scenario | |
| Regional Cost Multiplier | |
| OPEX Guidehouse scaling factor | |
| CAPEX Guidehouse Scaling Factor | |
| Regional Onshore Spure Line Cost | *$/MW-mile* |
| Technology Cost Development Scenario | |
| Grid Feature Cost | *$/kW* |
| Techno Resource Group (TRG) | |
| Commercial Date of Operation (COD) | *year* |
| Forecast period start | *year* |

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# Offshore Wind Data Sources and Process

## Data Sources

- Capital cost data from Guidehouse modeling tools
  - Updated Fall 2021
- O&M cost data from Guidehouse modeling tools
- Additional data sources considered:
  - Burns & McDonnell engineering study
  - EPRI annual wind cost and performance data
  - NREL ATB 2021
  - Lazard Levelized Cost of Energy 2021
  - EIA AEO 2021

## Process

1. Cost reports based on market data for offshore wind installations in US and globally
2. Information is tailored to account for specific NC and SC cost adjustment factors
3. EPC estimate generated from input data
4. Duke-specific owner's cost adder and onshore transmission adder included with cost (this is the "overnight" cost)
5. Overnight cost information is converted to "all-in" cost including financing, inflation, and disposal/recycling



# Stakeholder Questions and Discussion

Alignment with stakeholders' experiences and industry norms?

Questions

Feedback

Comments

Other cost or data sources Duke should be considering?

# Next Steps:

- Meeting materials will be uploaded to the website:

  **www.duke-energy.com/CarolinasCarbonPlan**

- Information/feedback can be sent to:

  **DukeCarbonPlan@gpisd.net**

- The next stakeholder meeting is next Wednesday, February 23rd.
  Please send an email if you need the registration link for this meeting.

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# Break

## Subgroup 3 will begin at 3:30pm

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# Participant Roles:

- **Observers:**
  - Not able to participate in meeting discussions
  - Can submit questions/comments to panelists using the chat function
  - Invited to send feedback via email (DukeCarbonPlan@gpisd.net) after the meeting

- **Panelists:**
  - Able to participate in meeting discussions
  - Can submit questions/answers using the chat function
  - Invited to send feedback via email (DukeCarbonPlan@gpisd.net) after the meeting

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# Today's Approach

- ~~Subgroup 1: Solar Interconnection Forecast (10:00am-12:00pm)~~
- ~~Subgroup 2: Solar/Wind Technology Operational/Cost Assumptions (1:00pm-3:00pm)~~
- Subgroup 3: Storage Operational/Cost Assumptions and System Configurations (3:30pm-5:00pm)

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# Meeting Ground Rules

- **Respect each other:** Help us to collectively uphold respect for each other's experiences and opinions, even in difficult conversations. We need everyone's wisdom to achieve better understanding and develop robust solutions.
- **Use the chat:** Panelists and observers can submit comments and questions in the chat. GPI staff will monitor the chat to pull out questions for Q&A portions. Please be respectful and focus on issues, not people.
- **Raise your hand:** During dedicated Q&A portions of the meeting, panelists should use the "Raise Hand" feature to indicate you would like to voice a question or comment. Observers are not able to use the "Raise Hand" feature.
- **Chatham House Rule**: Empower others to voice their perspective by respecting the "Chatham House Rule;" you are welcome to share information discussed, but not a participant's identity or affiliation (including unapproved recording of this session).

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# Storage Technology in Carbon Plan Model

Carolinas Carbon Plan Technical Subgroup Stakeholder Meeting

FEBRUARY 18, 2022

# Introductions

**Duke Energy Presenters and Panelists:**

- Matt Kalemba
  - Director, Distributed Energy Technologies Planning and Forecasting
- Adam Reichenbach
  - Lead Engineer, Generation Technology
- Sherif Abdelrazek
  - Director, Renewable Engineering
- Support:
  - Glen Snider
    - Managing Director, Carolinas Integrated Resource Planning
  - Laurel Meeks
    - Director, Renewable Business Development
  - Mike Rib
    - Director, Integrated Optimization

**Stakeholder Panelists:**

- Mark Johnson, Clemson University
- Neil Kern, Electric Power Research Institute
- Nathan Adams, Longroad Energy
- Brad Slocum, East Point Energy
- Jeff Thomas, NCUC Public Staff
- Dustin Metz, NCUC Public Staff
- Raafe Khan, Pinegate Renewables
- Kirsten Millar, Rocky Mountain Institute
- Ron DiFelice, Southern Current
- Tyler Fitch, Synapse Energy Economics
- Ed Burgess, Strategen Consulting

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# Storage in the Carbon Plan

- Energy storage is expected to be an important resource in the Carbon Plan
- Energy storage use cases in Carbon Plan modeling may differ from energy storage use cases at implementation
- Discreet storage technology assumptions are required for modeling purposes; these assumptions will likely differ from storage that is actually constructed on the Duke system
- ***Today's discussion will focus on the characteristics of storage that will be allowed to be selected by the model in the Carbon Plan development***

