Attachment D

DUKE ENERGY'S RESOURCE PLANS FOR THE CAROLINAS: AN EVALUATION AND ALTERNATIVE APPROACH

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PREPARED FOR

Natural Resources Defense Council, Sierra Club and Southern Alliance for Clean Energy

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EXECUTIVE SUMMARY

Daymark Energy Advisors (Daymark) was engaged by the Southern Environmental Law Center (SELC), on behalf of the Natural Resources Defense Council, the Sierra Club and Southern Alliance for Clean Energy, to provide comment on and supplemental analysis to the 2016 Integrated Resource Plans (IRPs) for Duke Energy Carolina (DEC) and Duke Energy Progress (DEP).

Daymark reviewed the IRPs and associated data provided through discovery to understand the process, assumptions, and methodologies employed by Duke and to provide a critique and alternative analysis. This review identified a number of concerns with the Duke analysis:

1. Duke prematurely limited the amounts of Energy Efficiency available as a resource to DEP and DEC through an overly restrictive screening process.
2. Duke prematurely limited the amount of solar photovoltaic energy (solar PV).
3. Duke did not include the potential for wind generated energy and capacity, particularly from imports through via transmission from Midwest wind facilities as options in developing resource portfolios for consideration.
4. Duke confined the primary Resource Portfolio development to only four portfolios and then picked from just those for its preferred plan.

Daymark constructed alternative analyses designed to address these concerns and illustrate the impact of a broader consideration of energy efficiency and renewable resources in least-cost planning. Based on this analysis, Daymark found:

1. Portfolio economic comparisons demonstrate that the Least Cost Plan for the combined Dec and DEP utilities should have a prominent role for renewables and energy efficiency.

2. The least-cost capacity expansion module favors solar and wind above the levels that Duke investigated, and selects as much solar and wind capacity as is provided as supply options.

3. While the current Duke process does not treat energy efficiency as a resource that can be easily incorporated as a potential resource for capacity expansion, the results of Daymark's portfolio analyses show that there is more economic energy efficiency available than the maximum amount tested by Duke.

4. Earlier retirement of Duke's coal plants is not only economic but reduces Duke's carbon footprint.

5. Daymark's portfolios demonstrate two important observations.

    a. By demonstrating that as more EE and Renewables are included (and thus less natural gas fired capacity is added) the total costs go down showing that these resources can economically avoid or delay the need for additional of uncommitted natural gas fired combined cycle and combustion turbine capacity.

    b. Since the Daymark portfolios, which did not select the new Lee nuclear plant, show lower costs than Duke's preferred portfolio they demonstrate that additional energy efficiency and renewable energy can also economically replace the uncommitted nuclear capacity.

6. Daymark's analysis of the amounts of non-carbon energy within the resources demonstrates that D7 – Green Resource Emphasis Case not only has Current Trends scenario favorable economics but also provides a pathway to compliance in the System Mass Cap future.

7. Even if Duke’s future load growth is less than anticipated in the IRPs, energy efficiency and renewable generation remain economic alternatives for displacing thermal generation

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I. INTRODUCTION

Daymark Energy Advisors (Daymark) was engaged by the Southern Environmental Law Center (SELC), on behalf of the Natural Resources Defense Council, the Sierra Club and Southern Alliance for Clean Energy, to provide comment on and supplemental analysis to the 2016 Integrated Resource Plans for Duke Energy Carolina (DEC) and Duke Energy Progress (DEP). Daymark was asked to first review the IRPs and the Duke responses to data requests in order to establish key parameters, assumptions or analysis, that might materially skew the IRP in favor of the utility's "preferred" resource plan, and that disadvantage clean energy resources.

Focusing on the key issues, and utilizing data obtained from Duke Energy, Daymark created its own analyses to test the validity of the Duke IRP process and conclusions. Daymark established and validated its capacity expansion and production cost model, AURORAxmp (Aurora), reasonably replicating the outputs of Duke Energy's modeling. Daymark developed alternative model inputs to address the key issues.

Daymark established the key issues in the Duke Energy IRP to be in the following areas:

1. Prematurely limiting the amounts of Energy Efficiency available as a resource to DEP and DEC.
2. Prematurely limiting the amount of solar photovoltaic energy (solar PV).
3. Duke did not include the potential for wind generated energy and capacity from local or imported through via transmission from Midwest wind generation farms as options in developing resource portfolios for consideration.
4. Confined the Resource Portfolio development to four portfolios.
5. Duke focused on the portfolio analysis on small incremental options for either 'high' renewable or 'high' energy efficiency

resource options rather than trying to obtain an indication of the strategic value of non-carbon resources.

6. Conducted resource portfolio evaluation on three scenarios of future for fuel prices, carbon emission prices, the condition of the regional economy and level of capital expenditures on existing facilities to test the economics of the four portfolios, while utilizing a very limited analysis of only two of the resource portfolios for an emissions-limiting future scenario, System Mass Cap.

7. Duke did not examine sufficient alternative 'paths' to a resource portfolio that can comply with the carbon emissions allowed under a System Mass Cap future.

In addition to the identified key issues, the Daymark analysis utilizing the Aurora optimized expansion modeling established that it would be economic for coal-fired generating capacity to retire due to economic obsolescence rather than assuming that they should operate through their book life within the DEP and DEC IRP analysis and report.

Daymark conducted its supplemental resource portfolio analyses to test whether there are additional portfolios could be a Least Cost Plan. A lower cost portfolio would have Duke choosing it as the preferred portfolio. Daymark acknowledged the Duke view in its IRP that the preferred portfolio should provide a pathway to the lowest cost resource plan under the scenario that the environmental regulations are established as those assumed under the System Mass Cap scenario. Clean energy resources of energy efficiency, solar PV, and wind generated energy can be developed as an alternative means to meeting future carbon limitations.

Thus, this report describes an analysis utilizing similar tools, similar assumptions, and the same decision criteria as employed by Duke Energy that with supplemental effort and consideration creates a lower cost resource portfolio that should be pursued as the preferred plan.

II. THIS REPORT

This report is divided into four main sections. Section III includes the results of long-term resource optimization expansion modules. Besides the simple retests of cases from the IRP, Daymark tested several conditions to investigate the impact of various assumptions on least cost resource expansion planning.

Section IV contains brief discussion regarding IRP review, different portfolios considered in the Duke IRP, and key issues and concerns. Moreover, this section also explains how Daymark included additional green resources – EE, wind, and solar –in its alternative cases. Please note that detailed discussion on resources considered in the IRP, screening analysis, and IRP assessment are included in Appendix A and Appendix B.

The Section V of the report includes a description on the alternative cases developed by Daymark under the carbon pricing scenario and the results associated with them. The results compare the long-term capacity additions and PVRR calculations of different alternative cases along with portfolios considered in the IRP. And Appendix C contains figures showing annual capacity additions in all portfolios considered for both DEC and DEP.

Finally, Sections VI contain the overall observations of different cases analyzed by Daymark and considered in the IRP. And Section VI concludes the report.

III. ECONOMIC RESOURCE EXPANSION OPTIMIZATION

Daymark's review of the Duke IRP identified constraints placed on the capacity expansion options as a key concern. To test the sensitivity of the results to these constraints, Daymark analyzed select scenarios with reduced constraints on the long-term capacity (retirements and additions) available to Duke. Based on these tests, Daymark determined the following:

1. Relieving constraints on the amount of solar PV led to the economic selection of additional solar capacity.

2. Adding wind imports from the West led to the economic selection of wind capacity.
3. Coal units could be retired ahead of Duke's schedule in an economic manner that would also lead to lower carbon emissions in Duke's footprint.
4. The Lee nuclear plants were not part of any least-cost plans.

For all cases, other than simple retests of cases from the IRP, Daymark utilized the Aurora long term resource optimization expansion module to ensure an optimal economic expansion through the selection of economic retirements and new generation to meet the long-term peak plus reserve margins for the Duke system. The Aurora optimization logic uses market economics to determine the long-term resource mix under the modeled future conditions including fuel prices, available generation technologies, environmental constraints, and future demand forecasts. Aurora does this by estimating price and dispatch using hourly demands and individual resource-operating characteristics in a transmission-constrained, chronological dispatch algorithm.

Using the Aurora model, Daymark tested the following scenarios to investigate the impact of various assumptions on least cost resource expansion planning.

1. Nuclear vs. Natural Gas Expansion Options

First, Daymark tested the mix of thermal options available under Duke's System Optimizer by holding retirements as fixed and re-selecting supply options by year as capacity was needed (Daymark LTCE-1). DEC's Lee nuclear facility was not selected in this plan, which confirms Duke's results that natural gas fired capacity is more economic than nuclear. See sub-section 5 below for summary level results for this Scenario.

This PVRR of this expansion plan was $111.26 Billion. As this scenario was closest to the Duke "High CC" scenario it served as a benchmark for alternative retirement and expansion plans tested by Daymark and reviewed below. From this scenario Daymark concluded that, consistent with the original Duke scenarios, inclusion of the Lee nuclear power plant increased total system costs.

2. Economic retirements

As noted in the Duke IRPs, coal assets were not retired based on economics, but rather "the depreciation book life was used as a placeholder for future retirement dates for coal assets, unless otherwise noted.[1]" Placing retirement dates based on the age of a plant is not a retirement test, so the first long term capacity expansion analysis looked at the economic retirement of all available existing plant.

After modeling Duke's fixed retirement portfolio in Aurora, Daymark next relaxed the constraint on early retirements and allowed the model to economically determine retirement dates in long term capacity expansion test (LTCE-2). A number of units were retired earlier than in the Duke fixed retirement scenario. Because no new supply was modeled in this case the same natural-gas fired units were added to the supply mix, although the timing of them varied from LTCE-1 slightly. See sub-section 5 below for summary level results for this Scenario.

This PVRR of this expansion plan was $112.08 Billion. While this is approximately the same as the fixed retirement scenario, the PVRR cost from emissions was reduced, indicating that for the same relative cost Duke could have met more of its long-term carbon reduction goals by looking for economic retirements of older, dirtier fossil generators.

3. Additional solar and wind resources as supply options

In addition to the test of economic retirements, Daymark utilized data from the Duke model and other publicly available data to construct additional local solar and imported wind configurations as supply options for the model to test against the nuclear and natural gas fired units already available for expansion. Up to seven 500 MW blocks of solar in both DEC and DEP was made available to the capacity expansion module. In

[1] Source: DEC IRP, Page 65

addition, five blocks of 100 MW wind from Oklahoma and five blocks of 100 MW Tennessee wind were made available in DEC and five blocks of 50 MW wind from Oklahoma were made available for selection in DEP. For both DEC and DEP service areas, all blocks of solar and wind modeled for capacity selection were in fact selected. Overall this scenario built approximately 3800 MW less thermal capacity while building approximately 8000 MW additional renewables. See sub-section 5 below for summary level results for this Scenario.

The PVRR of this expansion plan was further reduced to $110.06 Billion. The emissions cost component of PVRR was lower than in either thermal only capacity expansion, indicating further emissions reductions as would be expected with the additional renewable energy. This scenario indicates that there are higher volumes of renewable generation that would lower total system costs and reduce Duke system carbon emissions.

4. Low Load Sensitivity

The final long term capacity expansion test (LTCE-4) was a sensitivity designed to illustrate the impact that the current load forecast has on long term capacity planning. Daymark was not asked to review or opine on the quality of the load forecasts used in the IRP. It is our understanding, however, that that concerns have been raised about the winter peak forecasts for DEC and DEP.

To assist in illustrating the impact such a correction would make, Daymark constructed a simple low load case by reducing load growth by half. While this case assumes a slower load growth, it could also be seen as a lower reserve margin requirement, or some combination of all of these factors that lead to needing less supply to meet planning reserve criteria.

Once the new load was determined, the available supply options in LTCE-3 were then used to solve for the lower capacity requirement. As expected, this sensitivity led to significantly less capacity build over all due to lower loads. Almost all available renewable capacity was still selected, meaning that most of the reduction was natural-gas fired generation.

The PVRR of this sensitivity was $89.62 Billion, which shows the impact of load forecast assumptions on long term system costs.

5. Capacity expansion results by Scenario

The tables below (Table 1 – DEP, Table 2 – DEC, and Table 3 – DEC+DEP) show the cumulative capacity expansion results for all 4 long term capacity expansion runs for 2016 – 2031. See Appendix C for the timing and amounts of all capacity additions and retirements.

Table 1: DEP – Long-Term Capacity Expansions Summary for 2016 – 2031 period

Resource Type	*Daymark LTCE1*	*Daymark LTCE2*	*Daymark LTCE3*	*Daymark LTCE4*
Energy Efficiency	Base	Base	Base	Base
Wind	0	0	200	250
Solar	Base	Base	Base + 3500	Base + 3500
Lee Nuclear	0	0	0	0
Combustion Turbine	0	0	0	0
Combined Cycle	6,960	4,640	5,800	4,640

Table 2: DEC – Long-Term Capacity Expansions Summary for 2016 – 2031 period

Resource Type	*Daymark LTCE1*	*Daymark LTCE2*	*Daymark LTCE3*	*Daymark LTCE4*
Energy Efficiency	Base	Base	Base	Base
Wind	0	0	400	400
Solar	Base	Base	Base + 2000	Base + 1000
Lee Nuclear	0	0	0	0
Combustion Turbine	0	0	0	0
Combined Cycle	4,640	4,640	2,320	1,160

Table 3: DEC+DEP – Combined Long-Term Expansions Summary for 2016 – 2031 period

Resource Type	*Daymark LTCE1*	*Daymark LTCE2*	*Daymark LTCE3*	*Daymark LTCE4*
Energy Efficiency	Base	Base	Base	Base
Wind	0	0	600	650
Solar	Base	Base	Base+5500	Base + 4500
Lee Nuclear	0	0	0	0
Combustion Turbine	0	0	0	0
Combined Cycle	11,600	9,280	8,120	5,800

6. Coal Capacity Retirements results by Scenario

Daymark's use of the Long-term Capacity Expansion module of the AURORA system create a sharp increase in baseload coal unit retirements between 2021 through 2025. This shows that the economic drivers are making it uneconomic to continue to operate. Notice approximately 3,000 MW of coal capacity retires earlier than their book life assumptions per Duke. Table 4 includes the coal capacity requirements of different scenarios run by Daymark compared with Duke's Preferred Portfolio.

Table 4: Coal Capacity Retirements by different Long-Term Capacity Expansion Scenarios

Period	*Duke Preferred Portfolio*	*Daymark LTCE1*	*Daymark LTCE2*	*Daymark LTCE3*	*Daymark LTCE4*
2016-2020	2151	2151	2151	2151	2151
2021-2025	981	4024	981	4074	3478
2026-2030	1586	1079	1586	1029	2668
2031-2035	9613	7077	9613	7077	6414
2035-2041	4542	4542	4542	4542	4542

IV. IRP REVIEW & COMMENTS

Daymark has several concerns resulting from its review of the Duke IRPs. A larger discussion of the concerns is located in Appendices A & B. The major concerns are;

1. Duke did not utilize some energy efficiency potential identified in its own 2012 potential study,
2. Duke appears to have more room on their system for Solar PV, as they had limited it to 10%. This limit did not result from detailed studies but was considered as judgement.
3. The Wind resource did not advance for consideration in any Duke Portfolios.

The four portfolios provided very little in making portfolio strategy choices. The portfolio evaluation technique that Duke employed is known as scenario analysis. Several resource portfolio strategies are modeled and evaluated under primarily three futures of key parameters. In addition, Duke studied the impact of a future scenario described as the System Mass Cap for CO2. The different combinations of these parameters create scenarios that are shown below in a table from the Duke IRP Reports.

Table 5: Scenarios for Portfolio Analysis considered by Duke[2]

	Carbon Tax/No Carbon Tax Scenarios[1]	Fuel	CO2	CAPEX
1	Current Trends	Base	CO2 Tax	Base
2	Economic Recession	Low Fuel	No CO2 Tax	Low
3	Economic Expansion	High Fuel	CO2 Tax	High

[1]Run Portfolios 1 - 4 through each of these 3 scenarios

	System Mass Cap Scenarios[2]	Fuel	CO2	CAPEX
4	Current Trends - CO_2 Mass Cap	Base	Mass Cap	Base

[2]Run Portfolios 5 - 6 through this single MC2 scenario

[2] Source DEC IRP, Page 73 (Table A-3)

Duke Energy also performed an analysis of its Portfolio 1 (Base Case) in a joint planning methodology. In this methodology, the combined loads and resources of DEC and DEP are analyzed and new resources type and timing are chosen on a one system basis. The IRP demonstrated that for determining Portfolio 1 (Base Case) the results of joint planning yields a very similar expansion set of resources and thus near equal costs on PVRR basis.

Daymark has performed its supplemental analyses utilizing the Current Trends scenario to evaluate the economic benefits of one portfolio versus another.

A. Additional Resource Options

The Duke IRP followed a standard approach to a screening process to cull down the number of resource options are beginning Daymark has summarized the Duke screening process and results from the Duke IRP reports in this report within Appendix A: Resource Options.

Please note that the detailed discussion of resources considered in IRP is included in Appendix A: Resource Options. The following section only includes discussion on how Daymark considered incremental Energy Efficiency and renewable resources in addition to the amount that DEC and DEP included in their long-term planning.

1. Possibility of Additional EE Resources

Duke's energy efficiency screening process limited the amount of energy efficiency resource available by arbitrarily defining the limit of economic potential[3]. Since Duke set the amount of energy efficiency through its screening process, which Daymark believes limited energy efficiency. Daymark estimated potential addition EE savings to consider in the long-term planning leveraging the DSM supply curves reported in 2012 EE Market Potential Study. The screening process by Duke limits the amount of energy efficiency programs to between 60 to 90% the economic

[3] Please refer to the discussion in Energy Efficiency Resources for detailed discussion.

potential (determined by avoided costs. Described below is a high-level illustration as to how Daymark concludes that there is additional energy efficiency.

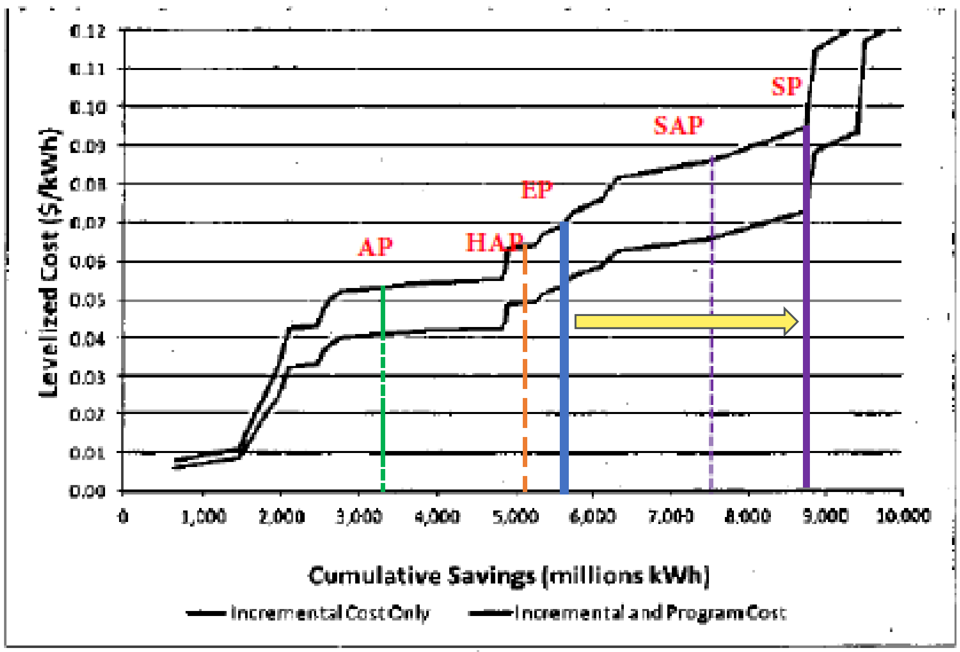
Figure 1 contains the residential energy efficiency supply curve from DEC's EE Potential study along with potential additional EE savings. DEC should consider additional EE savings from residential programs to the strategic potential[4] (SP) line in Figure 1. This figure illustrates where Economic Potential (EP) is established by comparisons to avoided costs. Duke limits its analysis to two bundles on energy efficiency, 60% of economic potential as Achievable Potential (AP) and 90% of economic potential as the High Achievable Potential (HAR). Daymark views that economic analysis will occur during the portfolio evaluations and thus established a Strategic Additional Potential (SAP) as 60% of the Strategic Potential (SP). The reason for considering new potential at the point specified by vertical SP line in Figure 1 is due to inelastic portion of the supply curve. The levelized cost of electricity for obtaining marginal EE savings beyond SP line increases substantially. Moreover, the resulting levelized cost at the SP line is little above $0.09/kWh which is still lower than the cost of additional nuclear generation shown in Figure 6, Appendix A. DEC residential EE programs have possibility of attaining additional 3100 GWh of savings by shifting from economic potential to strategic potential. Using the DEC's method of considering 60% of economic potential to estimate achievable portion, DEC has 1860 GWh[5] of energy savings from EE programs to consider in its long-term plan. Daymark used similar method to estimate additional energy savings from DEC's non-residential EE programs. DEC can

[4] The strategic potential (SP) is not a standard term in the EE Potential studies. Daymark is defining a new level of energy savings to emphasize on the possibility of additional EE savings to consider in the long-term planning. Moreover, Appendix D: Energy Efficiency Terms includes the definition of EE Potential Study terms.

[5] 3100 GWh * 60% = 1860 GWh

attain additional 1300 GWh of savings by pushing the EE potential to strategic potential.

Figure 1: Duke Energy Carolinas Residential DSM Supply Curve[6] with Additional EE Potential



Similarly, Daymark finds that DEC may have additional 4400 GWh of energy savings by combining strategic EE potential of both residential and non-residential customers. Daymark considered 60% of this additional energy to be achievable, DEC will have around 2640 GWh of energy savings from EE programs in 2017 – 2031 period[7]. Daymark will use this additional energy savings while modeling alternative cases. Daymark also used the strategic potential from DEC's study to project additional savings in DEP's service area[8]. We found that DEP can consider an additional cumulative energy savings of 1200 GWh, which is 60% of the difference in energy

[6] Source: 2012 DEC EE Potential Study, Page 32

[7] Additional Energy savings = 60% *(Strategic potential – Economic potential).

[8] DEP's EE market potential study was not available. Daymark used the Strategic potential of DEC and average of annual DEC's to DEP's EE energy savings of High EE case considered.

savings between Strategic potential and Economic potential. In total, DEC and DEP region will have additional 3300 GWh of cumulative energy to consider in the long-term planning.

