Capacity Expansion Planning Under the Risk of Hurricanes: An Analysis of The US East Coast

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1. **Database Construction For The Florida Energy System**
2. **Database Construction For The North Carolina Energy System**

Section 2 details the data and considerations followed in the construction of the database for the North Carolina Energy System.

* 1. **Technologies**

Tables 2.1 and 2.2 provide a description of the existing and new energy generation technologies considered in our simulations, and Table 2.3 describes the non-energy generation technologies.

**Table 2.1:** Existing Generation Technologies Represented in The Model

|  |  |
| --- | --- |
| **Technology Code** | **Description** (Following EIA 860 Nomenclature) [1] |
| AB\_ST\_EXISTING | Steam Turbine Using Agricultural By-Products |
| BIT\_ST\_EXISTING | Steam Turbine Using Bituminous Coal |
| BLQ\_ST\_EXISTING | Steam Turbine Using Black Liquor |
| DFO\_CC\_EXISTING | Combined Cycle Combustion Turbine Using Petroleum |
| DFO\_GT\_EXISTING | Combustion Turbine Using Petroleum |
| DFO\_IC\_EXISTING | Internal Combustion Engine Using Petroleum |
| LFG\_GT\_EXISTING | Combustion Turbine Using Landfill Gas |
| LFG\_IC\_EXISTING | Internal Combustion Engine Using Landfill Gas |
| MWH\_BA1H\_EXISTING | Battery Storage- 1h |
| MWH\_BA2H\_EXISTING | Battery Storage- 2h |
| NG\_CC\_EXISTING | Combined Cycle Combustion Turbine Using Natural Gas |
| NG\_GT\_EXISTING | Combustion Turbine Using Natural Gas |
| NG\_ST\_EXISTING | Steam Turbine Using Natural Gas |
| NUC\_ST\_EXISTING | Nuclear Turbine |
| OBG\_IC\_EXISTING | Internal Combustion Engine Using Other Biomass Gas |
| SUN\_PV\_EXISTING | Solar Photovoltaic - Utility |
| WAT\_HY\_EXISTING | Conventional Hydroelectric |
| WAT\_PS\_EXISTING | Hydroelectric Pumped Storage |
| WDS\_ST\_EXISTING | Steam Turbine Using Wood Waste |
| WH\_ST\_EXISTING | Steam Turbine Using Waste Heat |
| WND\_WT\_EXISTING | Onshore Wind Turbine |

**Table 2.2:** New Generation Technologies Represented in The Model

|  |  |
| --- | --- |
| **Technology Code** | **Description** |
| BATT\_2H\_NEW | Battery Storage 2h (NREL ATB 2023 Technology) |
| BATT\_4H\_NEW | Battery Storage 4h (NREL ATB 2023 Technology) |
| BATT\_6H\_NEW | Battery Storage 6h (NREL ATB 2023 Technology) |
| BATT\_8H\_NEW | Battery Storage 8h (NREL ATB 2023 Technology) |
| BIOMASS\_CC90\_NEW | Generation From Biomass With 90% Carbon Capture (Technology from NREL ReEDS model Using BECC-mod) |
| BIOMASS\_NEW | Generation From Biomass (NREL ATB 2023 Technology) |
| COAL\_95CC\_NEW | Generation From Coal With 95% Carbon Capture (NREL ATB 2023 Technology) |
| COAL\_99CC\_NEW | Generation From Coal With 99% Carbon Capture (NREL ATB 2023 Technology) |
| COAL\_NEW | Generation From Coal (NREL ATB 2023 Technology) |
| NG\_F-FRAME\_CC\_95CC\_NEW | Combined Cycle Natural Gas Turbine F-Frame With 95 % of Carbon Capture (NREL ATB 2023 Technology) |
| NG\_F-FRAME\_CC\_97CC\_NEW | Combined Cycle Natural Gas Turbine F-Frame With 97 % of Carbon Capture (NREL ATB 2023 Technology) |
| NG\_F-FRAME\_CC\_NEW | Combined Cycle Natural Gas Turbine F-Frame (NREL ATB 2023 Technology) |
| NG\_F-FRAME\_CT\_NEW | Natural Gas Combustion Turbine F-Frame - Simple Cycle (NREL ATB 2023 Technology) |
| NG\_H-FRAME\_CC\_95CC\_NEW | Combined Cycle Natural Gas Turbine H-Frame With 95 % of Carbon Capture (NREL ATB 2023 Technology) |
| NG\_H-FRAME\_CC\_97CC\_NEW | Combined Cycle Natural Gas Turbine H-Frame With 97 % of Carbon Capture (NREL ATB 2023 Technology) |
| NG\_H-FRAME\_CC\_NEW | Combined Cycle Natural Gas Turbine H-Frame (NREL ATB 2023 Technology) |
| NUCLEAR-AP1000\_NEW | Nuclear Generation Using AP1000 PWR (NREL ATB 2023 Technology) |
| NUCLEAR-SMR\_NEW | Small Modular Nuclear Reactor (NREL ATB 2023 Technology) |
| PV-COMMERCIAL\_NEW | Commercial Solar PV (NREL ATB 2023 Technology) |
| PV-RESIDENTIAL\_NEW | Residential Solar PV (NREL ATB 2023 Technology) |
| PV-UTILITY\_NEW | Utility Solar PV (NREL ATB 2023 Technology) |
| WAT\_HY\_NEW | Conventional Hydroelectric (NREL ATB 2023 Technology) |
| WAT\_PS\_NEW | Hydroelectric Pumped Storage (NREL ATB 2023 Technology) |
| WIND-LAND-C8\_NEW | Onshore Wind Turbine Class 8 From NREL ATB 2023 (NREL ATB 2023 Technology) |
| WIND-OFFSHORE-C6\_NEW | Offshore Wind Turbine Class 6 From NREL ATB 2023 (NREL ATB 2023 Technology) |

