Analysis of the Dynegy-Vistra Coal Fleet Future Viability in MISO Zone 4 (Southern Illinois)

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and other Stakeholders

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Contents

I. Background

In this study, Vibrant Clean Energy, LLC (VCE) analyzes alternative least-cost energy and capacity resource pathways to the continued operation of the Dynegy-Vistra coal power fleet in Southern Illinois, also known as "Zone 4" of the Midcontinent Independent System Operator (MISO)'s planning zones[1]. The study's primary purpose is to determine if Dynegy-Vistra's coal plants are necessary for resource adequacy ***and*** if subsidies Dynegy-Vistra has proposed for the plants are cost-effective. To this end, the analysis evaluates the state of resource adequacy in Zone 4 and the surrounding region, the ability of the grid to deliver electricity every hour as needed, and the cost of electricity under each alternative pathway to keeping the Dynegy-Vistra coal plants in operation.

The current study considers the eight (8) coal plants Dynegy-Vistra owns in Southern Illinois, and which Dynegy-Vistra asserts require subsidies to continue operating.[2] Dynegy-Vistra claims that the retirement of most or all of their plants in the near term would result in resource adequacy issues for Zone 4 and higher electricity prices for Illinoisans. Our analysis refutes Dynegy-Vistra's claims, and demonstrates that all 8 coal plants can be *reliably* replaced with cheaper and more efficient resources, while delivering large economic benefits to Illinoisans.

VCE uses the WIS:dom optimization model, a blended capacity expansion and production cost model that determines the most cost-effective resource mix and transmission investments to reliably meet electricity demand. The model has been customized for this study. The WIS:dom optimization model is also utilized by MISO in multiple studies that investigate various aspects of the evolution of its electricity grid over the coming decades to incorporate more utility-scale and distributed renewable generation. The WIS:dom model is described in more detail in Appendix B and Appendix C.

[1] Dynegy-Vistra is the largest power producer in Central and Southern Illinois. https://www.Dynegy-Vistra.com/locations
[2] Dynegy-Vistra recently introduced Senate Bill 2250 (House Bill 4141) that, if passed, would effectively provide subsidies for the 8 Dynegy-Vistra coal plants in Central and Southern Illinois. The bills are available at http://www.ilga.gov/legislation/BillStatus.asp?DocNum=2250&GAID=14&DocTypeID=SB&LegId=108155&SessionID=91&GA=100

II. Scenarios Evaluated

The Natural Resources Defense Council, Sierra Club, and VCE identified two (2) main scenarios to analyze over a 13-year period from 2017 to 2030. In both scenarios, the model compared the all-in costs of various energy resource options in Illinois including capital investments, operation and maintenance costs, and financing - over the next 13 years and made decisions to retire and invest in new resources based on their cost-effectiveness to serve electricity demand and reliability needs. In other words, the model solves for the cheapest generation mix in Illinois that reliably meets electricity demand.

The 8 Dynegy-Vistra coal plants analyzed are: *Baldwin Energy Station, Coffeen Power Station, Duck Creek Station, E. D. Edwards Generation Plant, Havana Power Station, Hennepin Power Station, Joppa Steam Plant, and Newton Power Station*. Together they have a nameplate capacity of 5,862 MW.

The main variants in the two modeled scenarios are the capital and operating cost assumptions for the Dynegy-Vistra plants. The scenarios were selected in this fashion to hone in on the impact of any Dynegy-Vistra plant closures on the electricity prices in Illinois, in addition to evaluating the plants' value to Zone 4 resource adequacy and reliability. And given that this cost data is in large part proprietary (particularly the capital costs), VCE designed the scenarios to reflect the capital and operating costs of the 8 Dynegy-Vistra coal plants in the most accurate and conservative manner possible.

The two main scenarios evaluated are:

1. **"Scenario 1": Regionally aligned fixed costs, low variable costs.** This scenario assumes fixed costs for the Dynegy-Vistra coal plants that are aligned with those incurred by the rest of the coal fleet in the Midwest region. Coupled with the regionally aligned fixed costs, the scenario assumes variable costs for the Dynegy-Vistra coal plants that are lower than what the rest of the coal fleet in the Midwest typically pays. The scenario also reflects the 2018 Illinois Power Agency's (IPA) Long-Term Renewable Resources Procurement Plan (LTRRPP) expected to drive the build out or purchase of

approximately 360 MW and 560 MW of new wind and solar, respectively, every year through 2030[3,4].