Figure 2 shows the total EE contribution for DEP and DEC service areas from EE Maximum Case along with Duke's Base and High EE cases considered in the IRP. The numbers associated with Duke's Base and High EE are same as presented in Figure 9. Duke considered the energy savings attributed to Base EE and High EE cases in the long-term planning. Daymark Max EE Case includes incremental EE savings achieved by comparing the levelized cost of EE with traditional supply side resources. The annual contribution of energy savings in the Max EE Case follows similar trend to the Base and EE case. Similarly, Figure 3 shows the peak load contribution of EE programs from three difference Cases for both DEC and DEP. Although we expect that there will be incremental EE savings after 2032, the Additional EE Case did not add more EE savings after 2032 to be consistent with Duke's assumption.

Figure 2: Amount of Energy Savings (GWh) considered for different EE Scenarios in DEC and DEP regions between 2017 and 2031

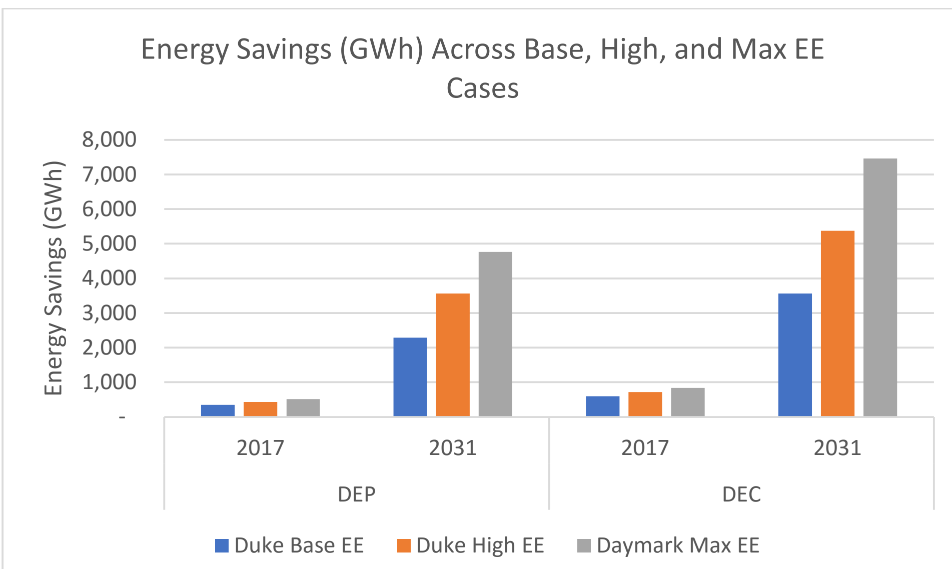
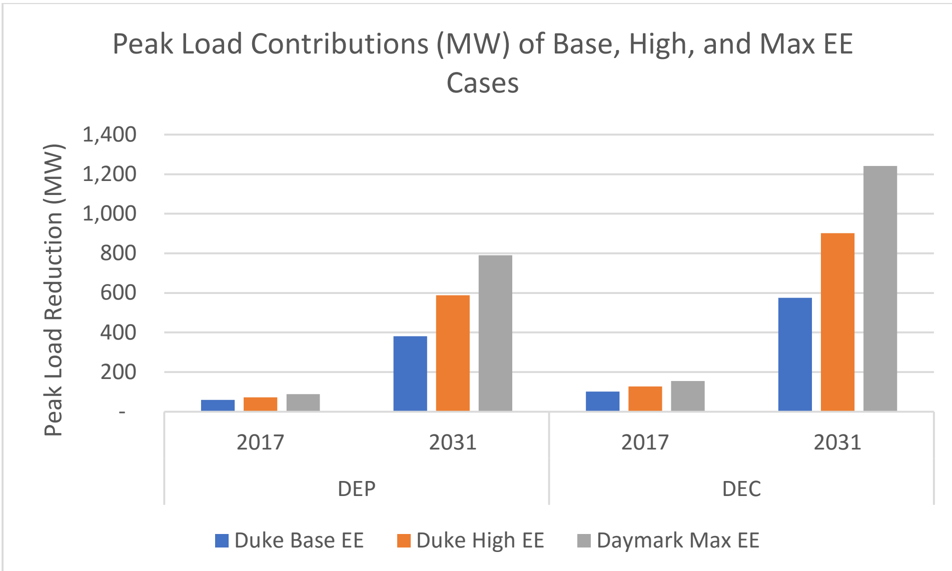


Figure 3: Peak Load Contributions (MW) of EE Programs considered in different scenarios for DEP and DEC between 2017 and 2031



2. Additional Solar Resources

Both DEC and DEP IRPs considered additional economical solar capacity in the System Mass Cap (SMC) scenario by assuming low cost solar sensitivity[9]. The long-term plans under system mass cap selected additional solar beginning in the early 2030s until solar generation reached the penetration of 10% level of DEC and DEP combined system. DEC's long-term plan based on SMC considered 3710 MW of incremental solar capacity between 2030 – 2037 period in addition to the capacity considered in the Base Solar Case. Similarly, DEP's plan had 1,732 MW of incremental solar to the Base Case in its SMC base portfolio (Portfolio 5).

Daymark considered the incremental solar included in Duke's System Mass Cap along with additional solar in one of its alternative cases. The amount of solar was calculated by limiting solar penetration to 14%. The

[9] The additional solar is incremental capacity to Duke's High Solar Case considered in Duke Portfolio 2 (High Renew).

incremental solar to the amount considered in the Duke's High Renewable Case was added gradually in the system such that the solar penetration reaches 14% in 2035.

The IRP of DEC and DEP also included solar integration cost while calculating the total cost of the system. The integration cost estimates were derived using Duke Energy Photovoltaic Integration Study[10] published by Pacific Northwest National Lab in March 2014. The Integration Study estimated the relationship between solar penetration level with integration cost as percentage of total system cost[11]. Daymark also used the same study to consider the solar integration cost of additional solar used in the alternative cases.

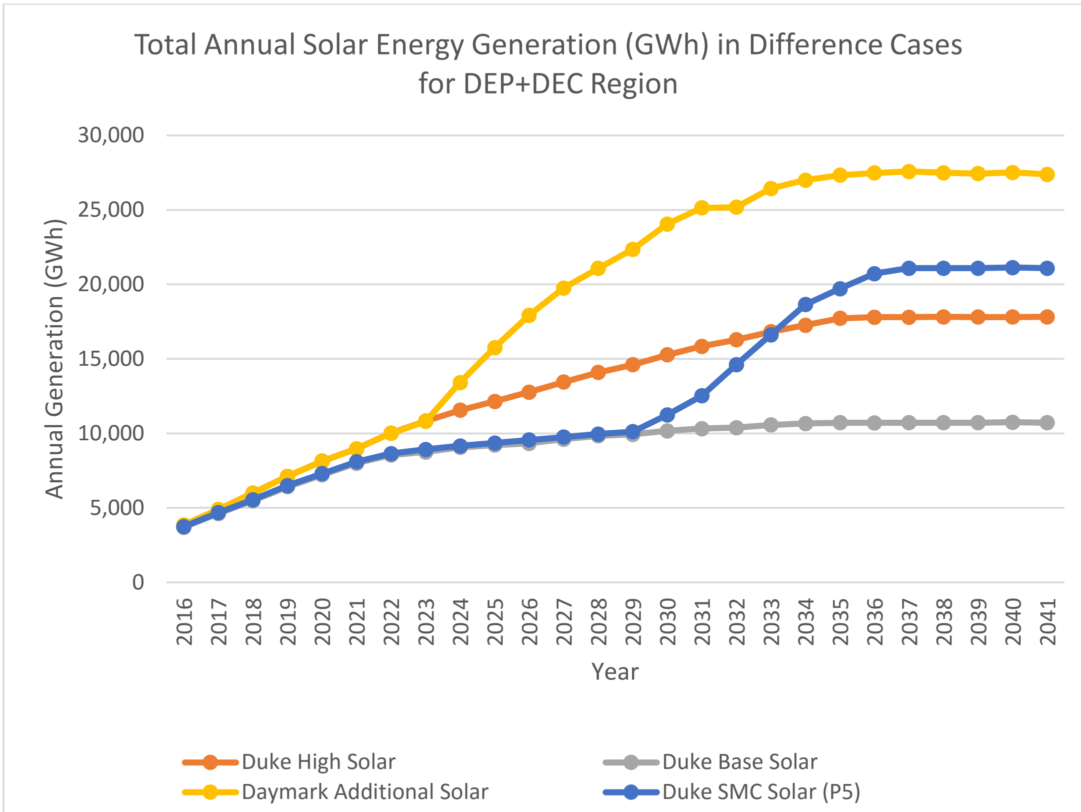
Figure 4 shows the annual cumulative solar energy generation across difference solar scenarios considered. Both DEC and DEP considered the Base and High cases in their long-term planning, whereas generation represented by SMC Solar (P5) was considered in IRP's Portfolio #5[12]. The "Additional Solar" which is included in one of the Daymark's alternative cases start considering more solar capacity in the energy mix from 2024 to early 2030s.

[10] Lu, S. and *et al.*, 2014, Duke Energy Photovoltaic Integration Study: Carolinas Service Areas, Pacific Northwest National Library, Source: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23226.pdf

[11] $Y = 4.4107 * X^2 + (0.0219 * X) + 0.007$ where Y is the PT integration cost as percent of total portfolio cost and X is the PV generation as percent of total system generation.

[12] Portfolio #5 is developed under the CO2 System Mass Cap scenario.

Figure 4: Annual Solar Energy Generation in DEC+DEP region across three difference cases



3. Wind Resources to Consider

DEC and DEP did not appropriately account for the availability of wind resources in the IRP, mainly in the form of limiting wind resources to land based, in state wind projects.

a) Out of State Wind

Importing wind from the central corridor of the United States to the Southeast via transmission lines has proven to be a cost-effective endeavor for many southern utilities. The 2015 Economic Planning Study[13] from

13
http://www.southeasternrtp.com/docs/general/2015/2015%20Economic%20Planning%20Study%20Results%20-%20Final%20Report.pdf

Southeastern Regional Transmission Planning (SERTP) identified two potential transmission projects that can be used to import wind generated energy to DEC and DEP service areas. One study analyzed the possibility of importing 3500 MW of Oklahoma generated wind through high-voltage Plains and Eastern Clean line project[14]. The transmission line is expected to be in operation by 2020. The SERTP Economic Planning study looked at the impact of DEC and DEP importing 407 MW and 254 MW, respectively, in the regional transmission system. Daymark used these numbers while considering additional renewable resources in the Alternative Cases modelling. Daymark also included the possibility of importing 500 MW of wind from Santee Cooper Border to DEC following the economic analysis of an economic analysis in the SERTP study. Daymark notes that considering the capacity and availability of transmission infrastructure included in the SERTP study is outside the scope of the IRP. However, Daymark included the capacity identified in SERTP to indicate that DEC and DEP have the possibility of considering out-of-state wind capacity in their long-term planning.

b) Offshore Wind

Although DEC and DEP eliminated Offshore wind from technical screening citing the technology not widely available, DEP and DEC may also have possibility to include offshore wind capacity in their resource mix in future. A recent study from National Renewable Energy Laboratory (NREL) ranks North Carolina fourth behind Florida, Louisiana, and Texas on offshore wind technical potential in the shallow water (that is water depths less than 30 meters)[15]. Similarly, Carolinas Offshore Wind Integration Case Study performed a detailed economic analysis of offshore wind potential in North Carolina and South Carolina[16]. The study analyzed three different

[14] The transmission project is among a list of 50 priority infrastructure projects compiled by Trump administration. The construction of the project is scheduled to start late 2017 or early 2018. Source: http://newsok.com/article/5535682

[15] Musial, Walt and et al. 2016, "2016 Offshore Wind Energy Resource Assessment of the United States." (Page 46), Source: http://www.nrel.gov/docs/fy16osti/66599.pdf

[16] The study was a collaborative effort among Duke Energy, ABB Inc., NREL, AWS Truepower, and University of North Carolina – Chapel Hill. Source:

levels of Offshore wind generation from cost-benefit and reliability perspectives. Given the Offshore wind technical potential in the Carolinas and increased interest in Offshore technology, DEC and DEP may have the possibilities of considering Offshore wind in their long-term planning or at least consider in the technical and economic screening process.

B. Duke Portfolio Assessment

This section provides summary of the IRP process, analysis method, and preferred portfolio selection of DEP and DEC. More detailed discussion is available in the Appendix B: Duke Portfolio Assessment Summary.

Duke's Portfolio Development process utilized expansion planning model to determine the best mix of capacity additions with an objective of minimizing present value of revenue requirement (PVRR) and meeting environmental regulations. Duke analyzed various expansion plans to find overarching trends with the goal of developing portfolios. Both DEC and DEP selected six representative portfolios - four of which considered three scenarios of the Carbon Tax paradigm and the remaining two under assumed CO2 Mass Cap paradigm. Finally, the selected portfolios were analyzed using a capital cost and an hourly production cost model under three distinct scenarios – Current, Economic Recession, and Economic Expansion[17] – for robustness and economic value.

The PVRR comparisons results, presented in Table 6, showed that Portfolio 4, the high combined cycles addition case as it is called, to be the lowest cost portfolio through 2061. The additions of more renewables (Portfolio 2) or more energy efficiency (Portfolio 3) to the base portfolio showed to be more expensive.

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http://nctpc.org/nctpc/document/REF/2013-06-06/COWICS_Phase_1_Final_Report1%5B1%5D.pdf

[17] The three scenarios included different levels for fuel cost, CO2 tax, and capital expenditures. In the Current Trend scenario, base fuel and capital expenditures (CAPEX) along with CO2 tax was considered. For the Economic Recession scenario, both fuel cost and CAPEX were lower than Current Trends. Moreover, there was no CO2 tax. Similarly, in the Economic Expansion scenario higher fuel cost and CAPEX were considered than the Current Trends. It also included CO2 tax.

Table 6: Delta PVRR Comparisons (2016 -2061) Across Different Portfolios considered under Carbon Pricing Scenarios.

DEC			
Portfolio	*Scenario #1 (Current Trends)*	*Scenario #2 (Economic Recession)*	*Scenario #3 (Economic Expansion)*
Duke Portfolio 1 (P1 - Base)	$0	$0	$0
Duke Portfolio 2 (P2- High Renew)	$322	$464	$430
Duke Portfolio 3 (P3 - High EE)	$69	$353	$22
Duke Portfolio 4 (P4- High CC)	-$4,992	-$6,077	-$6,212
DEP			
Portfolio	*Scenario #1 (Current Trends)*	*Scenario #2 (Economic Recession)*	*Scenario #3 (Economic Expansion)*
Duke Portfolio 1 (P1 - Base)	$0	$0	$0
Duke Portfolio 2 (P2- High Renew)	$1,184	$1,598	$1,522
Duke Portfolio 3 (P3 - High EE)	$76	$316	$13
Duke Portfolio 4 (P4- High CC)	$636	$814	$652
DEP+DEC - Combined			
Portfolio	*Scenario #1 (Current Trends)*	*Scenario #2 (Economic Recession)*	*Scenario #3 (Economic Expansion)*
Duke Portfolio 1 (P1 - Base)	$0	$0	$0
Duke Portfolio 2 (P2- High Renew)	$1,506	$2,062	$1,952
Duke Portfolio 3 (P3 - High EE)	$145	$669	$35
Duke Portfolio 4 (P4- High CC)	-$4,356	-$5,263	-$5,560

The second part of the portfolio evaluation, a scenario analysis technique, is to compare the economics of the portfolios that could meet the stringent emissions targets set out in the System Mass Cap scenario. Table 7 compares the PVRR of two portfolios considered under the system mass cap. For both DEC and DEP, the portfolio #5 is least cost option than the Portfolio 6.

Table 7: Delta PVRR Comparisons (2016 -2061) Across Different Portfolios considered under System Mass Cap.

DEC	
Portfolio	*Scenario #1 (Current Trends)*
Duke Portfolio 5 (P5 - SMC - Base)	$0
Duke Portfolio 6 (P6 - SMC - High EE & Renew)	$184
DEP	
Portfolio	*Scenario #1 (Current Trends)*
Duke Portfolio 5 (P5 - SMC - Base)	$0
Duke Portfolio 6 (P6 - SMC - High EE & Renew)	$829
DEP+DEC Combined	
Portfolio	*Scenario #1 (Current Trends)*
Duke Portfolio 5 (P5 - SMC - Base)	$0
Duke Portfolio 6 (P6 - SMC - High EE & Renew)	$1,013

Both DEP and DEC IRP selected Portfolio 1 as the preferred (Base) portfolio. The PVRR evaluation of various portfolios in the DEP system found Portfolio 1, a combustion turbine (CT) centric plan, to be the least-cost option. However, in the DEC region, Portfolio 1 was selected as Base Case even though combined cycle (CC) centric portfolio (Portfolio 4) was the least cost option. DEC's Portfolio 1 included two new nuclear units in addition to combined cycle (CC), combustion turbines (CT), and base amount of EE and renewables. Whereas, Portfolio 4 did not include nuclear generation and considered additional CC units in place of the nuclear capacity. DEC reasoned that the carbon footprint of Portfolio 4 would not be sustainable in the long term in a CO2 System Mass Cap scenario if the new nuclear generation was not available in 2028 – 2030 period. The choice of keeping nuclear in the short-term build plan would keep DEC on track if a System Mass Cap were to be implemented in the future.

Thus, Duke's decision steps were essentially:

- Identify the lowest cost portfolio under the three carbon pricing scenarios.
- Determine which portfolios can comply with regulations under a System Mass Cap future.
- Duke identified that despite the economic advantage, Portfolio 4 High Combined Cycles portfolio was not studied as to how it could evolve to comply with System Mass Cap constraints for carbon
- Duke constructed a compliant modified portfolio 1 as portfolio 5, Construct a modified portfolio 2 as a portfolio 6.
- Portfolio 5 costs less than portfolio 6. Portfolio 5 is a derivative plan of therefore Portfolio 1 should be established as the preferred plan because the Portfolio 4 which was least cost would not be compliant under the System Mass Cap scenario, effectively forgoing the least cost plan, Portfolio 4 High Combined Cycle.

The DEC IRP has not attempted to identify portfolios that could comply with the System Mass Cap emissions limit without new nuclear capacity. The limitations of the number of plans and the simplistic decision making process of eliminating the high CC Portfolio (Portfolio 4) which is most economic cannot test the value of the new nuclear generation.

In addition, Duke tested a joint planning methodology to demonstrate that the separate planning IRP process for DEC and DEP can be added together with similar results as a joint planning process.

The Daymark analysis in the next section discusses other portfolio options that can be considered as least cost.

V. DAYMARK ANALYSIS

A. Daymark Portfolio Analysis

In this limited study scope and time frame Daymark chose to do analysis within the Current Trends Scenario. In addition, Daymark analyses were conducted satisfying DEC and DEP resource needs independently and then added together for the purpose of demonstrating the results. The assessment of both DEC and DEP IRPs led Daymark to analyze few alternative cases in addition to the ones considered in the integrated resource planning of Duke Energy Carolinas and Progress. The overarching objectives of alternative cases is to provide additional information on the opportunity for more cost-effective energy efficiency and renewable in establishing a least cost resource plan and to help meet the Mass System Cap regulation if it or something similar is enacted. The portfolios that Daymark have chosen to analyze are intended to provide supplemental analysis and provide analysis that was unencumbered by the inclusion of the Lee Nuclear facility. The results of alternative cases will enable Daymark to answer these questions to the extent the information is available. These answers will demonstrate the strategic value of the green resource options (energy efficiency and renewable generation) and whether they lower the costs associated with a preferred portfolio.

Daymark Alternative Portfolios discussed earlier in Section IV-A, Daymark identified that there are significantly more green resources (renewable energy and energy efficiency) that had not been tested within the Duke IRP analyses. Daymark is suggesting that the strategic value of Green Resources is best demonstrated by stepping back to a resource plan that only includes committed resources, such as the hydroelectric and nuclear facility upgrades and new combined cycle facility identified by Duke. This means that Daymark is evaluating and discussing in this report green resources in portfolios that did not assume the Lee Nuclear facility was a committed resource. Our long-term capacity expansion modeling Section III discusses the process for determining the full resource portfolios out over time.

Under the Current Trends scenario, the proposed alternative cases consider even higher levels of renewables generation capacity, high EE, and nuclear optionality. The three cases include different amounts of renewables generation and energy efficiency.

1. Carbon Tax Scenario

As mentioned above, Daymark considered three alternative cases without assuming that Duke is committed to a new nuclear generation under Current Trends scenario, which included a per ton cost for carbon. These cases[18] consider varying levels of renewable and EE resources. A focus of the alternative portfolios was to answer the following questions:

- Can energy efficiency and renewable centric portfolios be lower in cost than the preferred portfolio plan by displacing nuclear or natural gas-fired generation?
- Can energy efficiency and renewable centric portfolios establish a pathway to compliance with carbon restrictions under the System Mass Cap future?

In order to create these alternative portfolios, additional energy efficiency and additional renewable energy resources were required. The additional energy efficiency was developed under the methodology described in "Possibility of Additional EE Resources" section of the report. In terms of renewable resources, additional resources were considering by adding the missing option to import significant amounts of wind generated energy via the "Clean Line" and the Additional Level of Solar PV described earlier in this report.

[18] We have labeled our cases with a D for Daymark and used similar numbering to indicated to which Duke case they are most similar. Where the case is not derived from a specific Duke case, or where the case is derived from more than one case in combination, we have numbered our new cases beginning with 7, after the first 6 that Duke performed.