**Table 2.3:** Non-Generation Technologies Represented in The Model

|  |  |
| --- | --- |
| **Technology Code** | **Description** |
| CO2\_STORAGE | CO2 Storage |
| DISTRIBUTION | Energy Distribution |
| FT\_BIOMASS | Fuel for Generation Technologies That Use Biomass |
| FT\_COAL | Fuel for Generation Technologies That Use Coal |
| FT\_NG | Fuel for Generation Technologies That Use Natural Gas |
| FT\_NUCLEAR | Fuel for Nuclear Generation Technologies |
| FT\_PETROLEUM | Fuel for Generation Technologies That Use Petroleum |
| TRANSMISSION\_INTERREGIONAL | Transmission Between Different Regions |
| TRANSMISSION\_REGIONAL | Transmission In the Same Region |

* 1. **Existing Capacity**

Data from existing generation capacity comes from the EIA-860M reports [1]. Figure 2.1 shows the vintage (operational year) of each existing technology on the NC system and its corresponding capacity. On the left legend, the total existing capacity is shown in parathesis.

A graph of different colored lines

Description automatically generated

**Figure 2.1:** Total Existing Capacity on the NC Power System by Different Operational Years (Vintage)

* 1. **Lifetime Tech and Loan**

The default lifetimes of the technologies considered in our models are detailed in Tables 2.4, 2.5, and 2.6 with their corresponding references.

**Table 2.4:** Default Technologies Lifetime and Loans For Existing Generation Technologies

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Technology Code** | **Lifetime Tech** | | **Loan** | |
| **Years** | **Reference** | **Years** | **Reference** |
| AB\_ST\_EXISTING | 50 | Average from DEC/DEP in IRPs [2, 3] | 20 |  |
| BIT\_ST\_EXISTING | 65 |  | 20 |  |
| BLQ\_ST\_EXISTING | 50 |  | 20 |  |
| DFO\_CC\_EXISTING | 50 |  | 20 |  |
| DFO\_GT\_EXISTING | 50 |  | 20 |  |
| DFO\_IC\_EXISTING | 50 |  | 20 |  |
| LFG\_GT\_EXISTING | 50 |  | 20 |  |
| LFG\_IC\_EXISTING | 50 |  | 20 |  |
| MWH\_BA1H\_EXISTING | 15 |  | 15 |  |
| MWH\_BA2H\_EXISTING | 15 |  | 15 |  |
| NG\_CC\_EXISTING | 50 |  | 20 |  |
| NG\_GT\_EXISTING | 50 |  | 20 |  |
| NG\_ST\_EXISTING | 75 |  | 20 |  |
| NUC\_ST\_EXISTING | 60 |  | 20 |  |
| OBG\_IC\_EXISTING | 50 |  | 20 |  |
| SUN\_PV\_EXISTING | 30 |  | 20 |  |
| WAT\_HY\_EXISTING | 120 |  | 20 |  |
| WAT\_PS\_EXISTING | 120 |  | 20 |  |
| WDS\_ST\_EXISTING | 50 |  | 20 |  |
| WH\_ST\_EXISTING | 50 |  | 20 |  |
| WND\_WT\_EXISTING | 24 |  | 20 |  |