2. **"Scenario 2": Low fixed costs, regionally aligned variable costs.** This scenario assumes low fixed costs for the Dynegy-Vistra coal plants compared to those incurred by the rest of the coal fleet in the Midwest region. Coupled with the low fixed costs, the scenario assumes variable costs for the Dynegy-Vistra coal plants that are aligned with those typically paid by the rest of the coal fleet in the Midwest region. This scenario also reflects the 2018 IPA LTRRPP, and all other inputs and assumptions are identical to Scenario 1.

We paired the costs as described above (a more accurate figure and a low figure) to ensure that the cost assumptions for the Dynegy-Vistra fleet were conservative. Both scenarios combined regionally aligned costs (fixed costs for Scenario 1 and variable costs for Scenario 2) with lower cost estimates based on publicly available S&P Global Market Intelligence data. It is worth noting that if regionally aligned fixed and variable costs were used, the Dynegy-Vistra coal plants would be even more expensive than what the two scenarios show, and the economic competitiveness of the coal plants relative to other resources therefore would drop further.

In Scenario 1, the regionally aligned fixed costs capture the escalating retrofit costs that the Dynegy-Vistra coal fleet, 53 years old on average, is expected to incur moving forward to keep operating. These assumed fixed costs for the Dynegy-Vistra plants are in line with our region-wide coal fleet assumptions. In Scenario 2, the regionally aligned variable costs capture more accurately the fuel costs likely paid by the Dynegy-Vistra plants based on the average coal price paid by other Illinois coal-burning power plants. The regionally aligned

[3] It is important to note that when this analysis was conducted, the Illinois Commerce Commission (ICC) had not yet approved the Illinois Power Agency's (IPA) filed 2018 Long-Term Renewable Resources Procurement Plan (LTRRPP). The model uses input from the IPA's LTRRPP filed for ICC approval on December 4, 2017. The ICC not only approved the plan but also expanded it beyond what the IPA had proposed by doubling the size of the First Subsequent Forward Procurement event and the Photovoltaic Forward Procurement event from 1 million new annual RECs each to 2 million new annual RECs. The expansion will drive the buildout of even more renewables by 2022 than the analysis shows, particularly the solar buildout.

[4] Illinois Power Agency, "Long-Term Renewable Resources Procurement Plan," Section 5.10, page 97, https://www2.illinois.gov/sites/ipa/Pages/Renewable_Resources.aspx. The plan talks about an ongoing expectation to conduct a 15-year contract procurement for new builds that adds 1 million new annual RECs of wind and 1 million new annual RECs of solar each year through 2030. Using the current average capacity factors for wind and solar projects in Illinois of 32 percent and 20 percent, respectively, these RECs requirements translate to approximately 360 MW and 560 MW of new wind and solar each year. Note that the expected advancements in wind and solar technology (higher hub heights and larger rotor diameters for wind, tracking panels for solar) are projected to improve the performance, and thus capacity factors, of wind and solar projects. Thus, our analysis likely overestimates the build numbers, as our build assumptions rely on lower capacity factors, and therefore overestimates the cost of complying with the IPA plan and replacing the Dynegy-Vistra plants with clean energy.

costs used in both scenarios (fixed costs in Scenario 1, variable costs in Scenario 2) reflect more accurately the capital and operating costs respectively likely incurred by the Dynegy-Vistra coal power plants in Southern Illinois[5].

In addition, a constant heat rate for the Dynegy-Vistra plants was assumed throughout the study period, when in reality the heat rate should be assumed to increase as plants age and become increasingly inefficient. Thus, the modeling is likely generous to the Dynegy-Vistra plants with respect to their capital and operating costs.

All sources for the assumptions, costs, and methodology are included in Appendix B and Appendix C.