Case D2: High Renewable:

- This Case considered high renewable capacity considered in Portfolio 2 (P2 – High Renew) of both DEC and DEP IRPs.
- Potential of additional renewables to P2 – High Renew Case. This case included wind generation of 407 MW and 254 MW to DEC and DEP, respectively, from Plain and Eastern Clean Line project. And the Case also includes 500 MW wind generation from Santee Cooper to DEC service area.
- New nuclear generation was not selected in the LTCE process.
- Approximately 2500 MW of coal unit early retirements due to economic obsolescence by 2031 (Mayo 1 and Roxboro 1-3)

Case D3: Maximum Energy Efficiency:

- Case D3 is comparable to Portfolio 3 considered in DEC and DEP IRPs.
- Potential of additional EE to High Case considered in the Portfolio 3. The Case included cumulative energy savings of 2100 GWh by 2031 for DEC region. This is 60 percent of the difference between Strategic and Economic EE potential. Similarly, the Case will also comprise of 1200 GWh of additional EE attributed energy in the DEP region by 2031.
- This Case also considered wind generation from purchase described in Case D2.
- New nuclear generation wat not selected in the LTCE process.
- Approximately 2500 MW of coal unit early retirements due to economic obsolescence by 2031 (Allen 4 & 5, Mayo 1 and Roxboro 1-3)

Case D7: Green Resource Emphasis:

- This Case is the combination of Case D2 and Case D3 considered above.
- The case contained additional EE amount and wind purchase amount considered in D3-Maximum EE Case.
- Moreover, this Case also included incremental solar capacity levels that were included in Duke's System Mass Cap scenario. DEC included 3,710 MW of additional solar in the Portfolio 5 that is under System Mass Cap. And DEP included 1,732 MW of additional solar capacity in System Mass Cap portfolio. In Daymark's Case 7, we included 3,643 MW of solar in DEC region starting 2024, whereas DEP has 1590 MW of additional Solar to its Base Case.
- New nuclear generation wat not selected in the LTCE process.
- Approximately 3500 MW of coal unit early retirements due to economic obsolescence by 2031 (Allen 5, Mayo 1 and Roxboro 1-4)

2. System Mass Cap Scenario

Daymark also considered additional cases under System Mass Cap scenario considered in the IRPs of DEC and DEP. The IRP assumed the System Mass Cap of 48.45 million tons of CO_2 in DEC and DEP service areas by 2030. The alternative cases analyzed by Daymark will explore the possibility of complying with System Mass Cap by either eliminating or reducing the amount of new nuclear generation.

B. Daymark Analysis

1. Daymark Portfolio Capacity Additions

Daymark analyzed three alternative portfolios discussed above under the "Current Trends" scenario. Evaluating the Daymark portfolio strategies starts with three steps;

- Choose the resources that characterize the portfolio strategy to be 'built in' to the resource expansion, e.g. renewable generation.

- Verify that the LTCE modular that selects additional resources the most economical of the resources available, mostly natural gas fired combined cycles and combustion turbines.
- The timing of the natural gas capacity was chosen to optimize the uncommitted and non-built-in resource choices.

Thus, the first set of results examine the types, amounts and, timings of resources chosen to complete the resource portfolio.

The are several important observations from examining the expansions of the Duke and Daymark portfolios.

- Within the Daymark portfolios modeled, efficient and cleaner combined cycles are selected to replace combustion turbines, nuclear capacity and base load coal retirements.
- As more green resources are added as built-in resources, less combined cycles are added,
- Our long-term capacity expansion process has shown that Green Resources can decrease the economic need for natural-gas capacity since additional combined cycle generation would not lower the costs of the portfolios

The overall economic results will be shown in the next section. The following paragraphs and tables describe the overall amounts of capacity added. Detailed year by year graphical representations of capacity additions for each portfolio modeled by Duke and Daymark, for both DEP and DEC are shown in Appendix D.

Table 8 shows the capacity expansion during 2016 – 2031 period of three alternative cases along with Duke's four portfolios reported in IRP document. The first column of Table 8 shows the capacity expansion by resource type for D2-High Renewable Case. This portfolio includes the same levels of Base EE and High Solar as considered in DEC's High Renewable Case included in the IRP (Portfolio 2). In addition, Daymark also included wind generation of 931 MW. The remaining load in the DEC was met by 3,480 MW of CC capacity during 16-year period.

Similarly, Table 8 also shows the capacity expansion for two other alternative cases considered in DEC region. There is slight difference in green resources considered between D2-High Renew and D3-Maximum EE cases. D3 considered higher amount of EE in its long-term planning, whereas only included the Base amount of solar. The long-term capacity expansion for both cases are equal mainly because there is not much energy contribution difference between two cases.

The D7 – Green Resource Emphasis, reported in the third column of Table 8, considered wind generation, EE from Max-EE Case, and additional solar discussed in "Additional Solar Resources" section. Besides considering significant amount of green resources, D7 will only add 1,160 MW of combined cycle in 2016-2031 period. The amount of CC considered in D7 Case is significantly lower than IRP's Portfolio 4 (High CC) – only portfolio included in IRP that didn't include solar. Moreover, the capacity of D7 also show that additional clean energy resources also eliminates the need of adding 1305 MW of CT plant considered in DEC's Preferred Portfolio (Table 8, Column 6).

When compared with DEC's preferred portfolio (Table 8, Column 4) that added two nuclear units along with 1,123 MW of CC, 870 MW of CT capacity and Base levels of EE and solar, Daymark Case 7 (third column) did not include nuclear units and contained 1,160 MW of CC and 931 MW of wind generation. Moreover, Daymark Case 7 also included additional amount of solar and EE to the amount considered in its High Case.

Table 8: DEC - Capacity Addition Comparisons of Alternative Cases with Base Preferred Case during 2016 – 2031 Period

Resource Type	*Daymark 2 (D2-High Renew)*	*Daymark 3 (D3 - Max EE)*	*Daymark 7 (D7 - Green Resource Emphasis)*	*Duke Portfolio 1 (P1 - Base)*	*Duke Portfolio 2 (P2- High Renew)*	*Duke Portfolio 3 (P3 - High EE)*	*Portfolio 4 (P4- High CC)*
Energy Efficiency	Base	Additional	Additional	Base	Base	High	Base

Wind	931	931	931	0	0	0	0
Solar	High	High	Additional	Base	High	Base	Base
Lee Nuclear	0	0	0	2,234	2,234	2,234	0
Combustion Turbine	0	0	0	870	870	870	1,305
Combined Cycle	3,480	3,480	1,160		1,123	1,123	3,369
Note: Appendix C: Annual Capacity Expansions – Visuals contains detailed annual capacity expansion figures.							

Table 9 includes the capacity expansion of alternative cases considered for DEP during 2016 – 2031 period. The alternative cases considered for DEP is consistent with DEC. The results show that in each of the cases considered, DEP will add 5800 MW of CC during 2016-2031 period. Daymark only considered the possibility of importing 254 MW of wind generation in DEP's territory. Similarly, the incremental EE and solar considered in Daymark's alternative cases is slightly greater than Duke's respective "High Case". Table 9 also includes capacity expansions of IRP portfolios for DEP service area.

Similarly, Table 10 shows the summary of capacity expansions of combined capacity expansions of DEC (reported in Table 8) and DEP (Table 9).

Table 9: DEP - Capacity Addition Comparisons of Alternative Cases with Base Preferred Case during 2016 – 2031 Period

Resource Type	*Daymark 2 (D2-High Renew)*	*Daymark 3 (D3 - Max EE)*	*Daymark 7 (D7 - Green Resource Emphasis)*	*Duke Portfolio 1 (P1 - Base)*	*Duke Portfolio 2 (P2- High Renew)*	*Duke Portfolio 3 (P3 - High EE)*	*Portfolio 4 (P4- High CC)*
Energy Efficiency	Base	Additional	Additional	Base	Base	High	Base
Wind	254	254	254	0	0	0	0
Solar	High	Base	Additional	Base	High	Base	Base
Lee Nuclear	0	0	0	0	0	0	0
Combustion Turbine	0	0	0	3,045	3,045	3,045	870
Combined Cycle	5,800	5,800	5,800	1,123	1,123	1,123	3,369
Note: Appendix C: Annual Capacity Expansions – Visuals contains detailed annual capacity expansion figures.							

Table 10: DEC +DEP - Capacity Addition Comparisons of Alternative Cases with Base Preferred Case during 2016 – 2031 Period

Resource Type	*Daymark 2 (D2-High Renew)*	*Daymark 3 (D3 - Max EE)*	*Daymark 7 (D7 - Green Resource Emphasis)*	*Duke Portfolio 1 (P1 - Base)*	*Duke Portfolio 2 (P2- High Renew)*	*Duke Portfolio 3 (P3 - High EE)*	*Portfolio 4 (P4- High CC)*
Energy Efficiency	Base	Additional	Additional	Base	Base	High	Base
Wind	1,185	1,185	1,185	0	0	0	0
Solar	High	High	Additional	Base	High	Base	Base
Lee Nuclear	0	0	0	2,234	2,234	2,234	0
Combustion Turbine	0	0	0	3,915	3,915	3,915	2,175
Combined Cycle	9,280	9,280	6,960	1,123	2,246	2,246	6,738
Note: Appendix C: Annual Capacity Expansions – Visuals contains detailed annual capacity expansion figures.							

2. Potential CO2 System Mass Cap Compliance

Using Duke's decision process described earlier, Duke selected Portfolio 1 (Base Case) as their preferred portfolio strategy. Their process tested to see which portfolios would be able to meet the carbon limits under the System Mass Cap regulation future. Duke felt compelled to choose Portfolio 1 by looking at the analysis. Duke eliminated its most economic portfolio, Portfolio 4 (High Combined Cycles) from consideration since they maintained but did not demonstrate that that portfolio could not provide a pathway to compliance. Daymark has assembled Table 11 below to show that the additional renewable energy and energy efficiency resources are substantial and in fact can provide as much carbon free energy as the nuclear facility in the compliance portfolios analyzed by Duke under the System Mass Cap future. The Duke preferred portfolio included the Lee Nuclear facility. By demonstrating that the green resources identified by Daymark provide sufficient carbon-free energy such that the Daymark portfolios remain under consideration for being selected as the preferred portfolio since they provide a 'pathway' to future compliance.

Table 11: Energy Generation Comparisons between Proposed Lee Nuclear Facility with other Non-Emitting Sources

Descriptions	*Capacity (MW)*	*Annual Energy (GWh)*
Lee Nuclear Facility	2,234	18,238
Replacing Resources in DEC+DEP Region		
Wind	931	4,803
Additional Solar	5,233	10,152
Additional EE		3,283
Total Energy from Replacing Resources (GWh)		18,238

Daymark analysis revealed that additional solar, beyond the Duke's high solar level, and additional energy efficiency that had been eliminated pre-maturely due to the avoided cost screening, and the wind generated energy from local or distant wind generation will comply under the System Mass Cap future.

3. Portfolio Economic Comparisons

Daymark first compared the cost of its portfolios to those reported in the IRP by Duke. In Figure 5 below, orange bars show the PVRR reported in the IRP, whereas the blue bar are estimated by Daymark's modeling work. The PVRR number in the figure is combined for DEC and DEP service areas. The figure also includes the PVRR of three alternative cases that Daymark developed where the LTCE did not include proposed Lee Nuclear units. The results show that alternative cases are lower cost options compared with portfolio analyzed by Duke. Daymark's alternative Case 7 (D7 – Green Resource Options) that also contains additional EE, solar, and wind generation is the least cost option among the portfolio analyzed.

Figure 5: Comparison of PVRR across Different Cases from Daymark Modeling and IRP reported PVRR

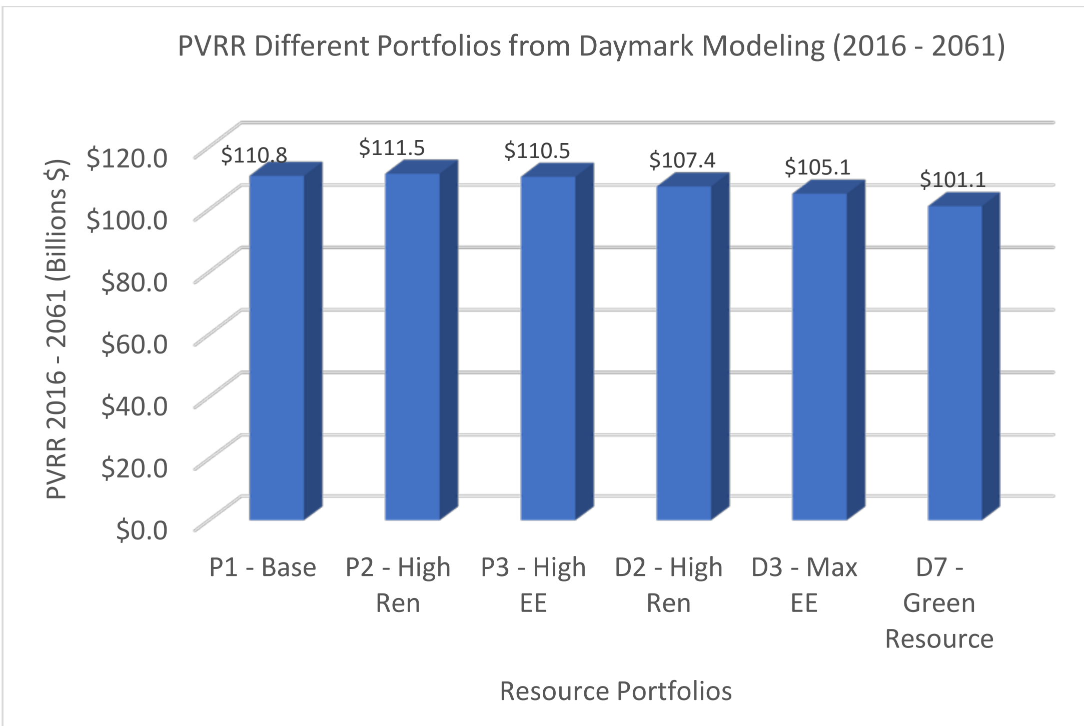


Table 12 contains the PVRR difference between different cases referencing to the Base Portfolio from the IRP document. The positive number indicate that the specific portfolio costs more than the Portfolio #1 (Base) during 2016 – 2061 period. Similarly, the negative numbers denote that the portfolio has lower net present values. Daymark found that D7- Green Resource Emphasis portfolio will cost 9.7 billion less than IRP's preferred portfolio (Portfolio#1 – Base).

Table 12: Daymark Portfolio Economic Comparisons compared to the Daymark modeling of Portfolio 1 (Base Case)

Portfolios	*Delta PVRR ($, Millions)*
Duke Portfolio 1 (P1 - Base)	$0
Duke Portfolio 2 (P2- High Renew)	$670
Duke Portfolio 3 (P3 - High EE)	-$304
Daymark 2 (D2-High Renew)	-$3,404
Daymark 3 (D3 - Max EE)	-$5,718
Daymark 7 (D7 - Green Resource Emphasis)	-$9,716

The Daymark analysis demonstrated some very important results. The Daymark analysis of higher and then even Additional Renewables and Energy Efficiency resources was conducted without assuming Lee Nuclear facility as a committed part of their portfolios. Duke had concluded that a strategy beginning with Portfolio 1 (Base Case) was a more preferred Least Cost Plan. The Daymark cases with High Renewables and High Energy Efficiency and both show that these plans, without the Lee nuclear facility, can produce a least cost plan. The economics of the combined resource portfolio is even lower in cost than the High Combined Cycle Portfolio 4.

Daymark analysis of the additional renewables, solar PV and wind imports, as well as additional energy efficiency, when added to a starting point of high EE/RE can meet the carbon emissions levels of the Duke Preferred Portfolio. These cases have lower costs under Current Trends and under the System Mass Cap Scenarios

Daymark's portfolio analysis would suggest that the preferred portfolio should be one that maximizes Green Energy Resources, since it produces the least cost plan under Current Trends and provides a pathway to compliance in the System Mass Cap future.

VI. DAYMARK OBSERVATIONS

Daymark makes the following observations from its review of the Duke IRP reports and the Daymark analysis.

1. The LTCE favors solar and wind above the levels that Duke investigated, and selects as much solar and wind capacity as we allow it to.
2. While EE is not set up in a way to allow it to easily be compared with resources in a capacity expansion model, the results of our runs show that there is more economic EE to be had versus what Duke selected.
3. Earlier retirement of Duke's coal plants is not only economic but reduces Duke's carbon footprint.
4. If least cost is the only consideration, then EE, solar, and wind are winners and coal units should be considered for earlier retirement.
5. Portfolio economic comparisons demonstrate that a more prominent role for renewables and EE as compared to nuclear and natural gas combined cycles is warranted for additional study and implementation.
6. Daymark's portfolios demonstrate three important observations.
    a. By demonstrating that as more EE and Renewables are included (and thus less natural gas fired capacity is added) the total costs go down showing that these resources can economically avoid or delay the need for additional of uncommitted natural gas fired combined cycle and combustion turbine capacity.
    b. Since the Daymark portfolios, which do not have the new Lee nuclear plant, show lower costs than Duke's preferred portfolio they demonstrate that additional energy efficiency

and renewable energy can also economically replace the uncommitted nuclear capacity.

c. Daymark's analysis of the amounts of non-carbon energy within the resources demonstrates that D7 not only has Current Trends scenario favorable economics but also provides a pathway to compliance in the System Mass Cap future.

VII. CONCLUSION

The Duke overall IRP process is a reasonable approach to long-term least cost planning, besides the use of economic test of energy efficiency versus supply avoided costs. Daymark's concern focuses on the very limited nature of the portfolio development and evaluation process. As described more fully below, this has caused Duke to choose a strategic portfolio direction without full consideration of renewable energy and energy efficiency.

There are lower cost portfolios that provide a path to compliance with a System Mass Cap future scenario.

Daymark established the key issues in the Duke Energy IRP to be in the following areas;

1. Pre-maturely limiting the amounts of Energy Efficiency available as a resource to DEP and DEC.
2. Prematurely limiting the amount of solar photovoltaic energy (solar PV) available as a resource to DEP and DEC.
3. Failing to include the potential for wind generated energy and capacity from local or imported through via transmission from Midwest wind generation farms as options in developing resource portfolios for consideration.
4. Confining the Resource Portfolio development to four portfolios.

The Duke Energy selection for the preferred resource portfolio was limited to five of six resource portfolios included the addition of the two-unit Lee Nuclear facility. The lowest cost resource portfolio was eliminated from consideration as unable to comply with the carbon emissions limitations in the future scenario, System Mass Cap

Daymark concludes that there is more work that should be done by Duke Energy before committing to the action plan it has presented. The availability of solar energy that shows economic promise despite the lack of capacity values attributed to it due to the utilities becoming winter peaking, means this switch to winter peaking should be examined in two steps.

1. The core technology and market penetration studies of the penetration of electric heating load should be examined to test its robustness.
2. Targeting energy efficiency programs to reduce winter peak demand, including pricing to achieve active peak demand management should be developed to the maximum as a resource option and tested within IRP for their strategic value.

In addition, more optionality for resources need to be investigated so that expensive resources are not part of the preferred portfolio strategy making the plan higher cost. Also, additional renewable resources need to be fully evaluated.

1. The ability to ramp up energy needs to be studied, perhaps creating a focus on lost opportunity programs such as new construction.
2. The ability to at least temporarily put the Lee Nuclear facility in a 'hot stand-by' condition to see it that facility is indeed required to meet tight carbon regulations since including that facility raised the cost of a preferred portfolio

3. Monitor the development of the transmission line to import wind energy should be given the highest resource priority as long as contractual terms are favorable.

Daymark also recommends a more inclusive IRP process, especially when it comes to strategy and portfolio developments and scenario creation. A more active stakeholder input development process would have improved visibility on many of these issues and allowed Duke to more fully consider the range of supply options available.

VIII. APPENDICES

Appendix A: Resource Options

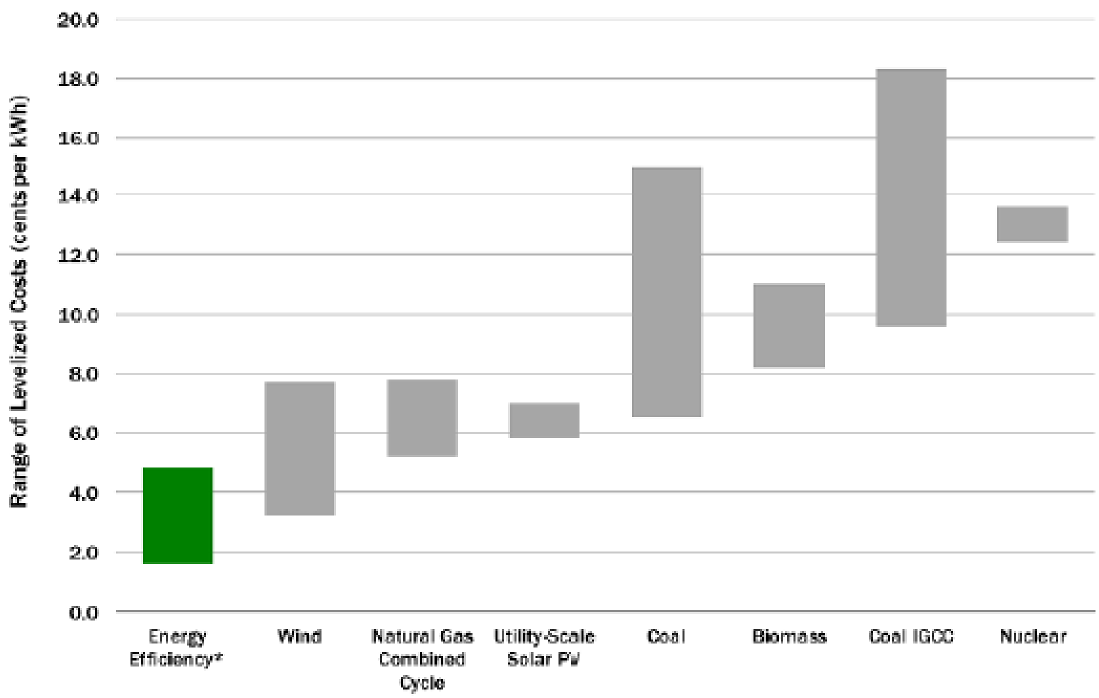
1. Energy Efficiency Resources

In this section, we will discuss a flaw in the energy efficiency screening process that leads to unnecessarily limiting the energy efficiency resources brought forward for economic evaluation within the portfolios. Daymark has also developed an estimate at the additional amount of energy efficiency for testing within the portfolio evaluation, that Daymark found is an important resource for determining that changes should be considered in Duke's preferred portfolio.

a) Duke's EE/DSM Resource

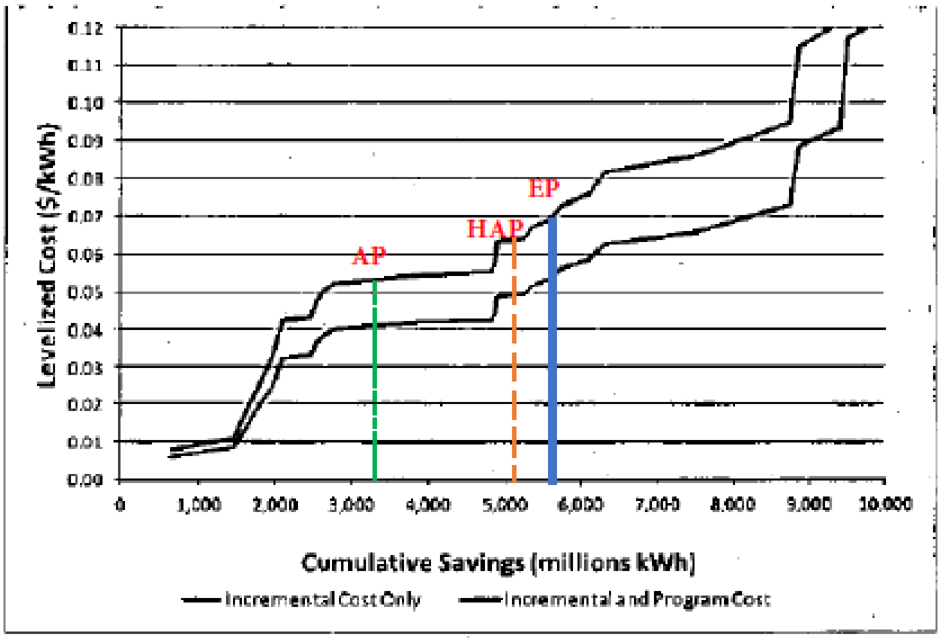
The development of the IRP EE and DSM options begins with a resource potential study. The energy efficiency resource potential considers the economic forecasts driving energy consumption, the existing end-uses of electric power for each customer class, the existence of replacement more efficient equipment, the potential for building shell improvements and the continued technology evolution that creates opportunities to have new equipment be installed and utilized that is most efficient. A thorough potential study identifies a 'supply' curve of energy efficiency resources for each customer class showing an increasing cost as more and more energy efficiency options are considered. The top end of these supply curves would be termed the technical potential. Based on existing program experiences, and the most recent market potential study, the potential study identifies 'achievable' potential levels. In most utility IRP screening analysis, the supply curve is utilized to establish a level of 'economic' potential. This is where Daymark believes that the energy efficiency resource is prematurely limited. The economic potential is established utilizing supply costs, i.e. avoided costs, to determine the amount of energy efficiency that is deemed economic. As discussed earlier in this document generation or supply resources do not undergo such testing. Figure 6 below illustrates how the costs of the various resource options compare on a generic basis. This comparison shows energy efficiency to be significantly lower than some generation options. Thus, by limiting the size of the energy efficiency resource at this stage, the opportunity to evaluate strategies or portfolios to determine the potential role for all energy efficiency rather than generation resource options are pre-empted. At this point in the evaluation process, screening, we do not know if portfolios could be enhanced by replacing additional higher cost supply options illustrated on this chart with energy efficiency.

