ASTRAPÉ CONSULTING
innovation in electric system planning

2023 Wind Effective Load Carrying Capability (ELCC) Study for Duke Energy Carolinas & Duke Energy Progress

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PREPARED FOR

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Wind ELCC Study Results

In addition to the 2023 Resource Adequacy Study performed for Duke Energy Carolinas & Duke Energy Progress, a wind resources ELCC study was conducted in order to determine the winter capacity value for future wind resources on the Companies' system which are ultimately used in the Companies' Resource Plan. All inputs used in the Wind ELCC Study are documented in the 2023 Resource Adequacy Study Report.

Because solar and wind are intermittent resources, a solar or wind facility's ability to provide reliable capacity when it is needed is different from that of a fully dispatchable resource such as a gas-fired turbine, which can be called upon in any hour to produce energy, notwithstanding unit outages.

The Wind ELCC study utilized the Base Case Combined Scenario as a starting point and then evaluated three different wind portfolios at four different capacity levels in conjunction with the 7,411 MW existing solar portfolio, and expanded solar portfolios that totaled 10,000 MW, 15,000 MW, and 20,000 MW. The wind resources were simulated along with the different solar portfolios in order to determine Surface ELCCs for the wind portfolios which is an ELCC methodology that captures the synergistic or deleterious effects of different classes of resources on each other and then allocates that to the appropriate resource type.

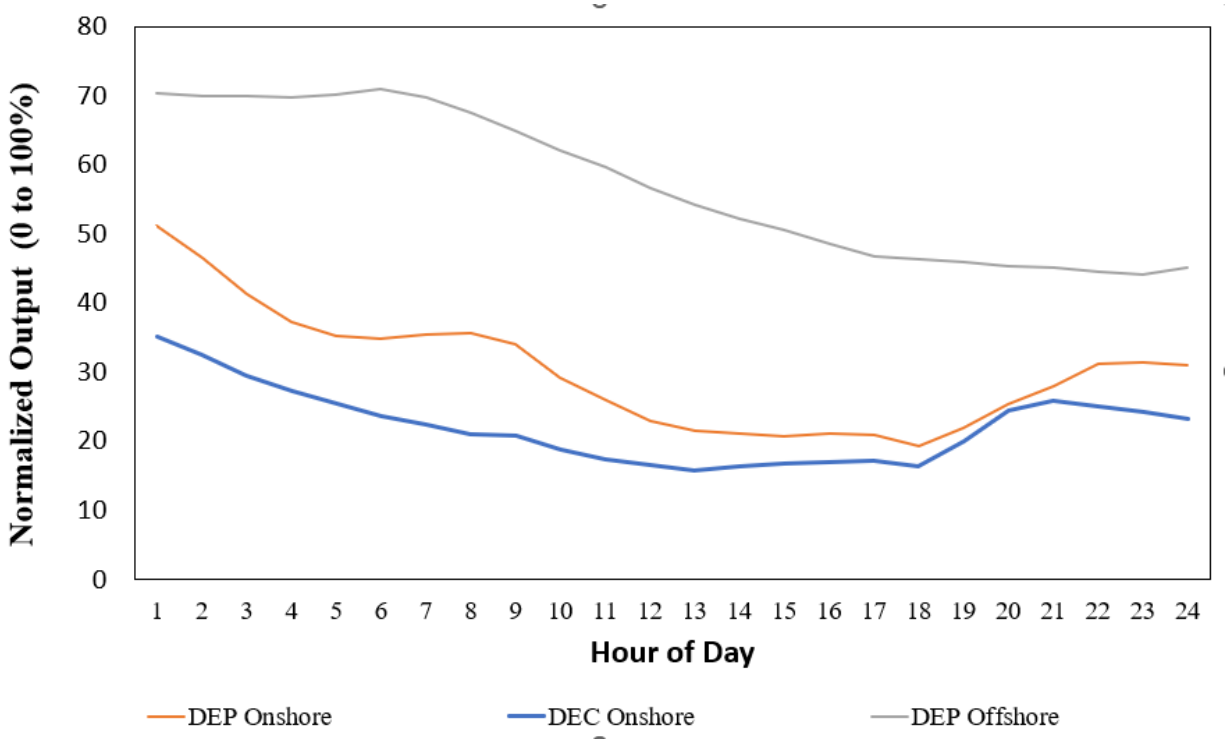
Table 1 lists the types of wind resources and their capacities along with the differing solar levels. Each capacity level of each wind portfolio is simulated along with each solar portfolio level. Figure

1 below shows the average output across all forty-three weather years of each wind resource type during winter high load hours.

Table 1. Wind and Solar Resource Tranches

Solar (MW)	DEC Onshore (MW)	DEP Onshore (MW)	DEP Offshore (MW)
7,411	300	300	800
10,000	600	600	1,600
15,000	900	900	2,400
20,000	1,200	1,200	3,200

Figure 1. Wind Shape by Hour of Day During High Load Periods



The ELCC of each tranche is calculated by first calibrating a base case system with no solar or wind that resulted in the DEC and DEP systems achieving a 1 day in 10-year industry standard of 0.1 LOLE. Once the base case is established, then the varying wind and solar tranches are added

to the system. Reliability will increase and LOLE will improve to less than 0.1. Then, load will be added to the system using a negative resource until the LOLE returns to the 0.1 reliability seen in the base case. The ratio of the load added to the capacity of the portfolio added is the ELCC of the portfolio. For example, if the 300 MW portfolio of DEC Onshore Wind is added and achieves the 0.1 LOLE reliability level when 100 MW of load is added, the ELCC of the portfolio is 33%. Wind resources were modeled with a 2.6% equivalent forced outage rate (EFOR). Astrapé recognizes that gas resources do not provide 100% ELCC due to forced outages. To adjust for this, the wind portfolio wasn't compared against a perfect load but a load that reflected a 4% derate which evaluates wind on a level playing field with a gas resource. The 4% outage rate represents the high end of new thermal resources such as new combined cycle or combustion turbine resources.

The resulting ELCC's of each wind/solar tranche are then post processed to allocate any synergistic benefits and a final average and marginal ELCC for each wind tranche is determined. These wind results are listed in

Table 2 and Table 3 below. The results for each tranche below are represented in two forms: marginal and average. Average ELCC represents the ELCC over the total MW of the tranche while marginal ELCC represents the ELCC of the next MW. For example, the average ELCC of the 300 MW of DEC Onshore wind is 33.8% while the 301st MW has an ELCC OF 23.9%.

Table 2. Average Wind ELCC Results

DEC Onshore		DEP Onshore		DEP Offshore	
Wind Capacity	Average ELCC (%)	Wind Capacity	Average ELCC (%)	Wind Capacity	Average ELCC (%)
300	33.8%	300	43.8%	800	74.9%
600	29.0%	600	36.8%	1,600	72.9%
900	25.9%	900	32.8%	2,400	71.9%
1,200	24.6%	1,200	31.8%	3,200	70.3%

Table 3. Marginal Wind ELCC Results

DEC Onshore		DEP Onshore		DEP Offshore	
Wind Capacity	Marginal ELCC (%)	Wind Capacity	Marginal ELCC (%)	Wind Capacity	Marginal ELCC (%)
First 300	33.8%	First 300	43.8%	First 800	74.9%
301st	23.9%	301st	28.2%	801st	74.9%
601st	22.2%	601st	27.7%	1601st	71.2%
901st	20.6%	901st	27.3%	2401st	67.5%
1201st	18.9%	1201st	26.8%	3201st	63.8%