III. Study Findings

1. Summary of Findings

a. The retirement of the Dynegy-Vistra coal plants does not adversely affect resource adequacy

In both scenarios, all of the Dynegy-Vistra coal plants retire by 2025 because they are too costly compared with other resources. By 2030 all coal plants (non-Dynegy-Vistra plants) in Zone 4 retire (there are nearly 3,000 MW of coal plants in Zone 4 owned by municipal utilities, cooperatives and other entities). Importantly, **the retirement of the Dynegy-Vistra coal plants does not adversely affect Zone 4 resource adequacy or electricity supply.** In Scenario 1, all 8 Dynegy-Vistra coal plants are retired by the model by 2020, while in Scenario 2, 6 of the 8 Dynegy-Vistra coal plants are retired by 2020, and the other two (Joppa and Newton) are retired by 2025.

Despite these retirements, MISO Zone 4 maintains excess generating capacity in both scenarios through 2030, owing to the replacement of the coal capacity with cheaper resources such as wind, solar, gas, and storage (capacity changes are discussed below). In addition, electricity demand growth in Illinois is projected to remain largely flat through at least 2035 thanks in part to the impressive energy efficiency provisions mandated by the

[5] The cost assumptions for the Dynegy-Vistra plants are discussed in more detail in Appendix C.2

Future Energy Jobs Act (FEJA)[6]. The flat growth, along with the state's abundant transmission infrastructure, enhances Illinois' ability to remain a net exporter of power and keeps reliably meeting demand.

It is also worth noting that in addition to being unnecessary to maintain Zone 4 resource adequacy, the retirement of the Dynegy-Vistra coal plants in the near-term does not hurt resource adequacy or reliability elsewhere (specifically in MISO and PJM)[7].

b. The retirement of the Dynegy-Vistra coal plants will save Illinoisans money

In addition, Illinois' transition from coal to a cleaner resource mix lowers electricity prices in both scenarios. In fact, Illinoisans would be expected to pay 2 to 4 percent less for electricity by 2030 compared to 2017. This is due to the fact that the Dynegy-Vistra coal plants are uneconomic compared to other resources, as the model retires them by 2025 in both scenarios.[8] Thus, replacing them with newer, more efficient, and cheaper generation reduces electricity production costs and delivers power to customers at lower prices. In fact, the coal plants are replaced with wind and solar resources that have very low operating costs (wind and solar projects do not burn any fuel, which makes up the bulk of the operating expenses for coal and gas plants). This results in electricity production cost savings that outweigh the initial construction (capital) cost of the renewable capacity and translate into lower electricity prices for Illinoisans over time.

The sections below discuss in further detail how the replacement of the Dynegy-Vistra coal plants with cleaner and cheaper resources maintains Zone 4 resource adequacy and lowers electricity prices for Illinoisans while dramatically cutting emissions of harmful pollutants.

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[6] As described in more detail in Appendix C.1, the analysis relies on 2016—2036 load forecasts computed by Illinois' 3 investor-owned utilities and submitted to the IPA for the purposes of conducting the 2018 Renewable Energy Procurement. The forecasts are available here.

[7] The WIS:dom model examines changes in the resource mix and reliability attributes across the entire Eastern Interconnection in addition to casting a closer lens on Illinois.

[8] The retirements were not hardwired in- the model made economic decisions to retire power plants.