Figure 6: Comparison of Levelized costs (cents/kWh) by energy sources



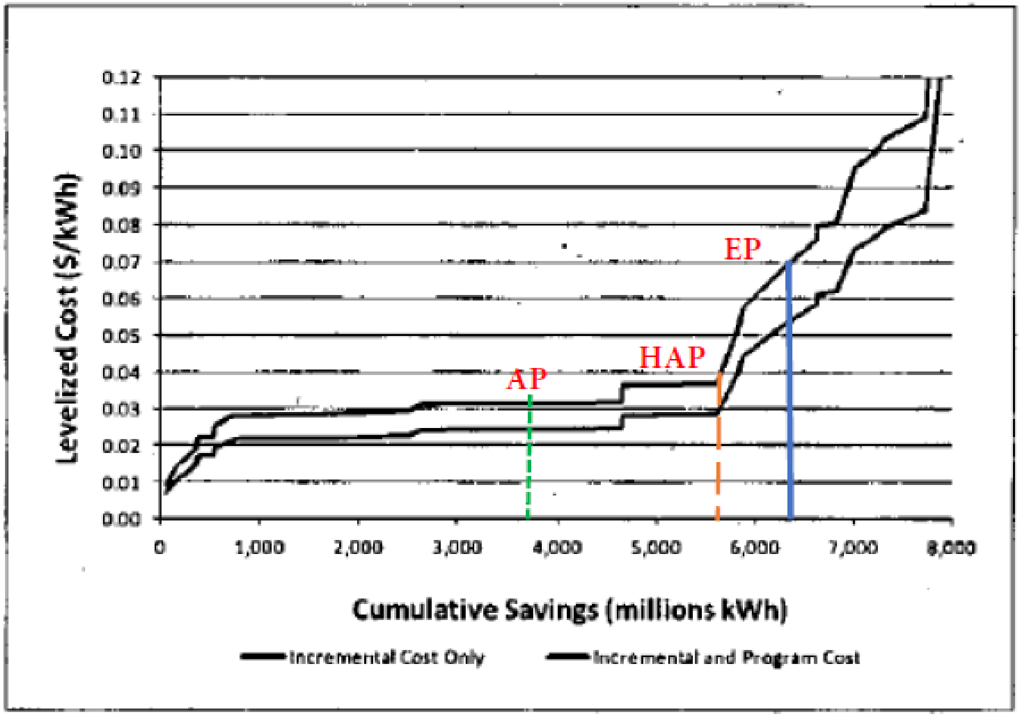
Duke Energy estimated the potential addition EE savings to consider in the long-term planning from the DSM supply curves reported in 2012 EE Market Potential Study. Figure 7 represents the DSM supply curve of DEC's residential customers. The lower line in the graph represents incremental cost to attain certain level of energy savings, whereas the upper line also includes program costs associated with each level of savings. The program cost is set at 30% of the incremental costs. The three vertical lines that represent economic potential (EP), high achievable potential (HAP), and achievable potential (AP) are added by Daymark and contain equivalent amount of energy savings included in DEC's IRP[19]. Economic potential is the energy savings associated with EE incremental and program cost being less than $0.07/kWh. DEC considered 60% of EP to be achievable and included in the Base preferred case. Whereas, the Duke's high EE case is analogous to the HAP line and is 1.5 times of the achievable potential. Similarly, Figure 8 shows the DSM supply curve of DEC's non-residential customers. The EE potential limits are estimated similarly to residential supply curve shown in Figure 7.

Figure 7: Duke Energy Carolinas Residential DSM Supply Curve[20]



[20] Source: 2012 DEC EE Potential Study, Page 32

Figure 8: Duke Energy Carolinas Non-Residential DSM Supply Curve[21]



Both DEC and DEP considered two different EE/DSM cases in the IRP planning. The Base EE/DSM case included EE savings projection from utility's five-year program plan for 2016-2020 period and assumed that the annual savings projected for 2020 continue to be achieved each year until the cumulative EE savings reaches 60% of the economic potential estimated from the study. In addition to the EE measures and assumptions considered in the Duke's Base EE case, the High EE case included additional offerings of new technologies at higher participation rate and program costs. Specifically, the High case consisted of a 50% increase in participation for all the Base EE programs and assumed that additional energy savings will be captured through LED programs. Figure 9 shows the energy savings associated with Duke's Base EE and High EE cases considered for DEP and DEC between 2017 and 2031. Similarly, Figure 10

[21] Source: 2012 DEC EE Potential Study, Page 32

includes the peak load contribution of EE programs included in Base and High EE cases between two years for both DEP and DEC.

Figure 9: Energy Savings (GWh) Attributed to Duke's Base and High EE Cases of DEP and DEC between 2017 and 2031

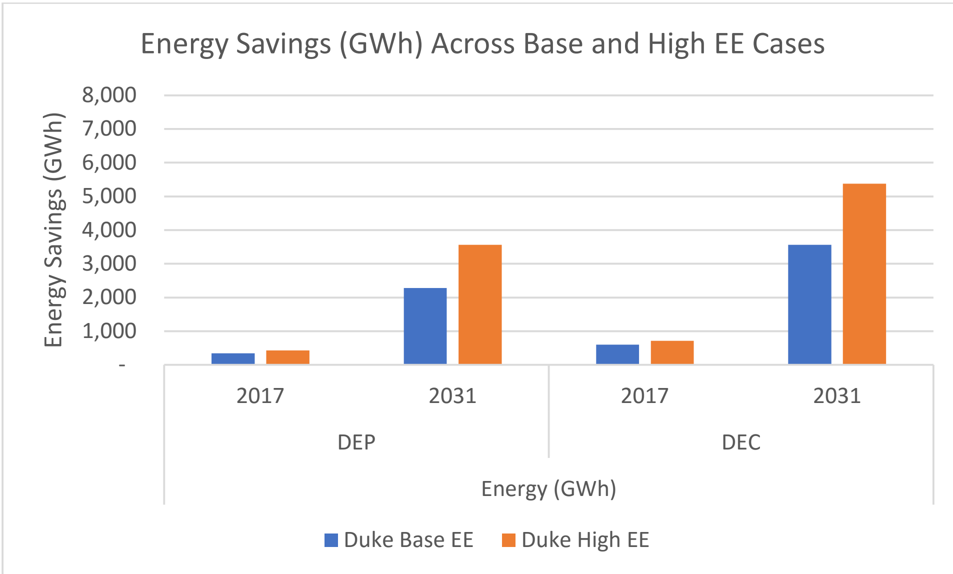
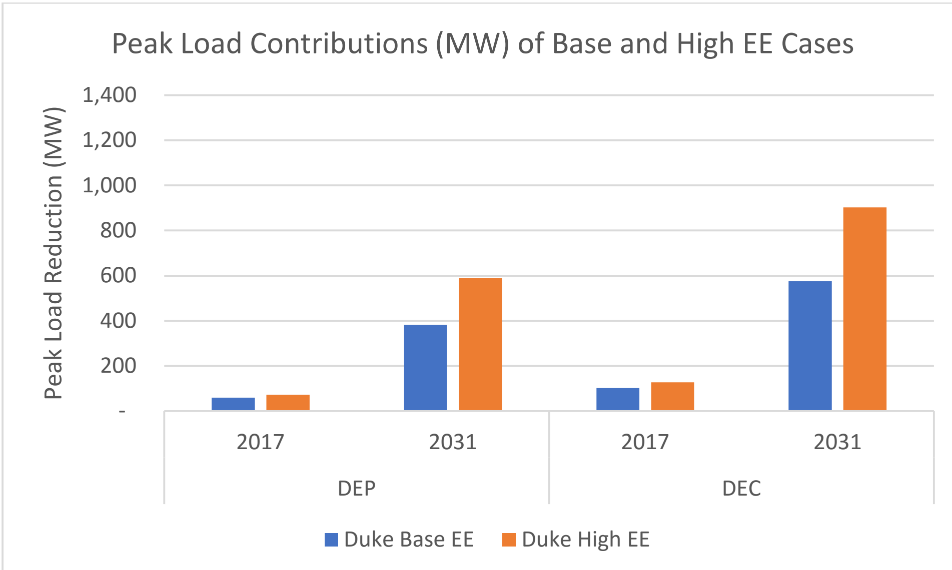


Figure 10: Peak Load contribution (MW) of Duke's Base and High EE Cases of DEC and DEP between 2017 and 2031



The energy savings attributed to EE/DSM programs was then used to reduce the load forecast before choosing the supply-side resources to remaining capacity requirement. The 2012 potential study incorporated estimates for the generation supply cost savings that energy efficiency could provide, avoided costs. This avoided cost level in 2012 was determined to be $0.07/kWh. Duke's screening process considered energy savings associated with levelized cost of energy that is lower than $0.07/kWh of the DSM supply curve to be economical. The DSM supply curve shows the cumulative kWh energy savings for all measures selected from cost-effectiveness tests. The choice of $0.07/kWh may have unnecessarily limited the amount of economic potential. Again, this step is unnecessarily limiting the amount of resource available for resource portfolio consideration.

2. Solar PV Resources

a) Duke Solar Resources considered

The only renewable resource evaluated within the resource portfolio analysis by DEP and DEC was Solar PV. The analysis considered the costs of the Solar PV under the utility ownership model. It is Daymark's opinion that this practice is common and does not create bias for or against the Solar PV resource. The Solar PV resource as applied to the DEP and DEC system has moved into the role of providing clean energy, but without the benefit of counting a portion of the nameplate capacity toward the utility meeting its capacity needs to provide adequate reliability. This is due to the transition from a summer peaking to a winter peaking system for both DEP and DEC are expected to see

The resource plan considered two different solar capacity forecasts in the long-term planning: Base Case and High Case in the carbon pricing scenario.[22] The Base Solar Case included "renewable capacity required for compliance North Carolina Renewable Energy Portfolio Standards, non-compliance Public Utilities Regulatory Policy Act (PURPA), as well as South Carolina Distributed Energy Resources, Green Source Rider, and other solar capacity associated with customer programs" (DEC 2016 IRP, Page 26). In addition to the solar capacity included in the Base Case, the High Case also included additional solar capacity by envisioning combined effect of scenarios favoring solar investments. Some of the scenarios favoring higher solar penetration are high carbon prices, lower solar capital costs, economical solar plus storage, continuation of renewable subsidies, and/or stronger renewable energy mandates.

Figure 11 includes the nameplate solar capacity included in Base and High Solar Cases for both DEP and DEC regions. Although DEP is smaller compared to DEC in terms of load, DEP region considered more solar capacity in its long-term planning than the DEC region. DEP included 3,270 MW of solar in the reference Case, whereas the high renewable Case

[22] The IRP forecasted three different renewable capacity forecasts: Low, Base, and High. However, only Base and High cases were used in the portfolio development.

considered 5,062 MW of solar capacity. Similarly, the solar capacity in the Base Case had 2,168 MW by 2031. And high renewable Case of DEC included nameplate solar capacity of 2,957 MW by end of its 15-year long-term planning. In addition, Figure 12 shows the energy generation from solar capacity added in Base and High renewable cases considered in DEC and DEP long-term planning.

Figure 11: Nameplate Solar Capacity (MW) in Base and High Renewable Cases

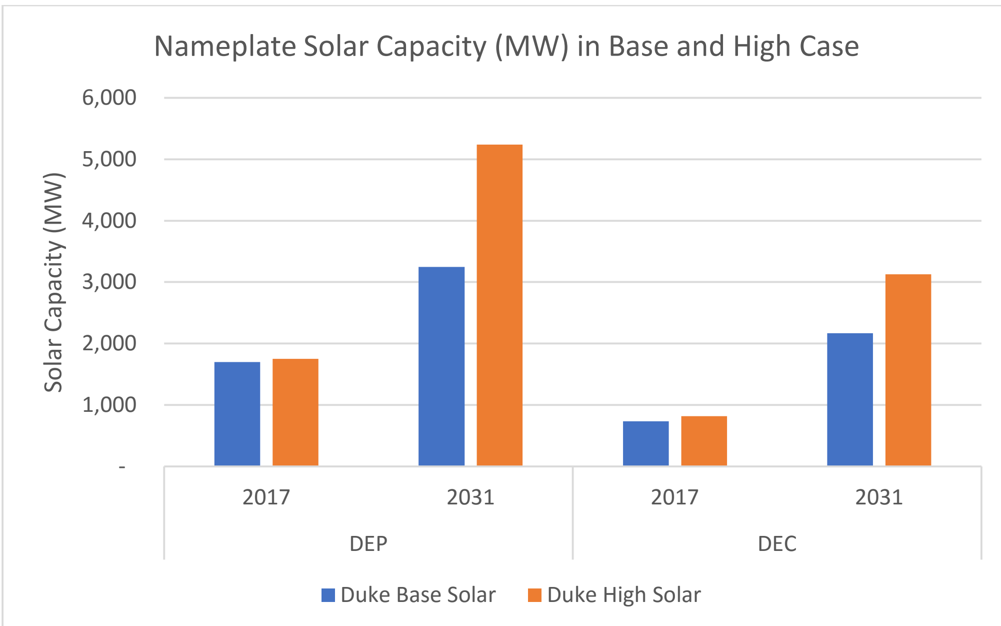
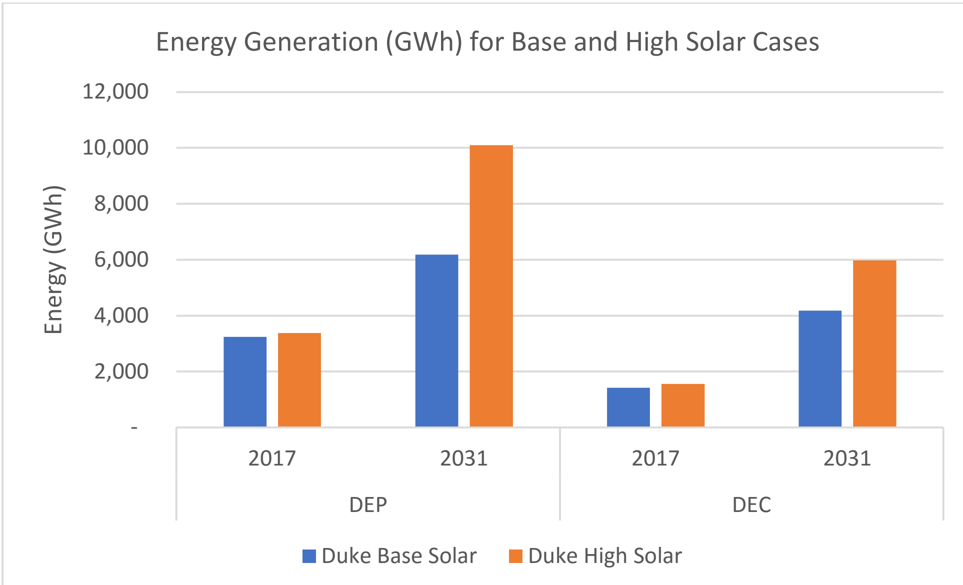


Figure 12: Energy Generation from Solar in Base and High Renewable Cases



3. Wind Resources

The IRP document considered onshore wind in the technical and economic screening process. However, IRP analysis did not include Onshore wind in its long-term portfolio evaluation. Even though Carolinas do not have a great potential for onshore wind[23], DEC and DEP may be able to consider wind-generated energy in the long-term plan by purchasing from neighboring regions and states or by pursuing Offshore option.

The IRP analysis used 150 MW wind capacity in the screening analysis. The analysis used relative dollar per kilowatt-year ($/kW-yr) versus capacity factor for comparing cost of each resource used in the screening process. [redacted][24]. However, it is not clear why wind generation was completely ruled out from the portfolio

[23] NREL renewable technical potential report states that the combined Onshore wind capacity of North and South Carolina is 0.01% of total technical wind potential of all US states. http://www.nrel.gov/gis/re_potential.html

[24] Source: DEC IRP, Page 147

development, but Solar generation was considered despite it being relatively cheaper. The IRP document, however, mentioned about technical limitations of intermittent resources and claimed that wind generation is not economically competitive with other generation technologies without State and Federal subsidies. Similarly, the IRP mentioned that Offshore was not considered in the technical screening because the technology is not widely applied and not easily permitted in the United States.

4. Nuclear

The DEC IRP included construction of W.S. Lee Nuclear Station (Lee Nuclear) in the long-term planning process. The proposed plant is assumed to come online at two different time periods – one unit in November 2026 (1117 MW) and another one in May 2028 (1117 MW). The company also received the Combined Construction and Operating License (COL) from Nuclear Regulatory Commission on December 2016[25]. The long-term plan of DEC considered new nuclear generation as a carbon-free, cost-effective, and reliable option within Company's resource portfolio (DEC IRP, Page 7). As a result, the proposed Lee Nuclear plant is included in five of the six portfolios evaluated in the IRP and is part of the selected Preferred Base plan. However, Duke hasn't considered the risks associated with nuclear plant fully in the IRP analysis. Cost overruns, construction delays, regulation hurdles are a few of the risks to consider.

There is variation in the capital cost reported publicly versus used in DEC IRP analysis. The recent publicly available report mentioned that the cost of completing plant will be around $11 billion. [redacted] Based on the projection of current nuclear plant under construction, it is likely that the capital cost will be higher than assumed. A similar size VC Summer Nuclear plant that is under construction in South Carolina reported that

[25] The Charlotte Observer, December 21, 2016. Source: http://www.charlotteobserver.com/news/business/article122205799.html

construction delay of at least one year increased cost by $1.2 billion[26]. Moreover, it is not clear whether DEC's analysis included pre-construction costs associated with the Lee Nuclear units in its economic evaluation. DEC reported that they have already spent $495 million in preconstruction costs since 2011[27].

5. Natural Gas-fired Generation

The results of the screening show important roles for combustion turbine based technology, combined cycle and simple cycle capacity, fueled by natural gas. Results of the baseload screening show that natural gas combined cycle generation is the least-cost base load resource. "With lower gas prices, larger capacities and increased efficiency, natural gas combined cycle units have become more cost-effective at higher capacity factors in all carbon scenario screening.

The peaking/intermediate technology screening included F-frame combustion turbines, fast start aero-derivative combustion turbines, and fast start reciprocating engines. The Duke screening curves show the F-frame CTs to be the most economic peaking resource unless there is a special application that requires the fast start capability of the aero-derivative CTs or reciprocating engines." [28]

[26] The increased in cost 2014 is 12.2% more than estimated project cost in 2008. The cost of the units was originally estimated at $9.8 billion in 2018. http://www.world-nuclear-news.org/NN-Cost-of-Summer-AP1000s-increases-0310144.html

[27] http://www.charlotteobserver.com/news/business/article122205799.html

[28] DEC IRP Report page 142

Appendix B: Duke Portfolio Assessment Summary

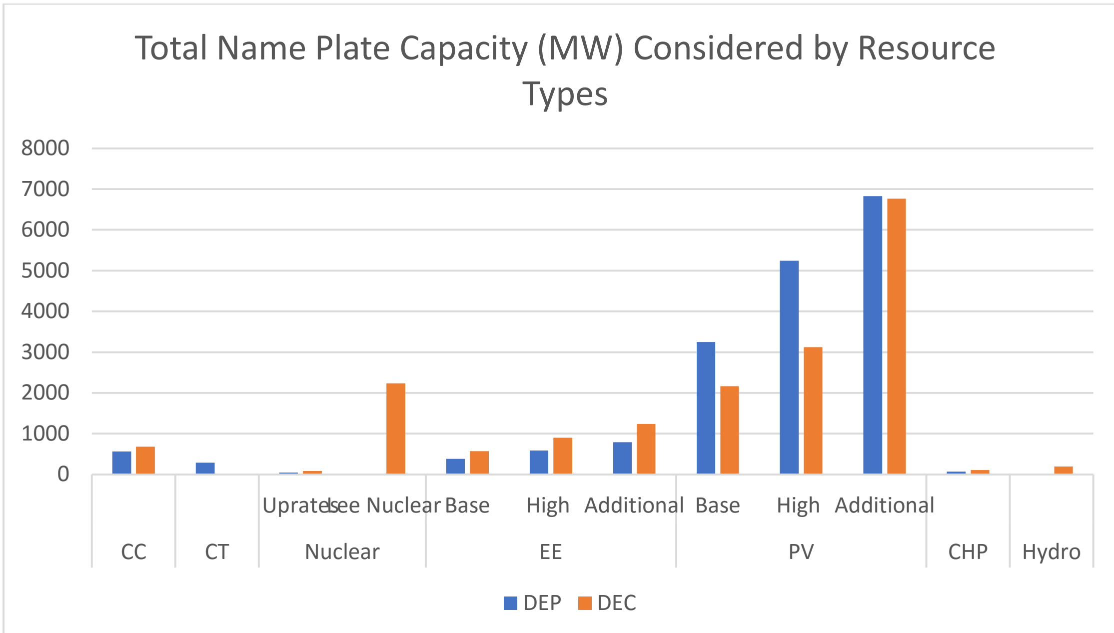
The Portfolio evaluation process has three elements. First, there is the choice of portfolios to analyze. This step should be designed to answer questions such as: how many clean resources? What plan is least cost? What plan is lowest risk? The Duke development of resources as we will discuss below is rather limited and simple. The second step is the analysis. Analysis includes the methods and the metrics. In addition, the analysis can test the robustness of portfolio performance under scenarios of futures. We will discuss the lack of breadth in the Duke IRP. Lastly, there is the decision process – what logic and what metrics are relevant to the decision.