# Storage Use Cases for Carbon Plan Modeling

| Use Case | Notes |
| --- | --- |
| Capacity | Based on ELCC study |
| Energy Arbitrage | Energy time shift |
| Ancillary Services | Regulation (including load following, AGC response), balancing and contingency reserves |

- Some use cases may be complementary while others may be mutually exclusive
- Grid reliability use cases are also being considered in ISOP and grid planning, including grid reliability improvement, grid project deferrals, voltage support and black start.
- Grid use cases involve site specific requirements and benefits and don't lend well to generic capacity expansion planning

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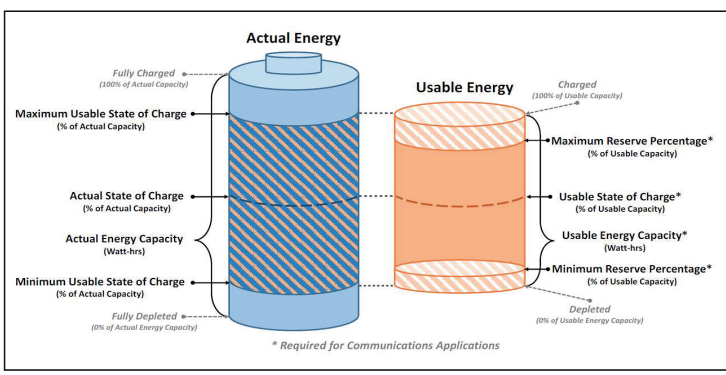
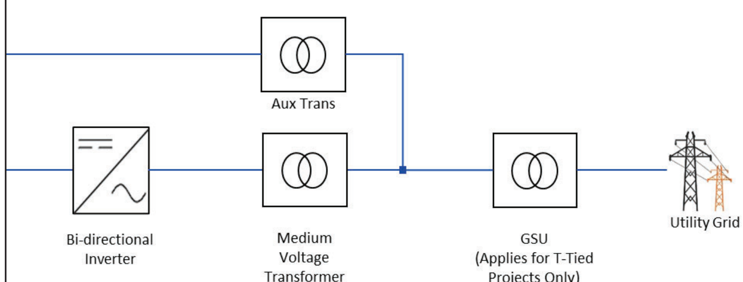
# Storage Technology Key Terms




- **Duration** – Duration of time a battery system can discharge at its rated power capacity
- **Roundtrip Efficiency** – Measured as a percentage, is a ratio of the energy charged to the battery to the energy discharged from the battery. Duke uses A/C – A/C efficiency as the production cost models only consider the charging/discharging at the point of interconnect to the power system
- **Depth of Discharge** – The amount of energy that must remain, unused, in the battery to satisfy the warranty of the battery and/or allow the battery to complete the expected number of cycles over the life of the asset
- **Degradation** – The loss of energy capacity of a battery storage system over time
  - Augmentation – Replacing or adding battery cells on a regular, or semi-regular, basis to maintain the usable energy of the battery storage system
  - Overbuild – Refers to an increase in the nameplate energy capacity to account for expected degradation

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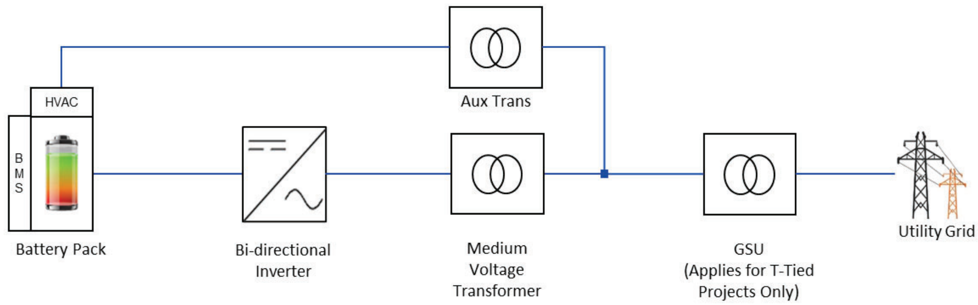
# Energy Storage Systems Configurations

## Stand-Alone Energy Storage




**Battery Pack**

- Battery Packs: Battery packs consists of racks/strings. Each string consists of modules in series, each module consists of cells in series and parallel

### Inverters

- Convert DC voltage to AC voltage and vice versa
- Battery inverters are bidirectional and can provide near instantaneous responses (ramp-rate) to operator control commands
- Output is low voltage (300V-700V)
- Consist of DC bus, IGBT stacks and output filters

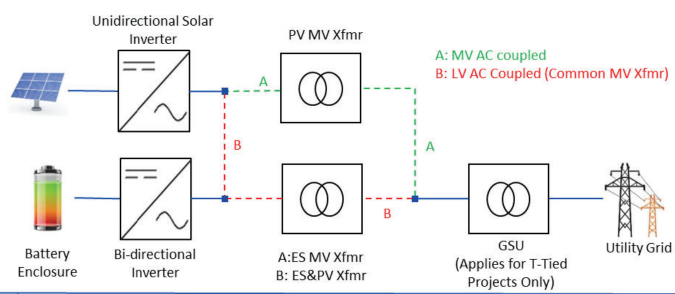


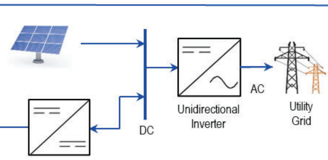
# Energy Storage Systems Configurations

## Solar Plus Storage

### AC Coupled

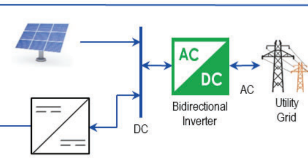
- Solar and storage are completely decoupled and can operate independently of each other.
- Separate bidirectional ES inverter included
- Charging the storage system from solar is less efficient than DC coupled systems
- Technology is mature for both solar and storage inverters