2. The Dynegy-Vistra Coal Plants can be Reliably Replaced with Cost-Effective Clean and Flexible Generation

a. Capacity Mix Results

In both scenarios, the model retires all 8 Dynegy-Vistra coal plants by 2025 without any impact on Zone 4 resource adequacy or reliability and keeps electricity prices in line with those in 2017 (costs are discussed in detail in subsection 3 below)[9]. Notably, the analysis assumes that the six Dynegy-Vistra plants currently selling capacity in the PJM capacity market keep doing so and thus have an additional revenue stream[10]. Despite the additional profits from the PJM market, the model still finds the six Dynegy-Vistra plants too costly to run compared to other resources and retires them by 2025 in both scenarios. In addition, Illinois remains a net exporter of power throughout the study period, despite the retirement of the Dynegy-Vistra plants, due to the additions of renewable capacity and the projected flat electricity demand growth. The expected wind and solar procurement needed to comply with the recent IPA renewable energy procurement plan, the flat electricity demand growth and the modest increase in gas generation are sufficient to reliably replace all of the output from the Dynegy-Vistra coal plants. It is worth noting that although our analysis assumed that the renewable procurement schedule laid out in the IPA LTRRPP will drive *in-state* wind and solar buildout, it is more likely that only a portion of the procurement will be supplied by in-state capacity (the larger portion, as the plan heavily favors in-state renewable buildout), while the rest will be met through renewable power purchase agreements (PPAs) from neighboring states. And considering the record-cheap wind PPA prices in Illinois' neighboring westward states and the rapidly decreasing solar PPA prices countrywide, the costs to meet the IPA plan would likely be lower than what we model, and thus replacing the Dynegy-Vistra plants with renewable energy would be cheaper than what our analysis shows.

As shown in Figure 1a below, in 2020, when all or most of Dynegy-Vistra coal plants retire, the installed capacity in Zone 4 falls before increasing in following years as wind and solar additions accrue. For example, in Scenario 1, the model retires all 8 Dynegy-Vistra plants, which make up nearly 5,900 MW, by 2020, along with nearly 1,600 MW of non-Dynegy-Vistra coal capacity and 1,000 MW of gas capacity in Southern Illinois. The model builds 1,500 MW

[9] As discussed in Appendix B.3 an important feature of WIS:dom is its ability to explicitly examine the need of a plant or set of plants to maintain resource adequacy by allowing a plant to come back online after retiring if it is found to be necessary for resource adequacy. In both scenarios, the Dynegy-Vistra plants were never brought back into operation after retiring, confirming once more that they are not needed to maintain resource adequacy in Zone 4.

[10] Baldwin and Havana are the only two Dynegy-Vistra plants in Southern Illinois that do not sell into the PJM capacity market. The rest of the 8 Dynegy-Vistra coal plants in Zone 4 sell into the PJM market as follows: Coffeen: 150 MW; Newton: 307 MW; Duck Creek: 330 MW; E.D. Edwards: 150 MW; Hennepin: 260 MW; Joppa: 240 MW.

of solar and roughly 2,500 MW of wind by 2020 both to comply with the IPA renewable procurement plan and to replace the aging Dynegy-Vistra plants with cheaper alternatives[11]. Thus, the coal and gas capacity that the model retires by 2020 is larger than the wind and solar additions, resulting in a capacity drop in 2020 compared to 2017. However, despite the capacity decrease in 2020, Zone 4 resource adequacy is maintained (i.e. the capacity still meets the Zone 4 Planning Reserve Margin), electricity demand is reliably met every hour, and Illinois remains a net exporter of power to other regions with exports slightly dropping between 2020 and 2025[12]. Under either scenario, the capacity mix in Southern Illinois transitions from one that is dominated by coal and gas in 2017 to one dominated by wind, solar and gas by 2030.