1. Portfolio Development Process

The Portfolio development process utilized expansion planning model to determine the best mix of capacity additions with an objective of minimizing present value of revenue requirement (PVRR) and meeting environmental regulations. The portfolios considered started with a common basis for committed resources.

Next portfolios are developed featuring certain resources. These resources can be added at the timing of the analyst or as chosen by the optimum expansion program. An optimized expansion program will also determine if there are any retirements of existing capacity that should be made due to economic obsolescence. The Duke portfolios were developed assuming limited coal unit retirements. In the Duke portfolios, this is described in the Figure 13 below.

Figure 13: Types of Resources and Capacity (MW) considered in DEC and DEP IRP



> "For the 2016 IRP, six representative portfolios were identified through the Sensitivity Analysis and Portfolio Development steps. Four of the portfolios were developed under a Carbon Tax paradigm where varying levels of an intrastate CO_2 tax were applied to existing coal and gas units as envisioned in EPA's Clean Power Plan. Three of these portfolios included Lee Nuclear Plant in 2026 and 2028 and varied levels of EE and renewable penetration, while the fourth portfolio replaced Lee Nuclear plant with mainly CC generation.
>
> The remaining two portfolios were developed under a System CO_2 Mass Cap that represented an alternative outcome of the CPP. In these portfolios total system CO_2 emissions were constrained starting in 2022 and declined until 2030, and total system emission were held flat from 2030 throughout the remaining planning horizon."[29]

The base portfolio or Portfolio 1 was established by Duke showing their plans going into the IRP analysis. It should be noted that this plan was also selected ultimately as the preferred development plan. This outcome

[29] DE IRP Report page 35

would not generally have been considered suspect if the plan on previous IRPs was established rigorously and tested for robustness. It also would not be suspect if many alternative portfolios were considered and tested for robustness against risks and alternative scenarios of the future. However, the number of portfolios selected was limited, calling into question whether Duke tested a sufficiently broad range of possible long term plans in order to identify which would be in customers' best interest.

Portfolio 1 included the Lee Nuclear facility, the achievable, so called 'achievable' 'economic' potential for energy efficiency and enough solar PV top meet renewable portfolio standards. As we described earlier achievable economic is defined as 60% of the economic potential

Portfolio 2 simply added more or the High Solar PV to Portfolio 1.

Portfolio 3 simply added energy efficiency be estimating the costs to capture 90% of the 'economic potential'.

Portfolio 4 was created by allowing the capacity expansion model to pick between natural gas fueled combined cycles or combustion turbines. Also, this was the only portfolio where the Lee Nuclear facility was not set to be in the plan nor was it chosen as an economic addition of generation.

Table 13 and Table 14 show the capacity additions for all six Portfolios considered in DEC and DEP long-term planning. Please note that the capacity included here only include undesignated resources. Both DEP and DEC have committed additions in the short-term as presented in Table 15.

Table 13: DEC - Resources Additions across Different Portfolios Considered during 2016 – 2031 Period

Resource Type	*Duke Portfolio 1 (P1 - Base)*	*Duke Portfolio 2 (P2- High Renew)*	*Duke Portfolio 3 (P3 - High EE)*	*Duke Portfolio 4 (P4- High CC)*	*Duke Portfolio 5 (P5 - SMC - Base)*	*Duke Portfolio 6 (P6 - SMC - High EE & Renew)*
Combined Cycle	1,123	1,123	1,123	3,369	1,123	0
Combustion Turbine	870	870	870	1,305	870	1,740

Lee Nuclear	2,234	2,234	2,234	0	2,234	2,234
Solar	2,168	2,957	2,168	2,168	3,168	2,957
Energy Efficiency	Base	Base	High	Base	Base	High
Total Undesignated Capacity Added	*6,395*	*7,184*	*6,395*	*6,842*	*7,395*	*6,931*

Table 14: DEP – Resource Additions across Different Portfolios Considered during 2016 – 2031 Period

Resource Type	*Duke Portfolio 1 (P1 - Base)*	*Duke Portfolio 2 (P2- High Renew)*	*Duke Portfolio 3 (P3 - High EE)*	*Duke Portfolio 4 (P4- High CC)*	*Duke Portfolio 5 (P5 - SMC - Base)*	*Duke Portfolio 6 (P6 - SMC - High EE & Renew)*
Combined Cycle	1,123	1,123	1,123	3,369	2,264	1,123
Combustion Turbine	3,045	3,045	3,045	870	1,740	2,610
Nuclear	0	0	0	0	0	0
Solar	3,270	5,062	3,270	3,270	3,450	5,062
Energy Efficiency	Base	Base	High	Base	Base	High
Total Undesignated Capacity Added	*7,438*	*9,230*	*7,438*	*7,509*	*7,454*	*8,795*

Table 15: Planned Additions by Resource Types in DEC and DEP Service Areas during 2016 – 2031 Period

Resource Types	**DEC Capacity (MW)**	**DEP Capacity (MW)**
Nuclear Uprates	85	44
CC	683	560
CT	0	100
Hydro Uprate	201.6	0
CHP	109	66
Total	*1078.6*	*770*

Daymark found Duke's process of preferred plan development to be somewhat arbitrary. The analysis did not run through enough scenarios or cases. The screening process looked like it was compelled to choose from actual plans analyzed. And the preferred plan selection was rather an economic analysis of options, rather than a portfolio study. There was no attempt to build a hybrid preferred plan or the lowest cost, minimum CO_2 Plan.

2. Scenario Analysis

Scenario analysis is a process that is considered useful in creating visibility as to how different resource portfolio strategies perform under different futures. Scenario analysis incorporates the issues and variations of sensitivity analysis of input variables such as load forecast, fuel costs, renewable energy, EE, and capital costs within the quantitative analysis portion of the resource planning process. Scenario Analysis differs from uncertainty analysis in that instead of varying one assumption parameter and looking at the change in results scenarios are developed that are based upon some plausible combination of assumptions for the future. Thus, sensitivity parameters are combined in differing values among the scenarios.

Table 8-A Scenarios for Portfolio Analysis

	Carbon Tax/No Carbon Tax Scenarios[1]	Fuel	CO_2	CAPEX
1	Current Trends	Base	CO_2 Tax	Base
2	Economic Recession	Low Fuel	No CO_2 Tax	Low
3	Economic Expansion	High Fuel	CO_2Tax	High

[1]Run Portfolios 1 - 4 through each of these 3 scenarios

	System Mass Cap Scenarios[2]	Fuel	CO_2	CAPEX
4	Current Trends - CO_2 Mass Cap	Base	Mass Cap	Base

[2]Run Portfolios 5 - 6 through this single MC2 scenario

3. Analysis

The portfolios were models utilizing production cost modeling and capturing all the costs of installing and operating a generation resource. The portfolios were compared on only one metric at this point – the present value of revenue requirements (PVRR). This present value metric included all the production costs for the DEC or DEP systems as well as accounting for the fixed cost savings of retirements and the fixed costs of new or additional resources. This is a very common metric for utility planning in general, including IRP. The PVRR's are shown in Table 16 below. The table shows delta PVRR across different portfolios as compared with the Base portfolio for DEC and DEP. The positive delta PVRR means that a certain portfolio costs more than the Base portfolio. The results show that Portfolio 4, the high combined cycles addition case as it is called, to be the lowest cost portfolio through 2061.

The additions of more renewables (Portfolio 2) or more energy efficiency (Portfolio 3) to the base portfolio showed to be more expensive. Daymark attributes some of that to the fact that there were no changes in selected resources despite the additions of high solar PV or high energy efficiency

Table 16: Delta PVRR Comparisons (2016 -2061) Across Different Portfolios considered under Carbon Pricing Scenarios.

DEC			
Portfolio	*Scenario #1 (Current Trends)*	*Scenario #2 (Economic Recession)*	*Scenario #3 (Economic Expansion)*
Duke Portfolio 1 (P1 - Base)	$0	$0	$0
Duke Portfolio 2 (P2- High Renew)	$322	$464	$430
Duke Portfolio 3 (P3 - High EE)	$69	$353	$22
Duke Portfolio 4 (P4- High CC)	-$4,992	-$6,077	-$6,212
DEP			
Portfolio	*Scenario #1 (Current Trends)*	*Scenario #2 (Economic Recession)*	*Scenario #3 (Economic Expansion)*
Duke Portfolio 1 (P1 - Base)	$0	$0	$0
Duke Portfolio 2 (P2- High Renew)	$1,184	$1,598	$1,522
Duke Portfolio 3 (P3 - High EE)	$76	$316	$13
Duke Portfolio 4 (P4- High CC)	$636	$814	$652
DEP+DEC - Combined			
Portfolio	*Scenario #1 (Current Trends)*	*Scenario #2 (Economic Recession)*	*Scenario #3 (Economic Expansion)*
Duke Portfolio 1 (P1 - Base)	$0	$0	$0
Duke Portfolio 2 (P2- High Renew)	$1,506	$2,062	$1,952
Duke Portfolio 3 (P3 - High EE)	$145	$669	$35
Duke Portfolio 4 (P4- High CC)	-$4,356	-$5,263	-$5,560

The second part of the portfolio evaluation, a scenario analysis technique, is to compare the economics of the portfolios that could meet the stringent emissions targets set out in the System Mass Cap scenario. Table 17 compares the PVRR of two portfolios considered under the system mass cap. For both DEC and DEP, the portfolio #5 is the least cost option than the Portfolio 6.

Table 17: Delta PVRR Comparisons (2016 -2061) Across Different Portfolios considered under System Mass Cap.

DEC	
Portfolio	*Scenario #1 (Current Trends)*
Duke Portfolio 5 (P5 - SMC - Base)	$0
Duke Portfolio 6 (P6 - SMC - High EE & Renew)	$184
DEP	
Portfolio	*Scenario #1 (Current Trends)*
Duke Portfolio 5 (P5 - SMC - Base)	$0
Duke Portfolio 6 (P6 - SMC - High EE & Renew)	$829
DEP+DEC Combined	
Portfolio	*Scenario #1 (Current Trends)*
Duke Portfolio 5 (P5 - SMC - Base)	$0
Duke Portfolio 6 (P6 - SMC - High EE & Renew)	$1,013

The DEC IRP has not attempted to identify portfolios that could comply with the System Mass Cap emissions limit without new nuclear capacity. The limitations of the number of plans and the simplistic decision making process of eliminating the high CC Portfolio (Portfolio 4) which is most economic cannot test the value of the new nuclear generation.

Similarly, renewable resources are treated with a minor role, not a true resource option. Duke has not looked at sufficient number of plans or portfolios under their base scenario assumptions to adequately determine if there is value to expanding renewable penetration (PV Solar) beyond their preferred Plan considerations. The IRP also ignored the potential for wind energy generation as potentially lowering costs and/or creating additional options for reducing carbon emissions in the constrained System Mass Cap scenario. The IRP only considered Onshore wind in the screening analysis. Whereas, Offshore wind and possibility of wind purchase from neighboring states were ruled out in the long-term planning process.

The results of the System Mass Cap scenario analysis of two portfolios are shown below

Duke also used the comparisons of the performance of the resource portfolio strategies across the scenarios to determine that while the Base Case was lowest cost for DEP, the High Combined Cycle Portfolio 4 brought significant savings to DEC. When combined the High Combined Cycle Portfolio 4 is the least cost across the scenarios. Daymark observes that this is the only portfolio studied without the Lee Nuclear Generating Station.

Since the cost and risks associated with new nuclear units are very high, DEC could consider alternative resources to meet the future energy needs. DEC can assess the cost of other non-emitting – such as EE/DSM and renewable – resources required to replace the generation capacity of new nuclear units. DEC can also find the cost required to keep new nuclear capacity as optionality. The cost for keeping nuclear option in the table may include additional licensing and updating the plan regularly. DEC’s primary reason for choosing a long-term plan with new nuclear generation is to be on a compliance path should there be a System Mass Cap regulation in future. Keeping the new nuclear option in the “ready-to-go” position will increase the system cost, but will provide DEC flexibility if a carbon regulation passes in the future.

Appendix C: Annual Capacity Expansions – Visuals

1. Daymark Alternative Cases

In addition to the summary of 25-year capacity additions, Daymark also analyzed annual capacity additions of alternative Cases considered. Figure 14 - Figure 19 contain annual capacity additions and retirements considered for DEC and DEP separately for each of the alternative cases analyzed. Please note that these figures do not include EE resources and solar capacity depicting Base or High Case. We only include incremental solar capacity of “Additional” Case. As described previously in the report, D2-High Renewable case includes Base EE and High Solar capacity levels and are not included in the following figures. Similarly, the figures for D3-Maximum EE do not show EE resources of “Additional EE” case and Base Solar Case. For figures showing annual capacity expansion of Case D7-Green Resource Emphasis Case, the figures do not include the solar capacity of High Case and capacity reduction associated with Maximum EE case.

Moreover, the following capacity expansion figures do not include committed short-term additions of DEC and DEP. Table 15 includes the summary of total capacity that are committed in the short-term. DEC is scheduled to add 1078.6 MW of capacity, whereas DEP will add 770 MW in the short-term. Moreover, since the committed resources will be same in all the cases analyzed, excluding committed resources from the figure will not affect the analysis since the interest is in the comparison of resource additions in different Cases.

Figure 14 shows the annual capacity changes from D2 Case (High Renewable) for DEC by resource types. The horozintal axis represets capacity amount, whereas vertical axis includes years. Moreover, the right side of the horizontal axis shows the capacity additions and left-side includes all the retirements. And the figure only include years that contained capacity changes. As mentioned before, the figure doesn’t include High Case solar capacity that is included in the D2 portfolio. The figure shows that most of the additions in the DEC region is going to combined cycle units in D2 case. The D2 Case also included 8,764 MW capacity of coal, nuclear, and CT retirements during the 2016 – 2041 period[30].

Similarly, Figure 15 includes annual capacity chnages in DEP region for D2-High Renwable Case. Besides capacity additions, the figure shows that DEP region’s D2

[30] DEC capacity changes included following retirements by resource types: 3,187 MW of coal, 3,192 MW of nuclear, 2383 MW of CT, and 92 MW of CC.

considered significant amount of capacity retirements during the study period. In total, DEP's D2 Case included 8,629 MW of total retirements[31].

The subsequent figures include annual capacity changes of D3-Maximum EE and D7-Green Resource Emphasis Case. These two cases contain varying levels of EE and solar capacity than considered in D2-High Renewable Case. Even though capacity additions differ slightly across alternative cases, the total retirement capacity is same in all the cases during 2016 – 2041 period.

Figure 16 shows the annual capacity changes of D3-Maximum EE case for DEC. And Figure 17 includes the annual capapcity development of same D3 case for DEP. Similarly, annual capacity changes from D7- Green Resource Emphasis Case are included in Figure 18 and Figure 19 for DEC and DEP, respectively.

[31]DEP included 3,593 MW of coal, 2,725 MW of Nuclear, and 2,311 MW of CT retirements.