**Table 2.5:** Default Technologies Lifetime and Loans For New Generation Technologies

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Technology Code** | **Lifetime Tech** | | **Loan** | |
| **Years** | **Reference** | **Years** | **Reference** |
| BATT\_2H\_NEW | 15 |  | 15 |  |
| BATT\_4H\_NEW | 15 |  | 15 |  |
| BATT\_6H\_NEW | 15 |  | 15 |  |
| BATT\_8H\_NEW | 15 |  | 15 |  |
| BIOMASS\_CC90\_NEW | 50 |  | 20 |  |
| BIOMASS\_NEW | 50 |  | 20 |  |
| COAL\_95CC\_NEW | 65 |  | 20 |  |
| COAL\_99CC\_NEW | 65 |  | 20 |  |
| COAL\_NEW | 65 |  | 20 |  |
| NG\_F-FRAME\_CC\_95CC\_NEW | 60 |  | 20 |  |
| NG\_F-FRAME\_CC\_97CC\_NEW | 60 |  | 20 |  |
| NG\_F-FRAME\_CC\_NEW | 60 |  | 20 |  |
| NG\_F-FRAME\_CT\_NEW | 50 |  | 20 |  |
| NG\_H-FRAME\_CC\_95CC\_NEW | 60 |  | 20 |  |
| NG\_H-FRAME\_CC\_97CC\_NEW | 60 |  | 20 |  |
| NG\_H-FRAME\_CC\_NEW | 60 |  | 20 |  |
| NUCLEAR-AP1000\_NEW | 60 |  | 30 |  |
| NUCLEAR-SMR\_NEW | 60 |  | 30 |  |
| PV-COMMERCIAL\_NEW | 30 |  | 20 |  |
| PV-RESIDENTIAL\_NEW | 30 |  | 20 |  |
| PV-UTILITY\_NEW | 30 |  | 20 |  |
| WAT\_HY\_NEW | 120 |  | 20 |  |
| WAT\_PS\_NEW | 120 |  | 20 |  |
| WIND-LAND-C8\_NEW | 24 |  | 20 |  |
| WIND-OFFSHORE-C6\_NEW | 24 |  | 20 |  |

**Table 2.6:** Default Technologies Lifetime and Loans For Non-Generation Technologies

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Technology Code** | **Lifetime Tech** | | **Loan** | |
| **Years** | **Reference** | **Years** | **Reference** |
| CO2\_STORAGE | 100 |  | 20 |  |
| DISTRIBUTION | 60 |  | 20 |  |
| FT\_BIOMASS | 100 |  | 20 |  |
| FT\_COAL | 100 |  | 20 |  |
| FT\_NG | 100 |  | 20 |  |
| FT\_NUCLEAR | 100 |  | 20 |  |
| FT\_PETROLEUM | 100 |  | 20 |  |
| TRANSMISSION\_INTERREGIONAL | 60 |  | 20 |  |
| TRANSMISSION\_REGIONAL | 60 |  | 20 |  |

**Discuss problem with lifetime of existing tech and period of simulation**

**>Table with Life Tech and Loan**

* 1. **Costs**

**>Table with Cost Investment (Also put discount rate)**

**>Table with Cost Fixed**

**>Table with Cost Variable**

**If otherwise not state the costs values of the tech is zero**

* 1. **Efficiency**
  2. **Emission Activity and Limits**

**>emission per activity**

**>Limits of emission**

* 1. **Capacity Factors**
  2. **Capacity Credit and Planning Reserve Margin**
  3. **Maximum Capacity**

**>Hydro and pumped**

* 1. **Maximum Activity**

**>Biomass**

**>Wind (Discuss)**

**>Solar (Discuss)**

* 1. **Minimum Activity**

**>Solar Residential**

**>Solar Commercial**

* 1. **Regionalization**

**>**Differentiate existing and future tech

**>**Plot with their Location

* 1. **Fragility Curves and Damage Statistics**

>Define fragilities considered

>Table with damages at each hurricane speed and per scenario

# **References**

|  |  |
| --- | --- |
| [1] | EIA, "Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860)," February 2023. [Online]. Available: https://www.eia.gov/electricity/data/eia860m/. [Accessed July 2023]. |
| [2] | D. Energy, "Duke Energy Progress Integrated Resource Plan Update 2022," 2022. |
| [3] | D. Energy, "Duke Energy Carolinas Integrated Resource Plan Update 2022," 2022. |