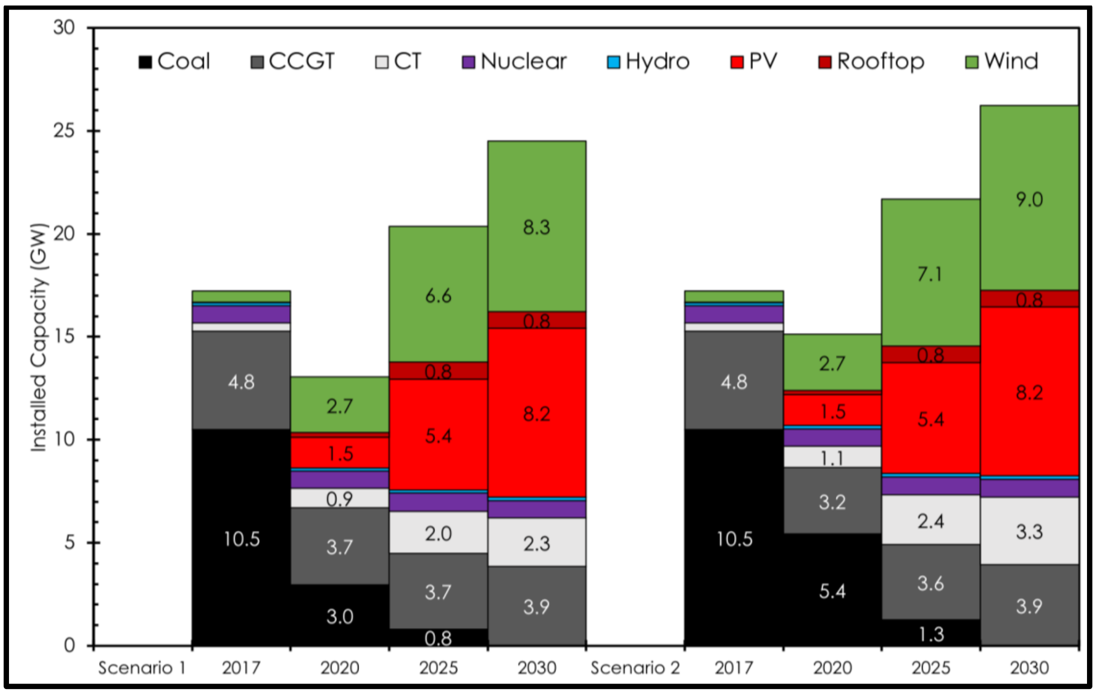

Figure 1a: Installed capacity in Zone 4 for Scenarios 1 and 2. In this figure, CCGT refers to combined cycle gas turbines; CT refers to combustion turbines; PV refers to utility-scale solar PV; and rooftop refers to rooftop solar PV[13].

[11] As explained in Section II. Scenarios Evaluated, the IPA's 2018 LTRRPP will have the effect of driving the addition of approximately 360 MW of new wind and 560 MW of new solar every year in Illinois, through 2030.

[12] MISO Zone 4's Local Clearing Requirement (LCR), Capacity Import Limit (CIL) and Capacity Export Limit (CEL) are all constraints in the WIS:dom model, meaning that *any and all* solutions must meet all three. This means that despite the capacity drop in 2020 in both scenarios, all three constraints are satisfied.

[13] Although the capacity numbers are expressed in Installed Capacity (ICAP), WIS:dom derates the generating capacity of resources to Unforced Capacity (UCAP) in evaluating compliance with Zone 4 resource adequacy requirements.

To further assess the importance of the Dynegy-Vistra coal plants for resource adequacy and reliability, we also modeled a "worst-case" shock scenario where the IPA renewable procurement plan is not implemented and all 8 Dynegy-Vistra coal plants retire between 2017 and 2025 (roughly 4,600 MW of the coal plants retire by 2020 and the remaining 1,300 MW are retired by 2025).[14] The "worst-case" scenario results confirm again that the Dynegy-Vistra coal plants are not necessary to meet Zone 4 resource adequacy needs. In fact, the model only needs to build roughly 2,000 MW of wind capacity by 2020 and increase imports from Northern Illinois to Southern Illinois to maintain Zone 4 resource adequacy[15]. Even in this worst-case scenario, Illinois remains a net exporter of power to other regions. Figure 1b below displays the Zone 4 capacity mix in this "worst-case" scenario.

In sum, the worst-case scenario confirms that the near-term retirement of more than 75 percent of the Dynegy-Vistra coal plants by 2020 would have minimal impact on Zone 4 resource adequacy or reliability. The scenario also demonstrates that multiple options are available to replace the Dynegy-Vistra plants. While scenarios 1 and 2 rely on new renewable resources in Southern Illinois to replace the plants, this "worst-case" run relies on additional imports from Northern Illinois and a small amount of new wind capacity in Southern Illinois.

[14]The retirement schedule that we adopted is based on the rationale that the Dynegy-Vistra coal plants located in Zone 4 but selling most of their power into PJM would retire at a later date, in 2025. The line of reasoning being that the PJM capacity market prices are providing these plants with a sufficient revenue to keep running. The plants selling most of their capacity into the PJM market and retired in 2025 are: Newton, Hennepin and Duck Creek.