Figure 14: DEC - Annual Capacity Expansion (MW) of Daymark 2-High Renewable Case

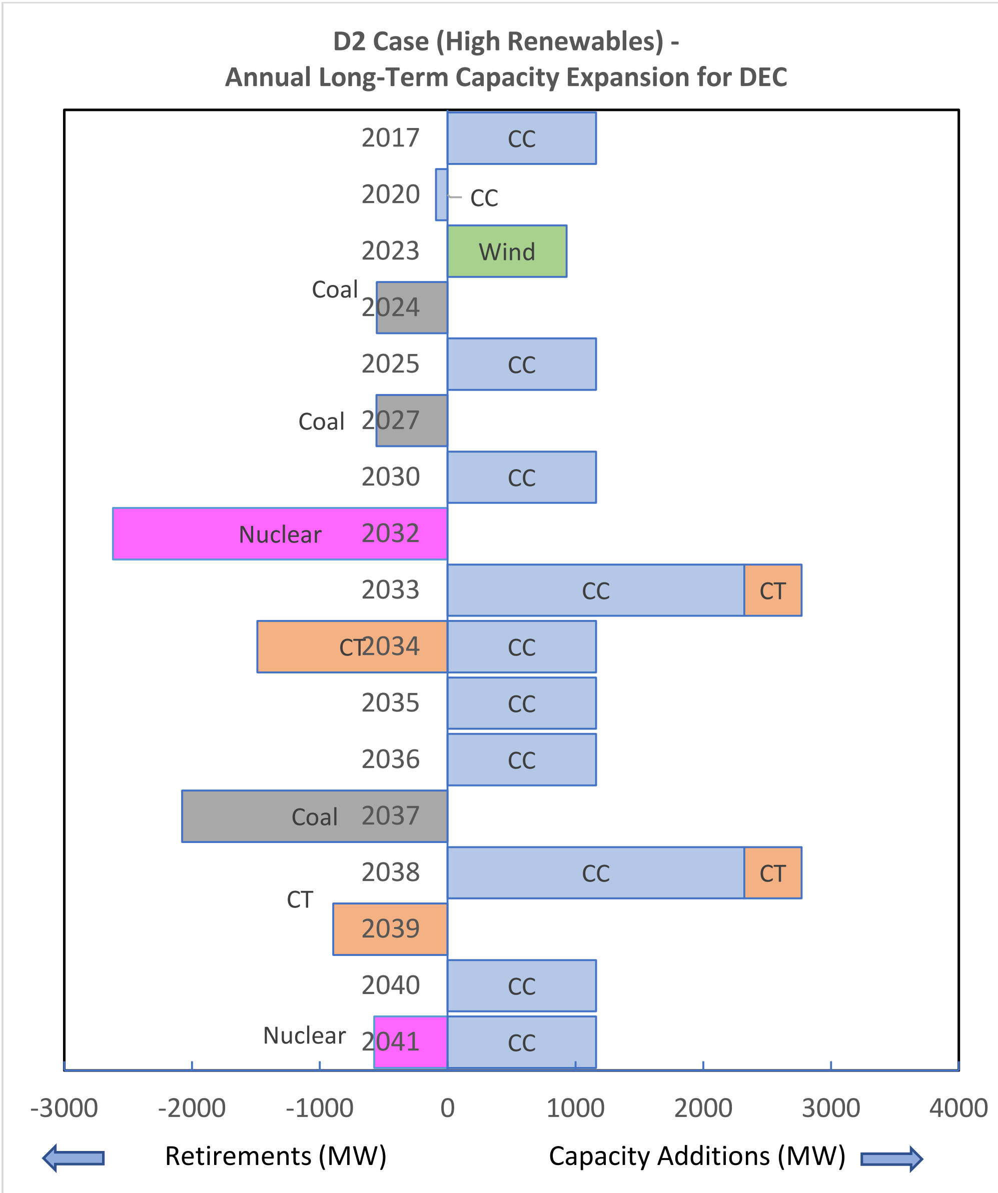


Figure 15: DEP - Annual Capacity Expansion (MW) of Daymark 2-High Renewable Case

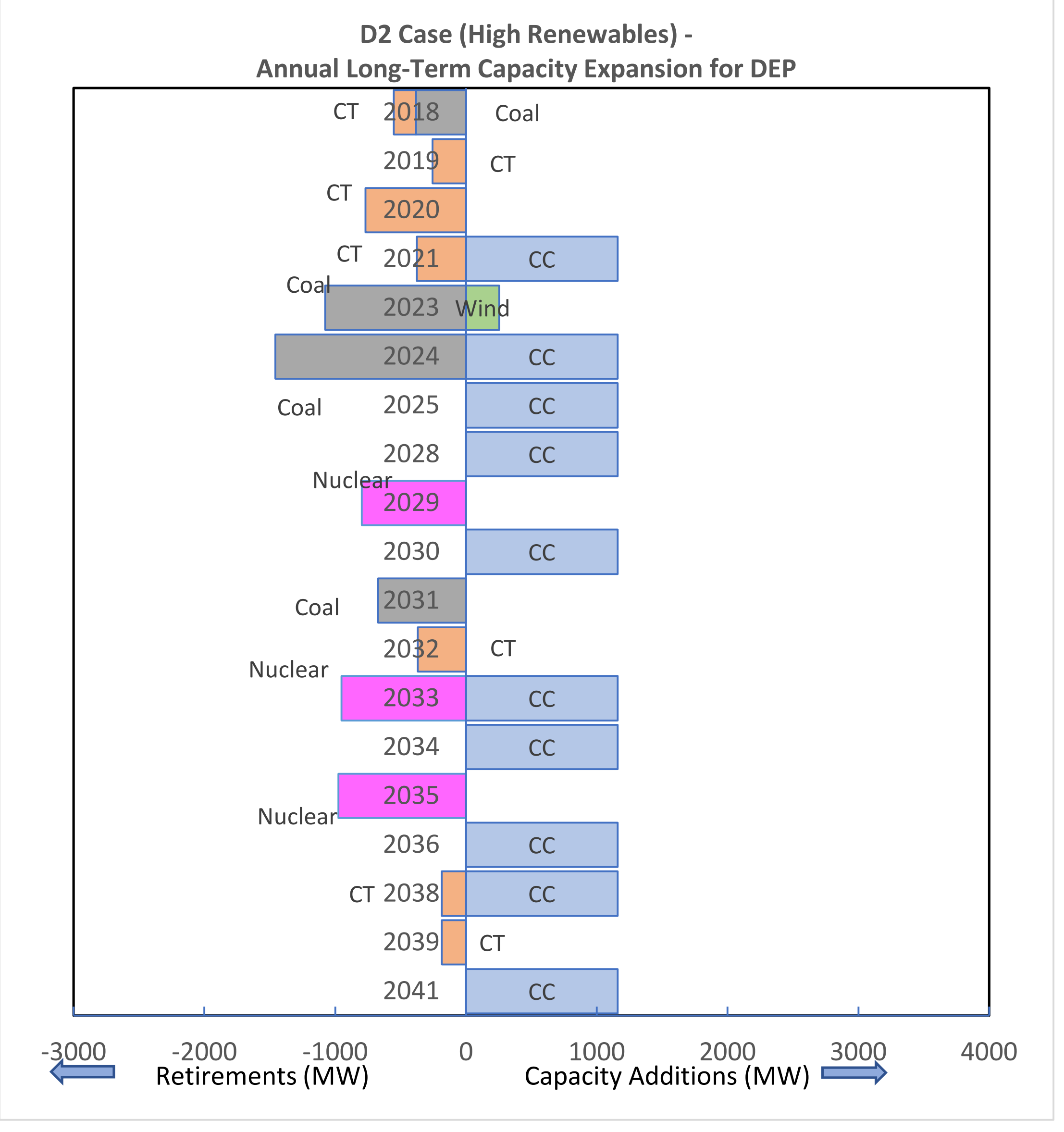


Figure 16: DEC - Annual Capacity Expansion (MW) of Daymark 3-Maximum EE Case

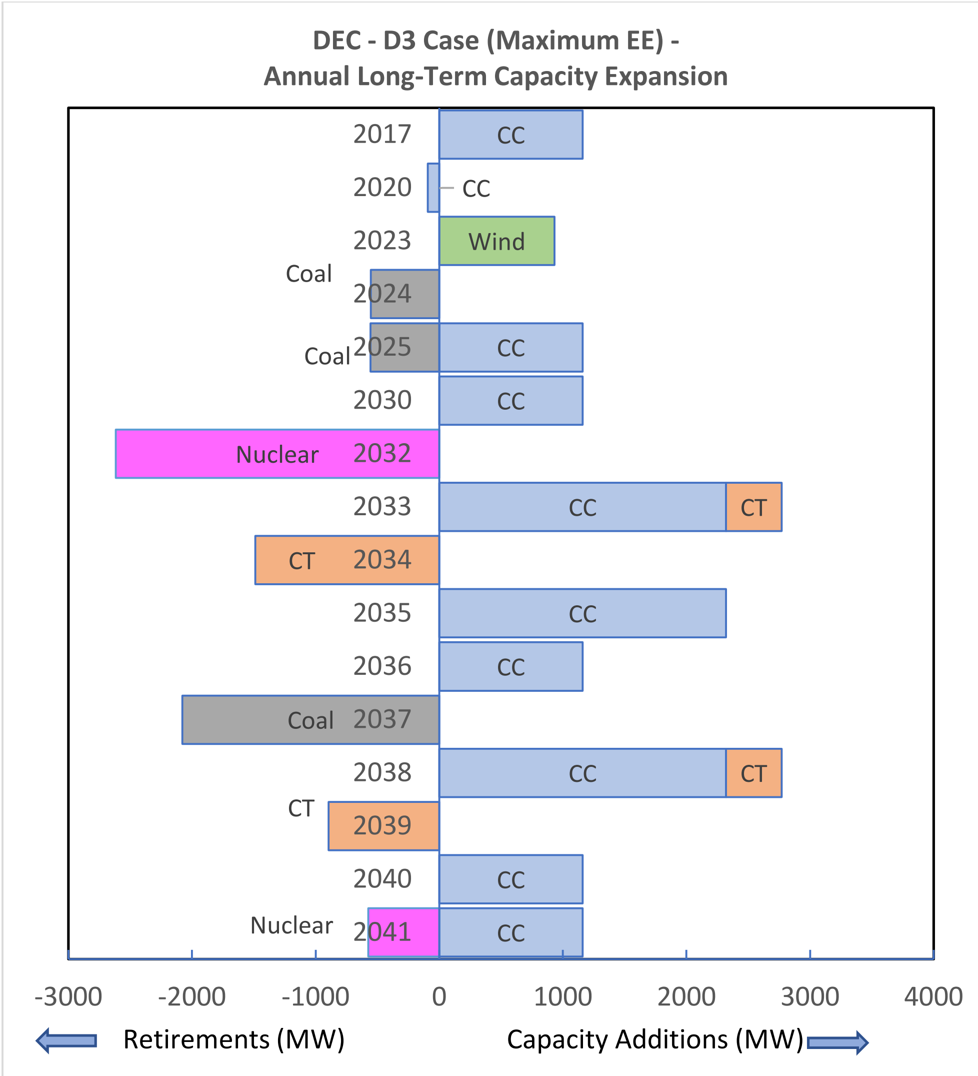


Figure 17: DEP - Annual Capacity Expansion (MW) of Daymark 3-Maximum EE Case

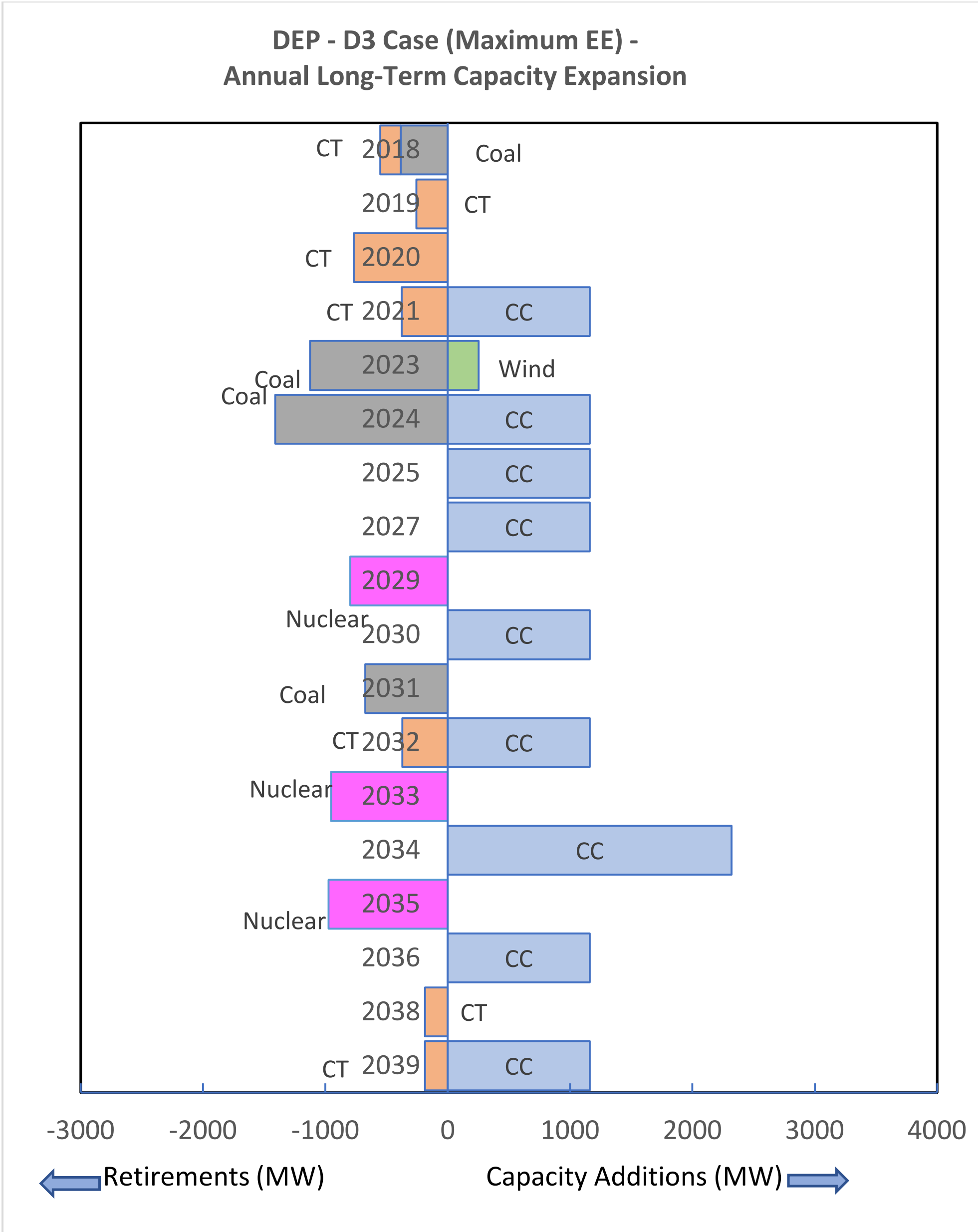


Figure 18: DEC - Annual Capacity Expansion (MW) of Daymark 7-Green Resource Emphasis Case

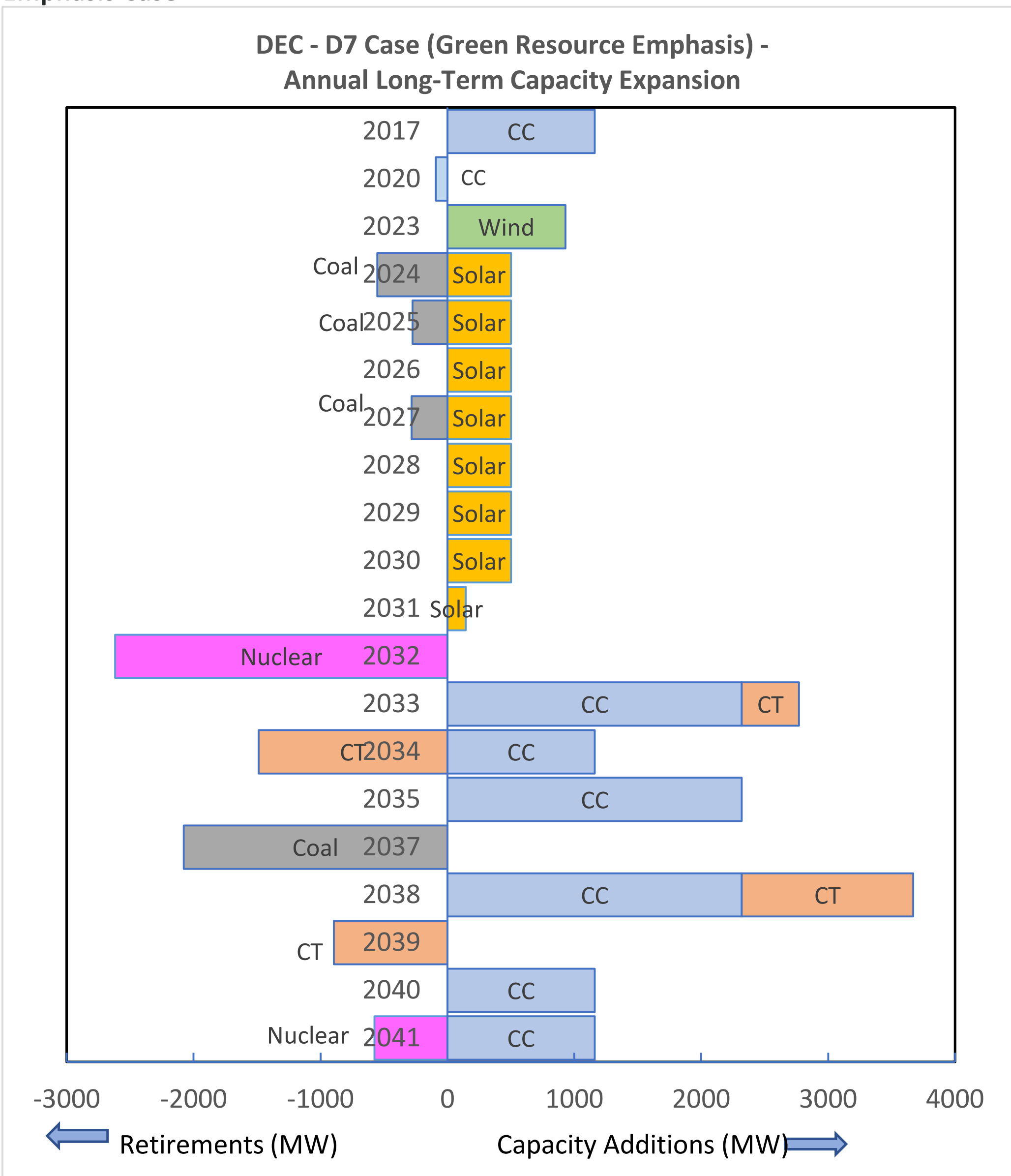
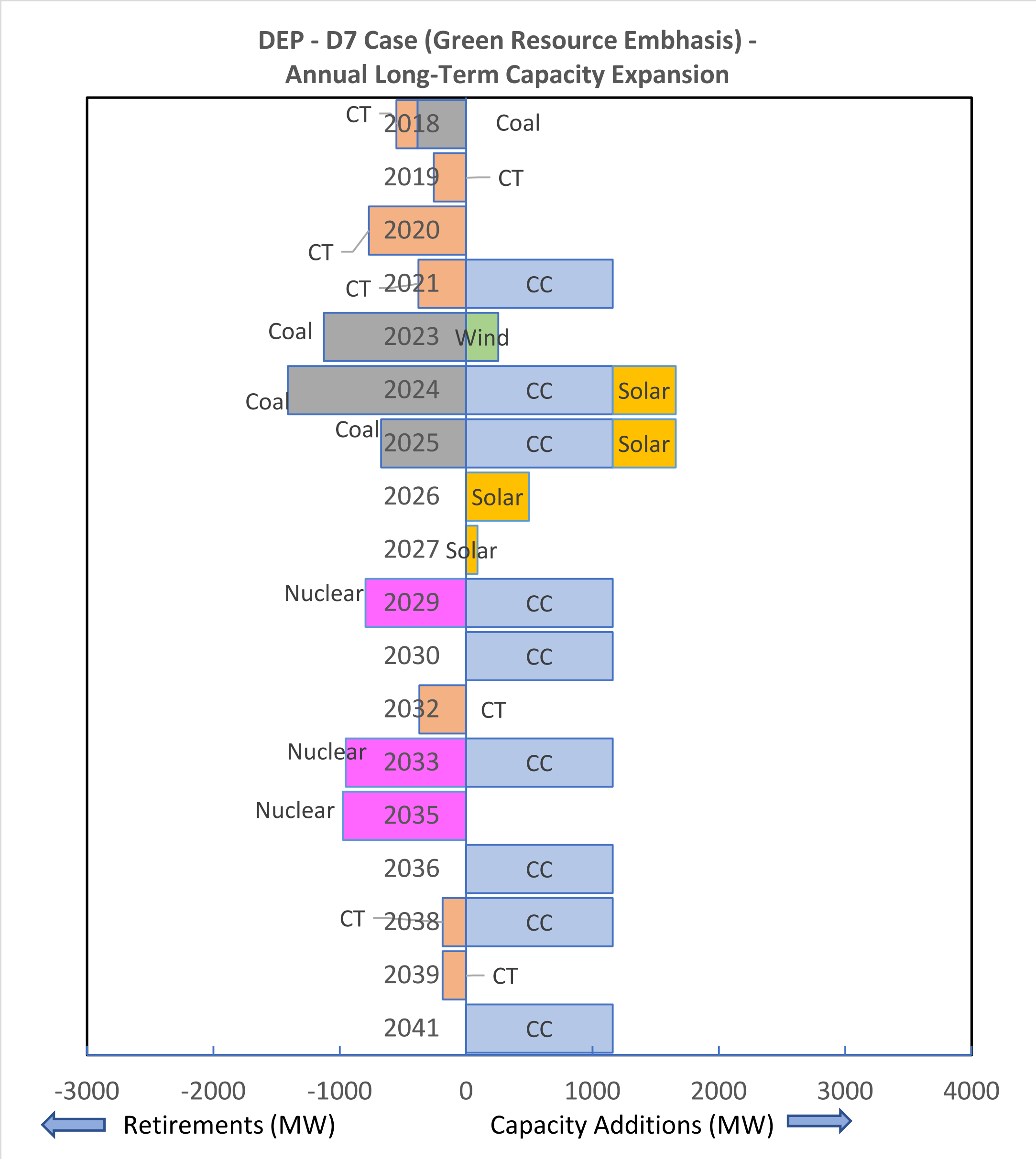


Figure 19: DEP - Annual Capacity Expansion (MW) of Daymark 7-Green Resource Emphasis Case