- Inverter is Unidirectional
- This topology mostly results from retrofitting solar plants with high DC/AC ratios to harvest clipped energy.
- ES discharge is limited by inverter capacity and solar production time.
- ES can only be charged through solar power.
- An ES DC/DC converter between battery and solar inverter DC input.
- ESS charge from solar is more efficient than AC coupled systems

### Sole Solar Charging - DC Coupled




- Inverter is bidirectional
- ES discharge is limited by inverter capacity and solar production time.
- ES can be charged from both the solar facility and the grid.
- An ES DC/DC converter included between battery and common inverter DC input.
- ESS charge from solar is more efficient than AC coupled systems
- Example: Lake Placid Solar Plus Storage Facility

### Flexible Charging - DC Coupled

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# Lithium Ion Battery Technology Assumptions

- **Common Parameters**
  - 90% depth of discharge limit – 10% overbuild for DOD
  - 85% round trip efficiency
  - LFP-quality chemistry
  - Annual replenishment – no overbuild for degradation
  - Carolinas region
- **Standalone Storage**
  - 50 and 100 MW facilities
  - 4, 6, and 8 hour durations
- **Solar Plus Storage**
  - 20 MW
  - 4 hour duration
  - 1 mid-life rebuild

| Cost Parameters | *Unit* | **Input value** |
|---|---|---|
| Use Case | - | Capacity + Bulk Power Services |
| Power Capacity | *kW* | 50,000 |
| Usable Energy[a] | *kWh* | 200,000 |
| Overbuild Ratio[b] | - | 1.00 |
| Lithium Ion or Flow | | Lithium_Ion |
| Battery Technology/Scenario | - | Base (LFP) |
| PCS Performance | - | Base Quality |
| Software and Controls | - | Complex: Real-Time Optimization |
| Balance of Plant | - | High/Custom |
| Systems Integration | - | Base |
| Site Installation | - | Base |
| Project Development | - | Base |
| Annual O&M[c] | - | Base |
| Replenishment | - | Yes |

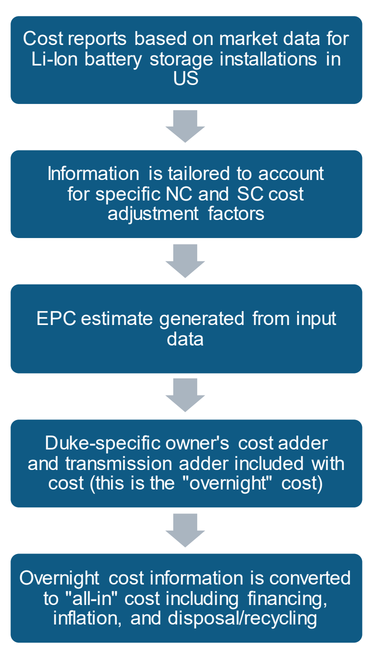


# Battery Storage Data Sources and Process

## Data Sources

- Capital cost data from Guidehouse modeling tools
  - Updated Fall 2021
- O&M cost data from Guidehouse modeling tools
- Additional data sources considered:
  - Internal battery development team and supply chain department
  - Burns & McDonnell engineering study
  - EPRI annual wind cost and performance data
  - NREL ATB 2021
  - Lazard Levelized Cost of Energy 2021
  - EIA AEO 2021

## Process



# Other Storage Options Modeled

- Li-Ion can likely meet system need through Carbon Plan planning period (2030)
- Flow Battery
  - 20 MW, 8-hour duration
  - Costs from Guidehouse and Burns & McDonnell
- Advanced Compressed Air Energy
  - 300 MW, 10-hour duration
  - Costs from Burns &McDonnell referencing Hydrostor
- Pumped Hydro
  - 750 MW, 10-hour duration
  - Costs from Burns & McDonnell
  - Siting concerns for new pumped hydro
- Evaluating many long duration technologies through Emerging Technology Assessment Team (battery and non-battery)

| |
|---|
| Advanced Compressed Air Energy Storage |
| Flow Batteries |
| Flywheel Energy Storage |
| Gravitational Energy Storage |
| Hydrogen Storage |
| Li-Ion Batteries |
| Liquid Air Energy Storage |
| Metal-Air Batteries |
| Sodium-Based Batteries |
| Solid-State Batteries |
| Subterranean Pumped Storage |
| Thermal Energy Storage |
| Traditional Pumped Storage |
| Underground Compressed Air Energy Storage |
| Zinc Aqueous Batteries |

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# Stakeholder Questions and Discussion

Questions
Feedback
Comments

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# THANK YOU