[15] In this shock scenario, Southern Illinois imports 2.7 percent of its power from Northern Illinois. It is worth noting that the small amount of imports from Northern Illinois do not count towards meeting Zone 4's LCR, but are only needed to meet the portion of the Zone 4 PRMR that is in excess of the Zone 4 LCR

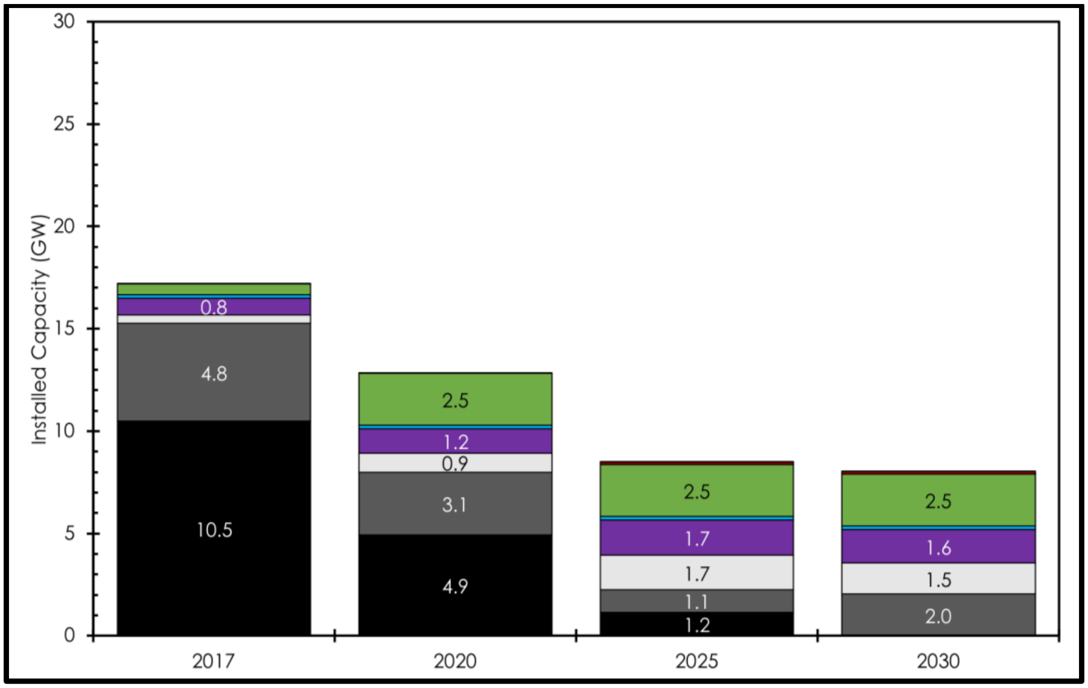

Figure 1b: Installed capacity in Zone 4 in the "worst-case" scenario[16].
Chart legend is identical to Figure 1a.

b. Generation Mix Results

Under the primary two scenarios, the generation mix in Illinois significantly changes between 2017 and 2030 (refer to Figures 2 and 3 below). Coal generation is completely phased out by 2030, while renewable generation sees a fivefold increase compared to 2017. Nuclear generation remains largely constant between 2017 and 2030, owing to the Zero Emissions Credit (ZEC) program, although its share in the generation mix increases by 6 percent between 2017 and 2020. And gas generation modestly increases (in large part from existing gas plants) to make up 25 percent of total generation in 2030. The increase in gas generation can be attributed in part to the need for flexible resources to be dispatched in tandem with the growing wind and solar capacity. It is important to note that other flexible resources such as demand response and storage can also be deployed alongside the renewable capacity

[16] The 800 MW of new nuclear between 2017 and 2030 are driven by the ZEC program, which enhances the cost-effectiveness of nuclear expansion. However, this is unlikely to occur in real life given that the ZEC program does not apply to new nuclear units (note that we did not allow any new nuclear expansion in Scenarios 1 and 2). The new nuclear capacity can be easily replaced with a mix of other resources like gas and renewables, as well as an increased deployment of demand-side resources like energy efficiency, demand response and distributed generation. It is also worth noting that the model retires a measurable amount of existing gas capacity——2,800 MW- between 2017 and 2030. Keeping a portion of this gas in operation could also replace the new nuclear capacity.

and reduce the need to build new gas combustion turbines and ramp up gas generation. In addition, increasing energy efficiency investments and the deployment of distributed resources like rooftop solar would reduce electricity demand and reduce or eliminate the need to ramp up gas and nuclear generation.