2. Long Term Capacity Expansions

Figure 20: DEC - Annual Capacity Expansion (MW) of Daymark LTCE1 Case

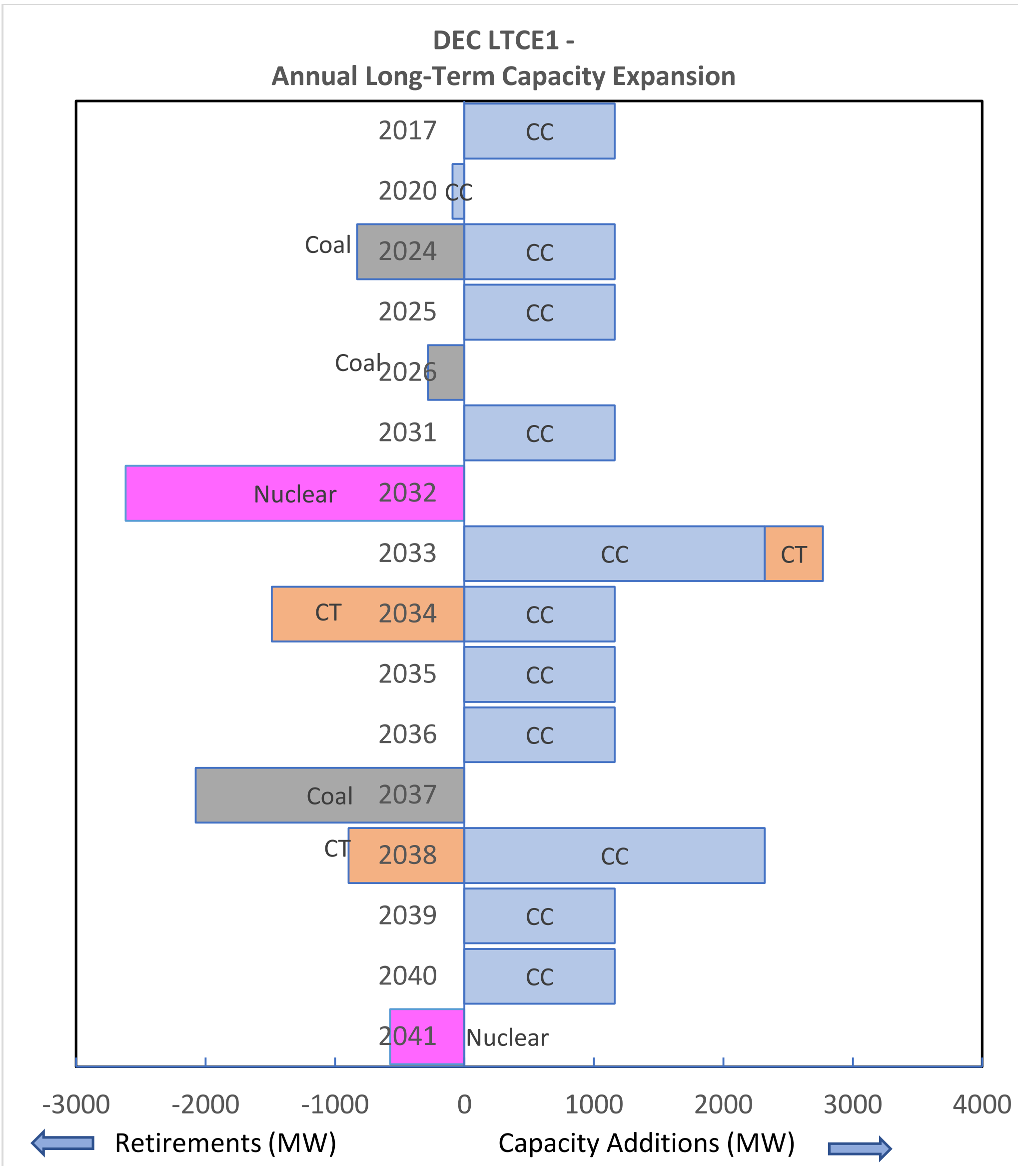


Figure 21: DEP - Annual Capacity Expansion (MW) of Daymark LTCE1 Case

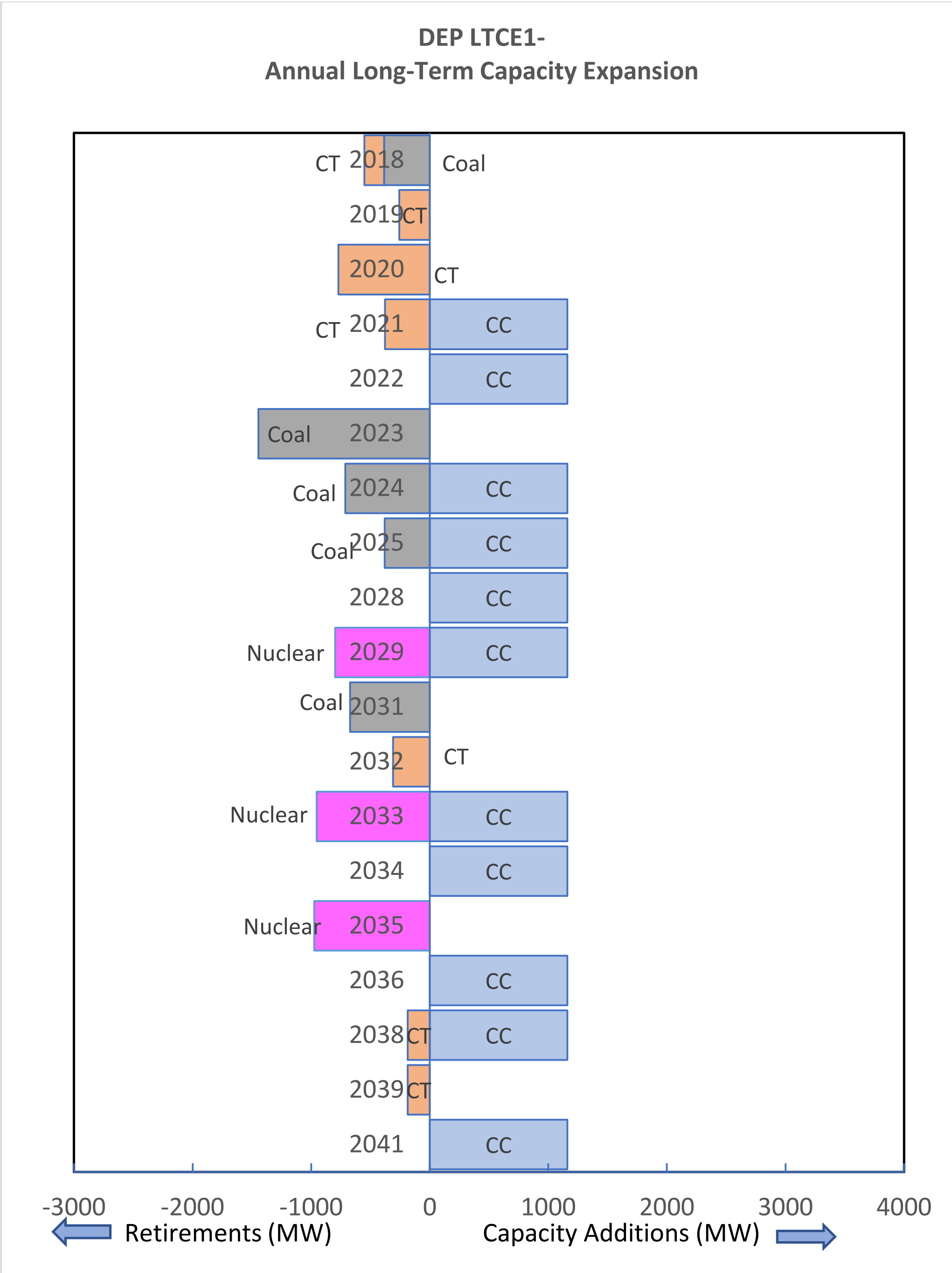


Figure 22: DEC - Annual Capacity Expansion (MW) of Daymark LTCE2 Case

Figure 23: DEP - Annual Capacity Expansion (MW) of Daymark LTCE2 Case

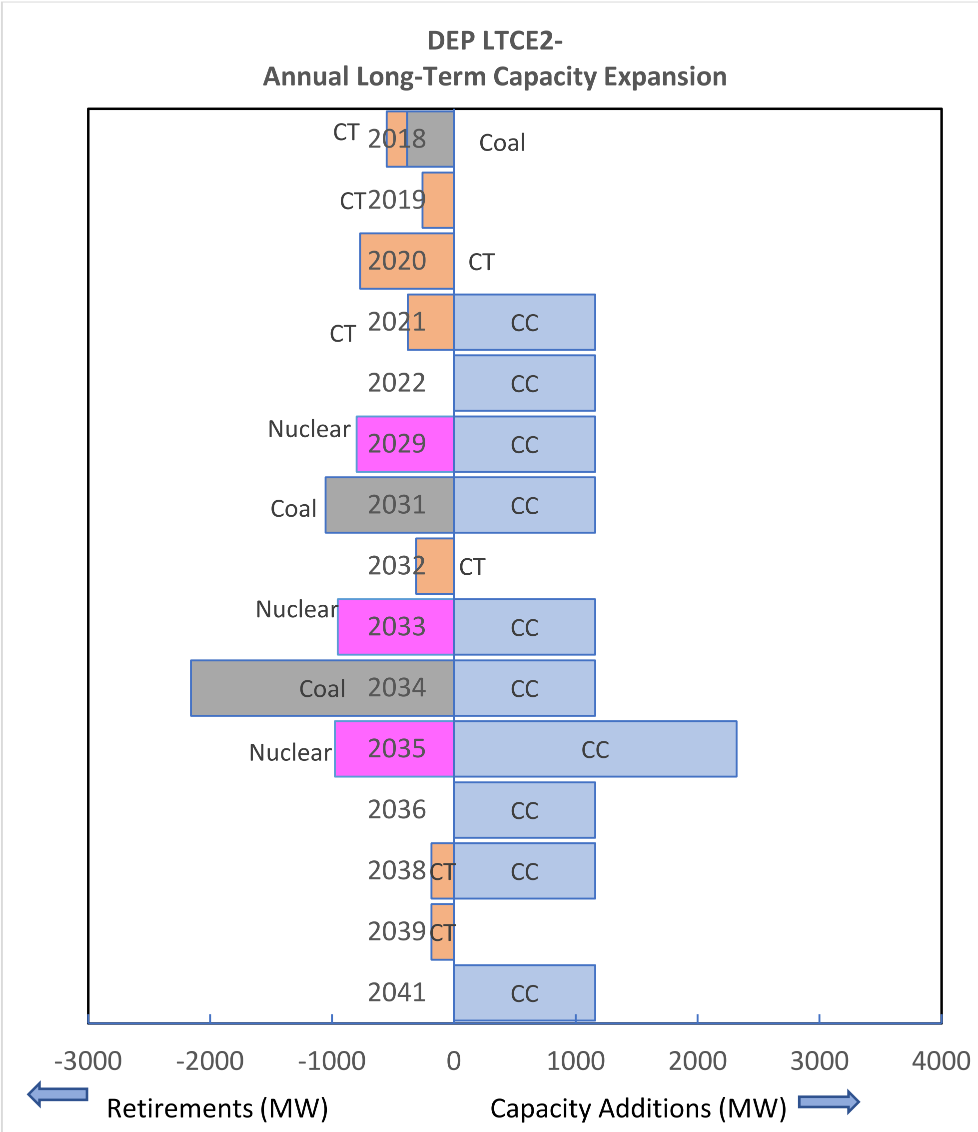


Figure 24: DEC - Annual Capacity Expansion (MW) of Daymark LTCE3 Case

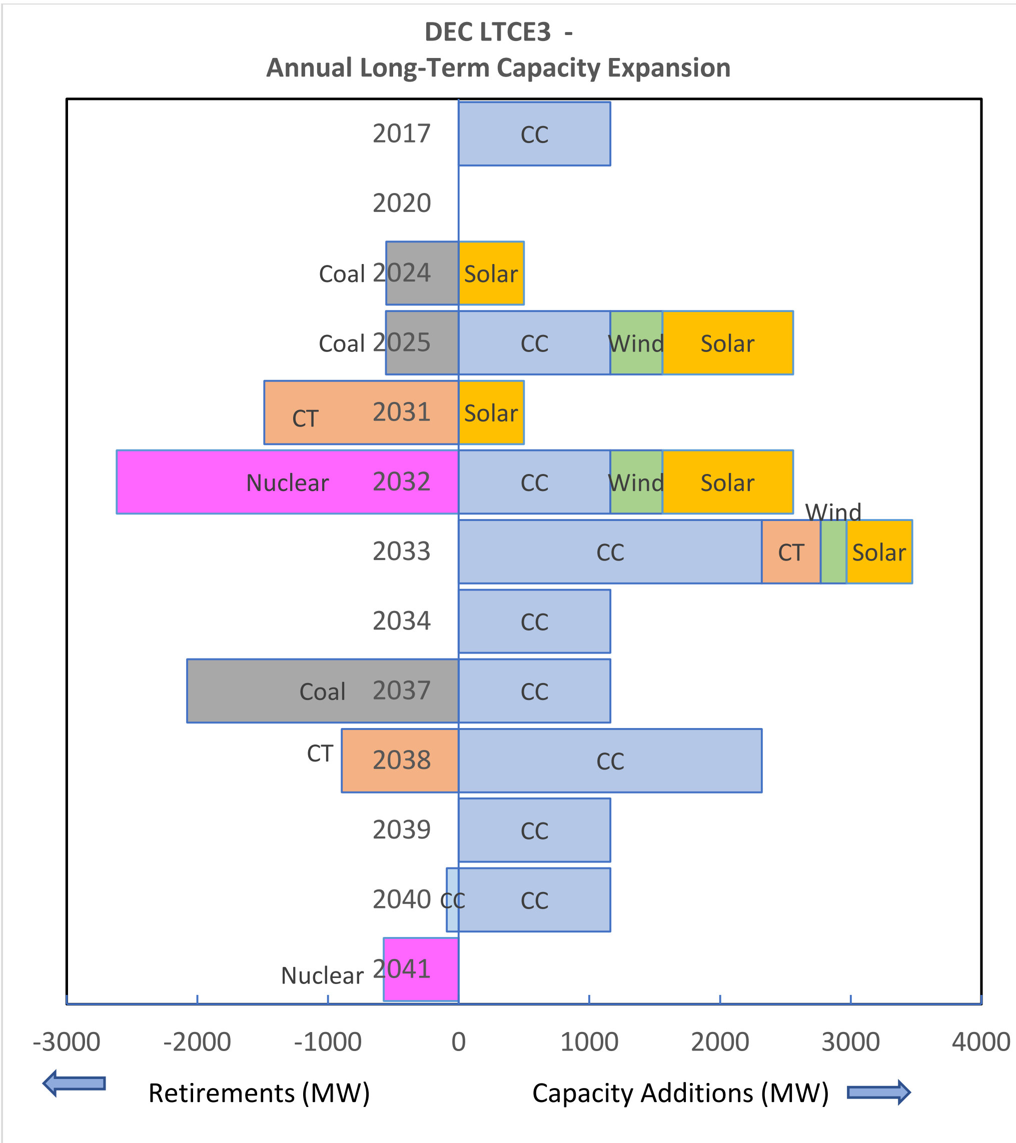


Figure 25: DEP - Annual Capacity Expansion (MW) of Daymark LTCE3 Case

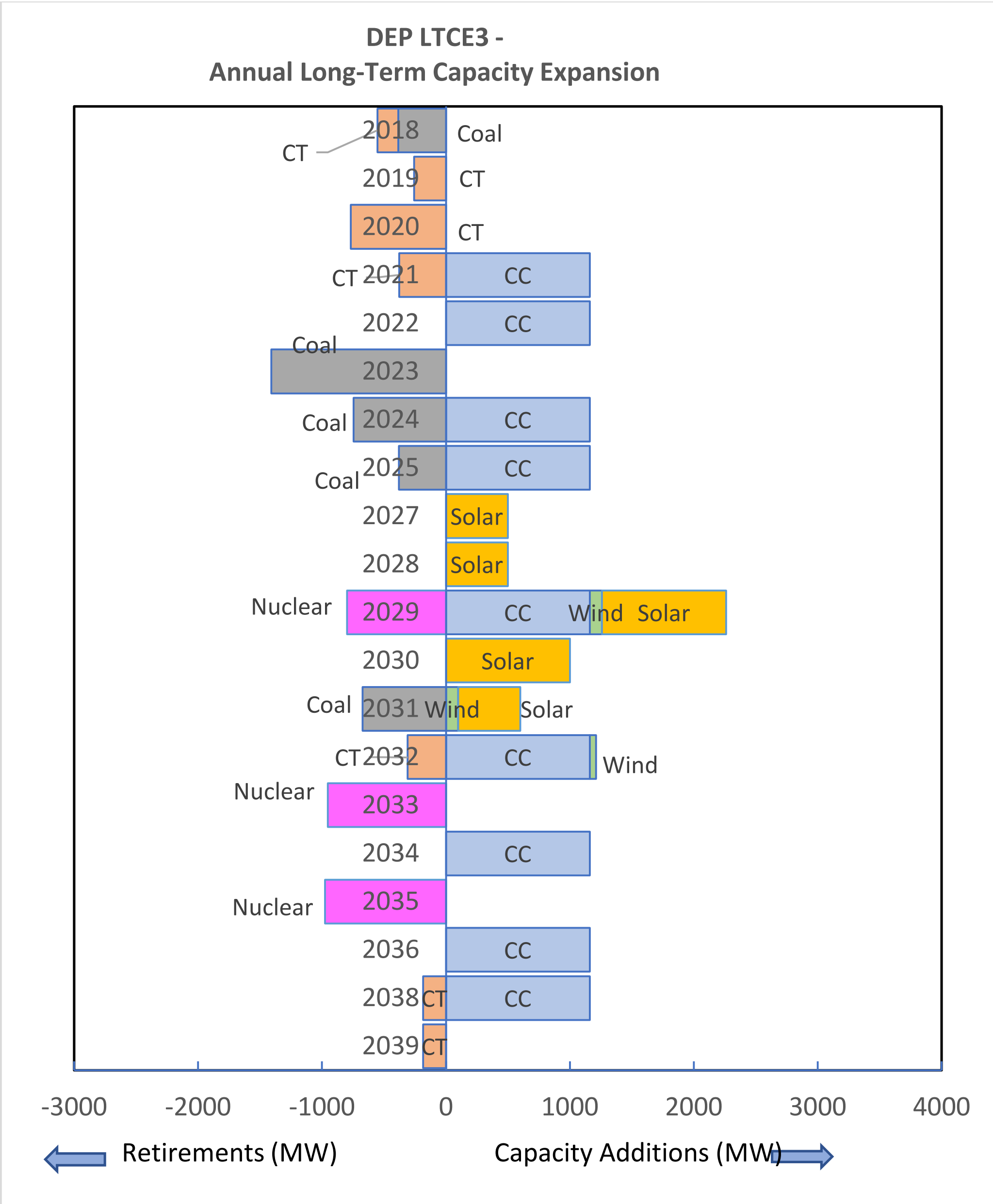


Figure 26: DEC - Annual Capacity Expansion (MW) of Daymark LTCE4 Case

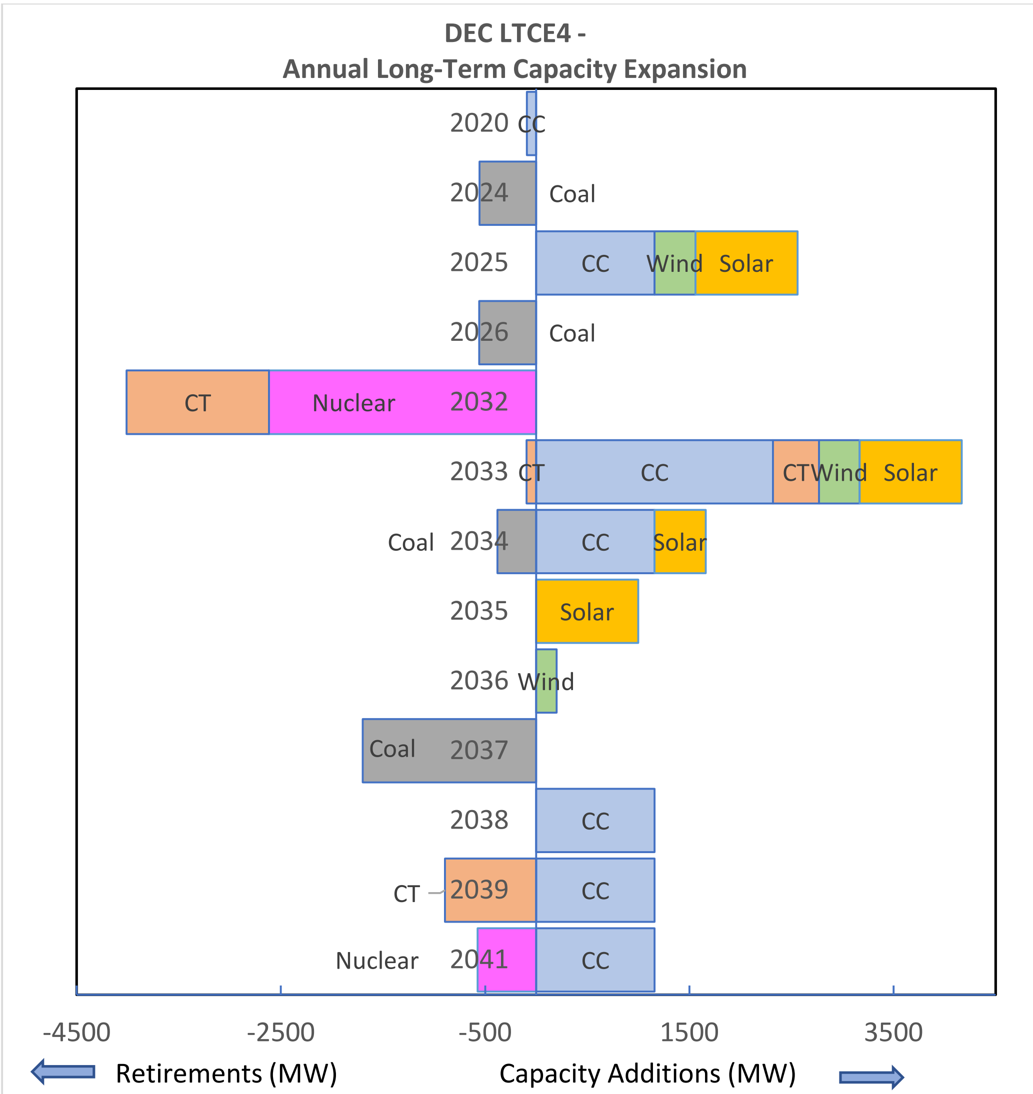
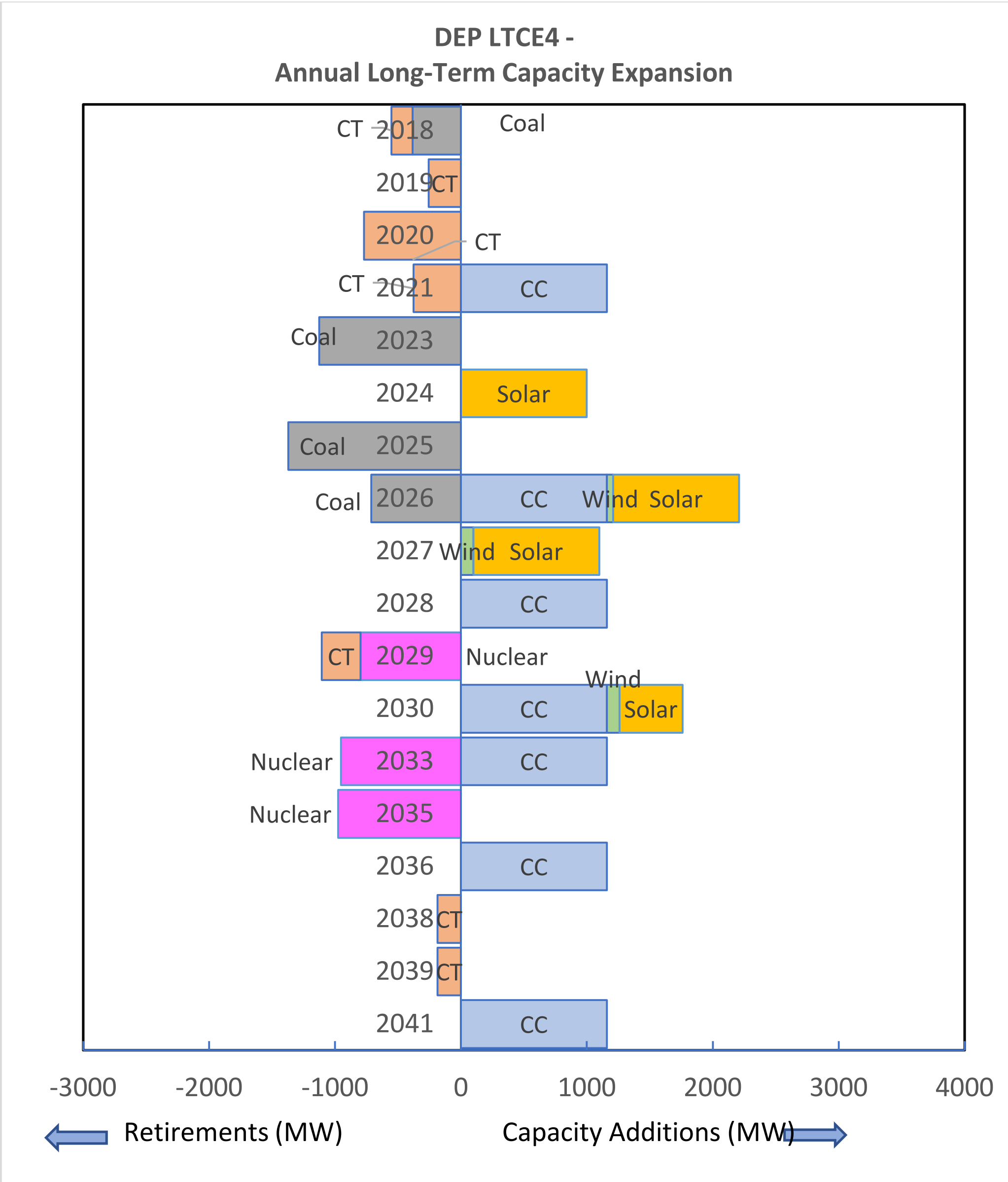


Figure 27: DEP - Annual Capacity Expansion (MW) of Daymark LTCE4 Case



3. Duke's Portfolios considered in IRP

Figure 28: DEC - Annual Capacity Expansion (MW) of Duke Portfolio 1 (Base)