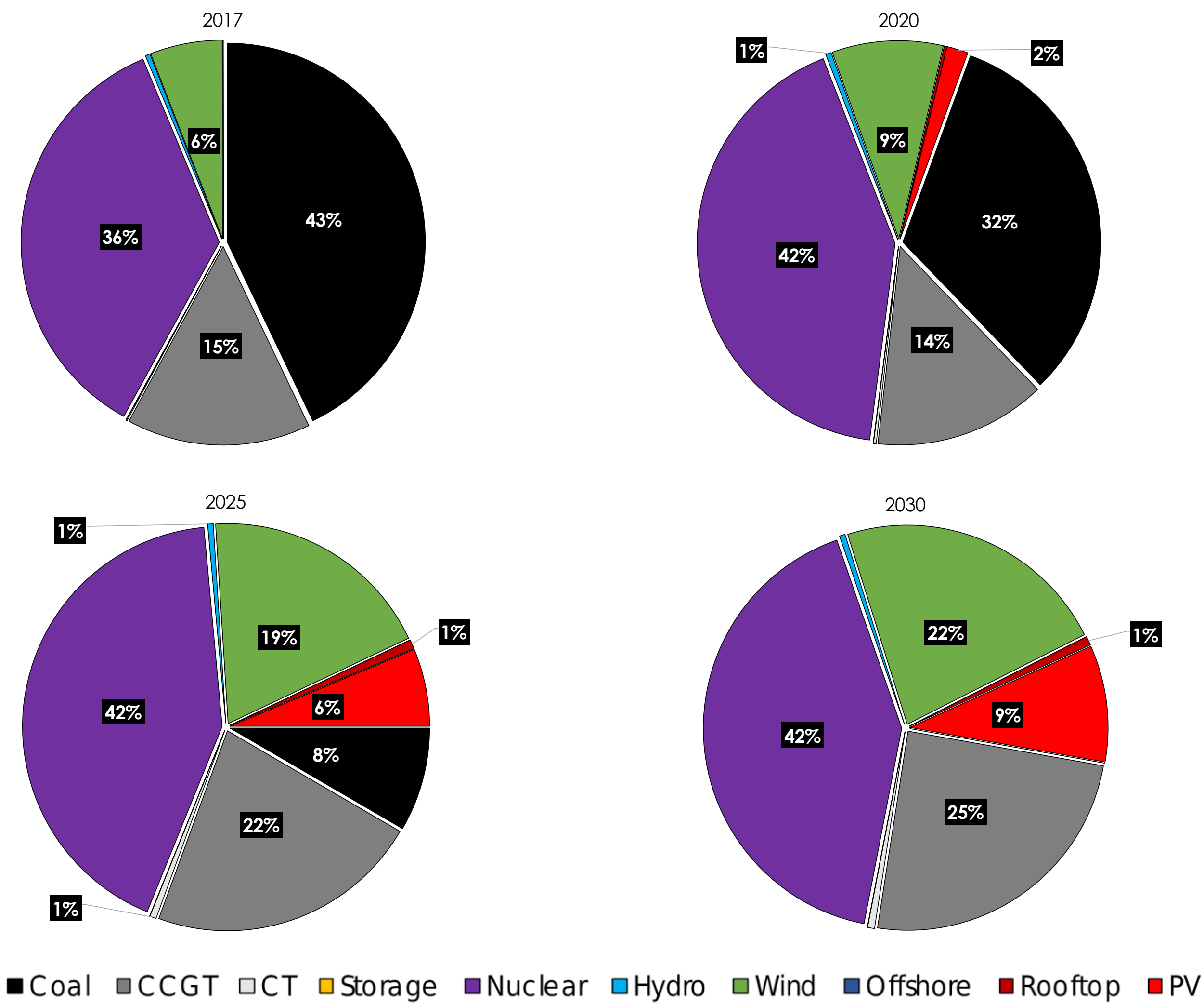

Figure 2: The generation mix in Illinois in Scenario 1. Coal is entirely replaced by wind, solar and natural gas.