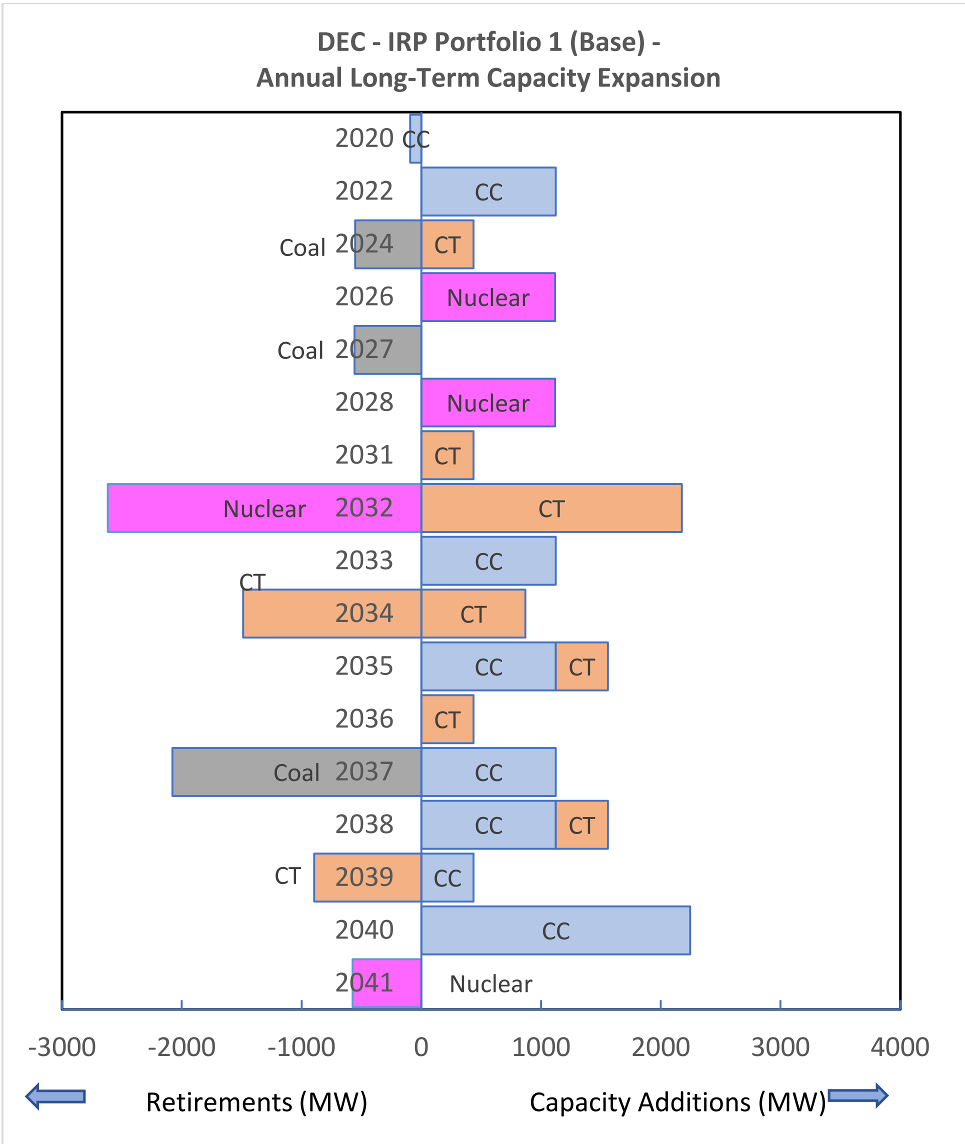


Figure 29: DEP - Annual Capacity Expansion (MW) of Duke Portfolio 1 (Base)

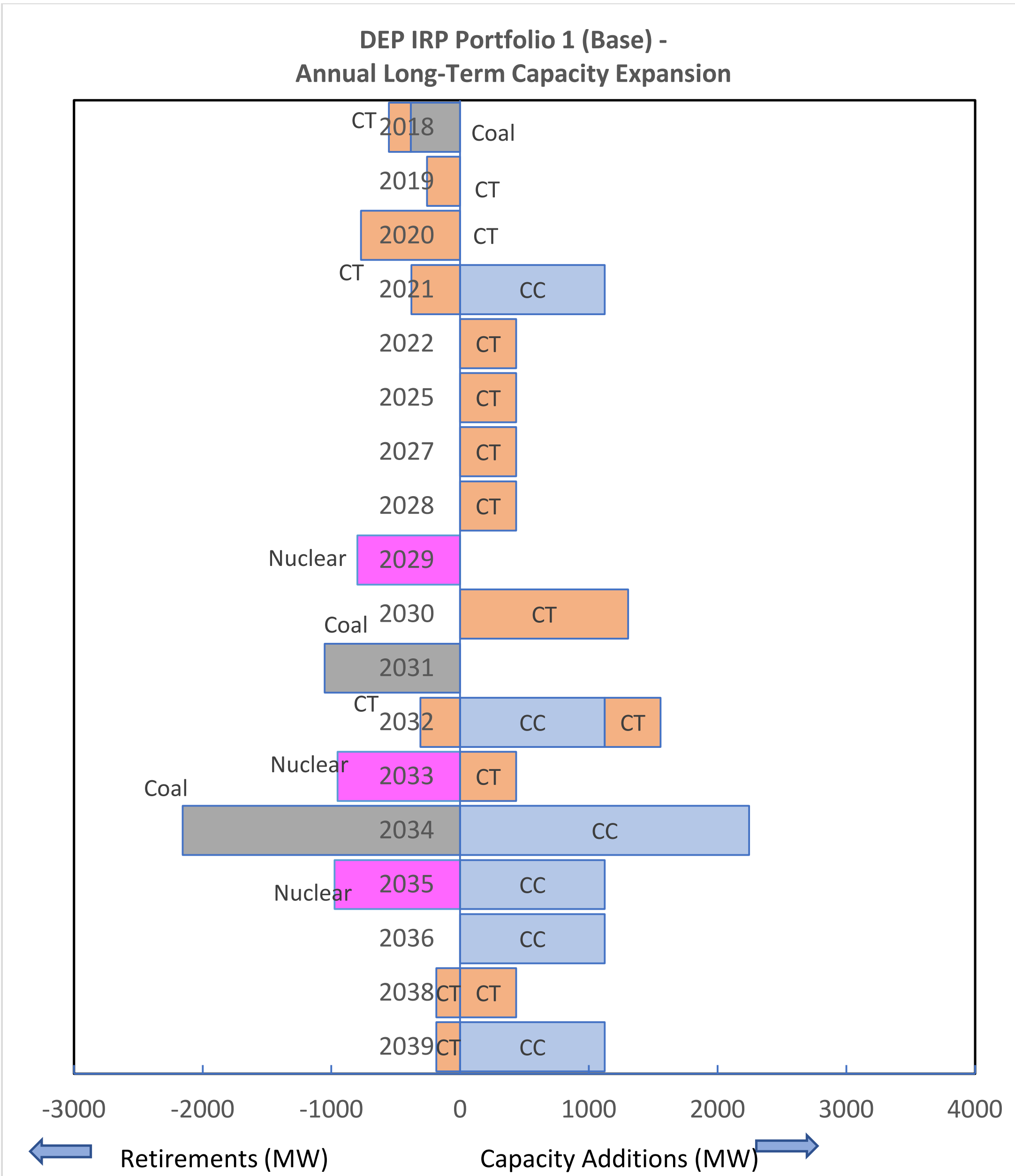


Figure 30: DEC - Annual Capacity Expansion (MW) of Duke Portfolio 2 (High Renew)

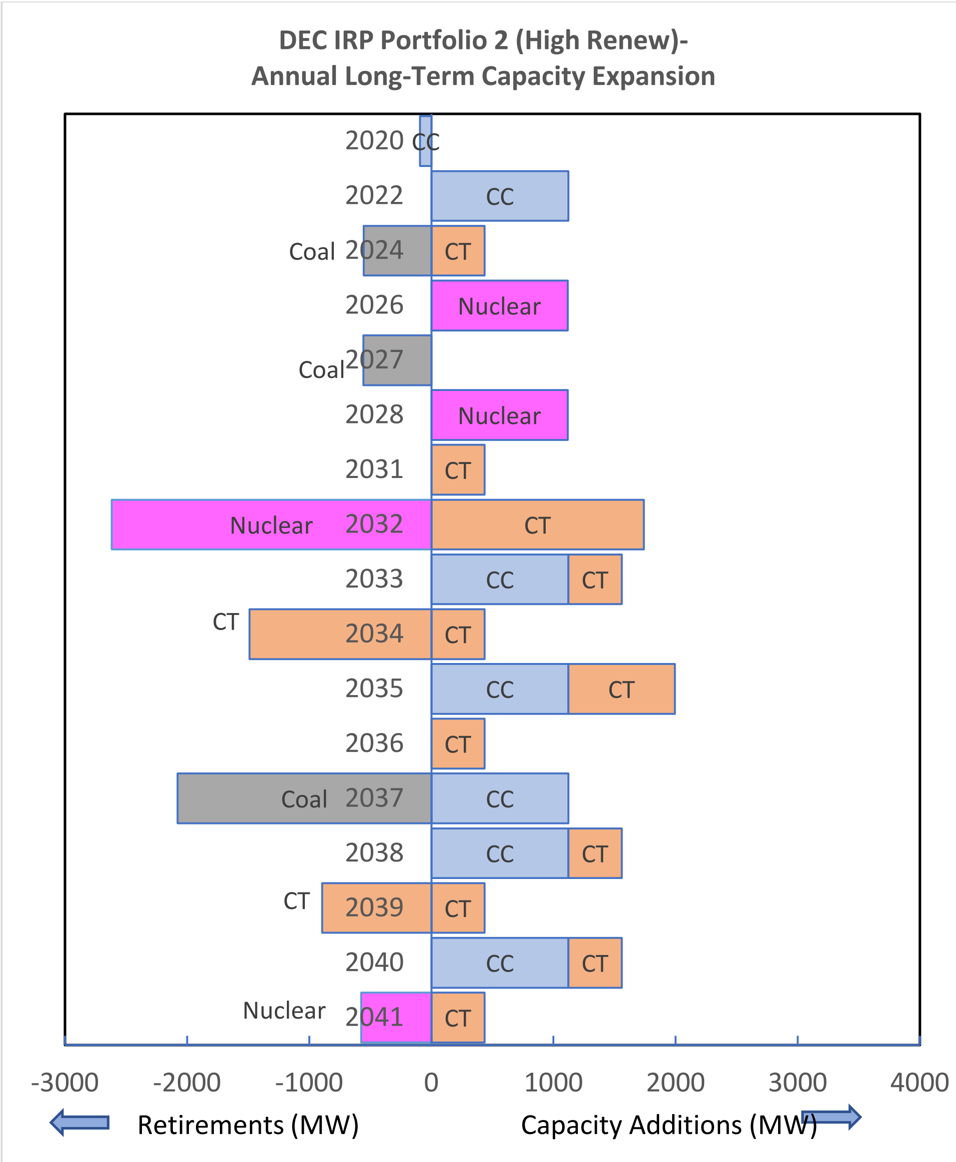


Figure 31: DEP - Annual Capacity Expansion (MW) of Duke Portfolio 2 (High Renew)

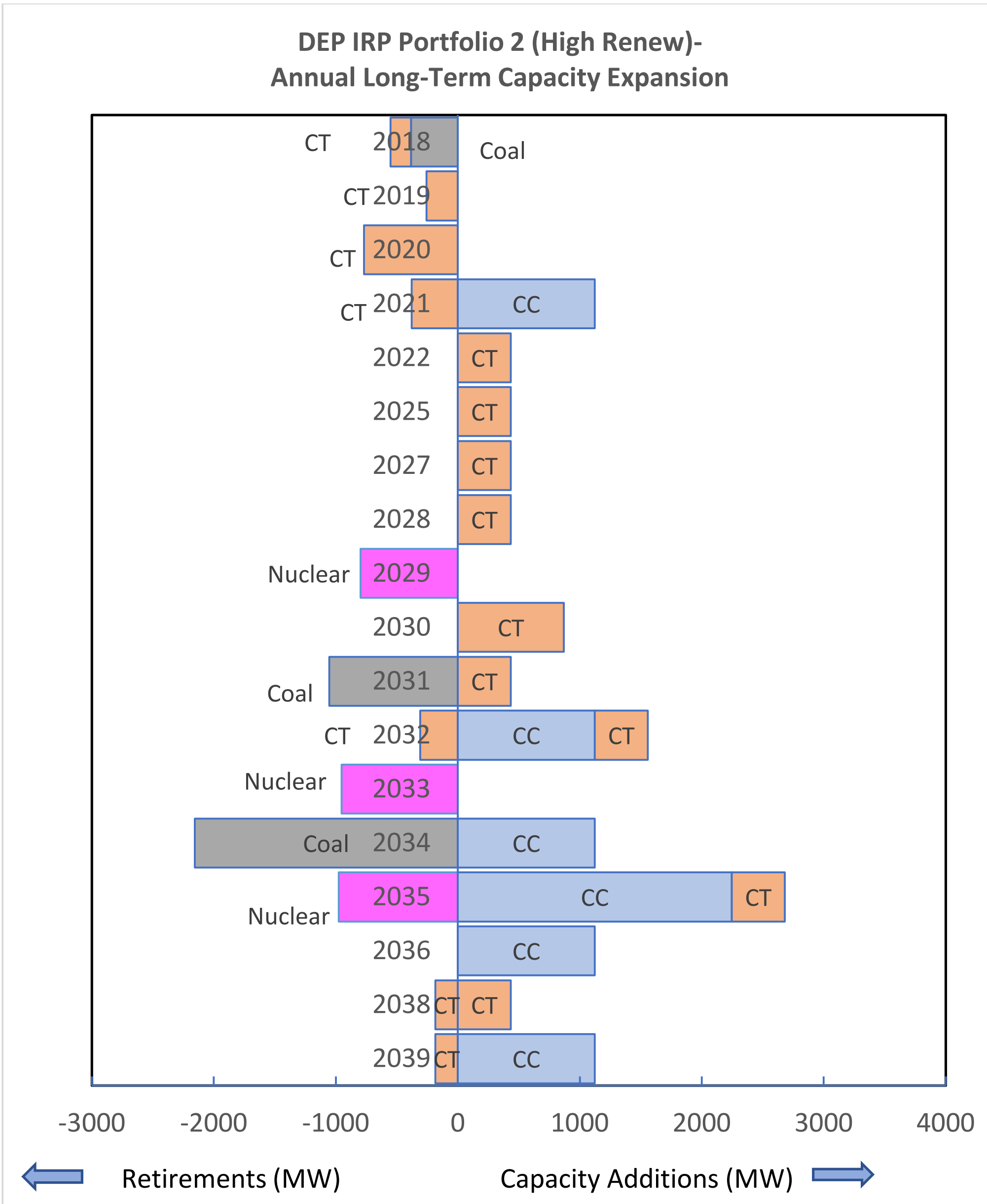


Figure 32: DEC - Annual Capacity Expansion (MW) of Duke Portfolio 3 (High EE)

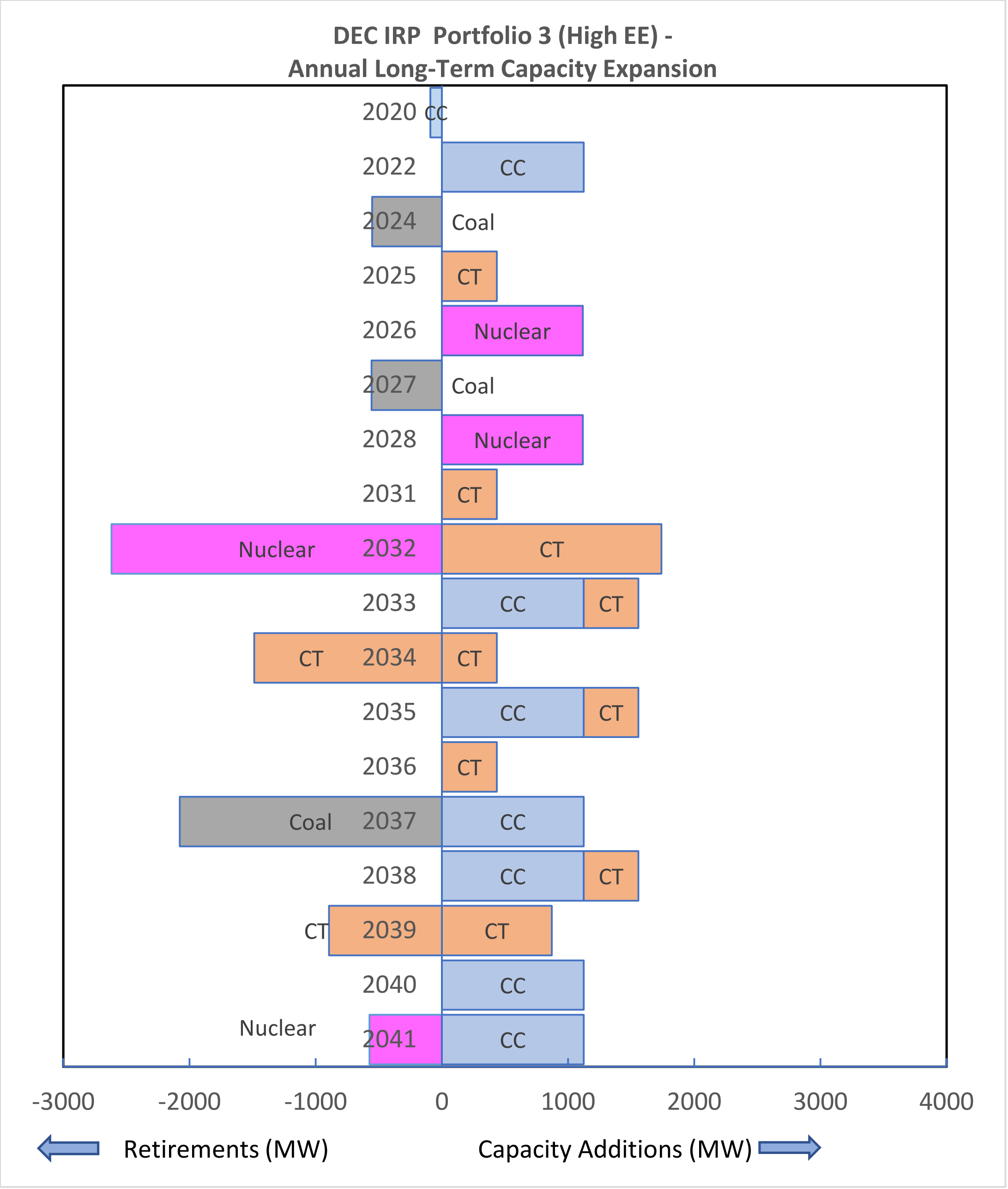
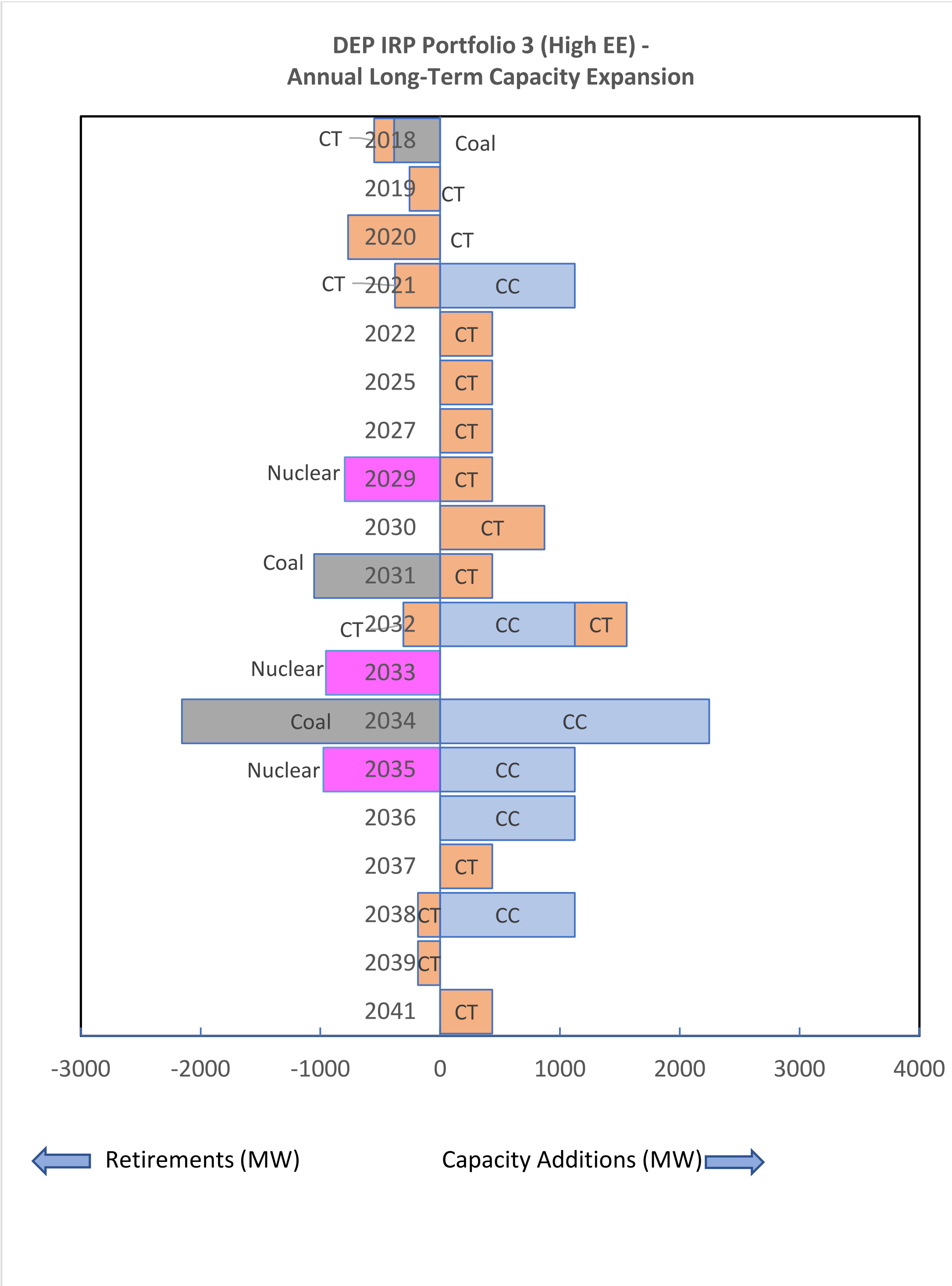


Figure 33: DEP - Annual Capacity Expansion (MW) of Duke Portfolio 3 (High EE)



Appendix D: Energy Efficiency Terms

Energy Efficiency Potential Study Terms

Technical Potential (TP): Represents an ideal scenario which sums all energy efficiency measures that are feasible given technology limitations. The technical potential bears no consideration of technology costs (Eldridge, 2008).

Economic Potential (EP): Represents the fraction of the technical potential that is cost-effective, which can be evaluated in several ways. Some options include the Total Resource Cost (TRC) test or, from the consumer's perspective, such as a participant's cost of saved energy (CSE) (Eldridge, 2008).

Achievable Potential (AP): Represents a fraction of the economic potential that is attainable given actual program infrastructure and both societal and market limitations. Achievable Potential is 60% of Economic Potential in DEC and DEP Potential study (Eldridge, 2008).

High Achievable Potential (HAP): Represents achievable potential along with additional savings by accounting barriers that limit customer participation. The standard way of estimating HAP us by applying market acceptance ratios to the economic potential savings from each measure. However, DEC's HAP is 1.5 times achievable potential (EPRI, 2014).

The following two terms are not standard in the EE potential study. Daymark is defining them to represent the possibility of additional savings from EE programs.

Strategic Potential (SP): Additional EE potential that are cheaper than traditional supply side resources.

Strategic Achievable Potential (SAP): Represents the fraction of strategic potential that is attainable given the cost

Sources:

State-Level Energy Efficiency Analysis: Goals, Methods, and Lessons Learned. *2008 ACEEE Summer Study on Energy Efficiency in Buildings.* Link

U.S. Energy Efficiency Potential Through 2035. EPRI, Palo Alto, CA: 2014. 1025477