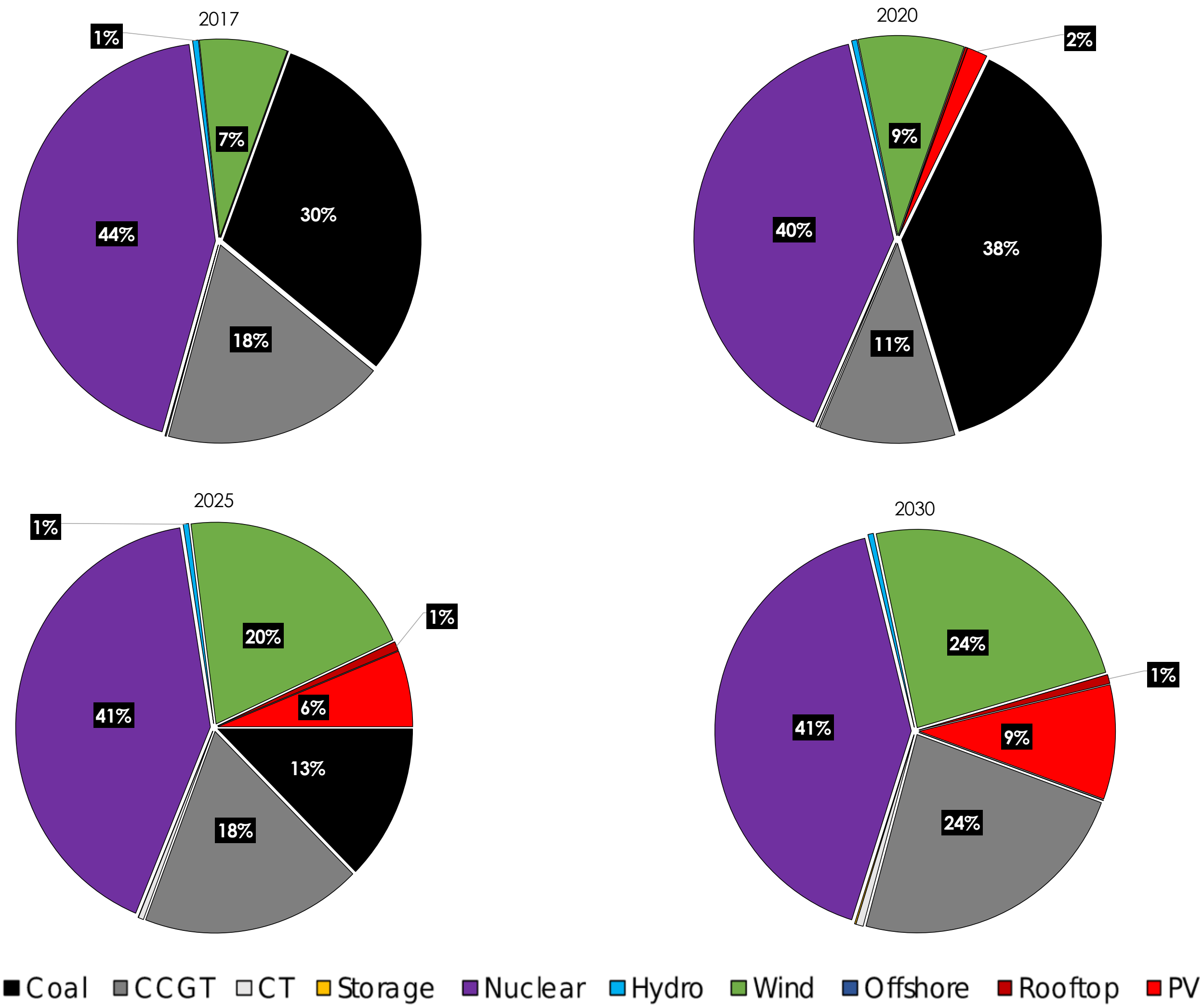

Figure 3: The generation mix in Illinois in Scenario 2. Similar to Scenario 1, coal is entirely replaced by wind, solar and natural gas by 2030[17].

It is important to note that the retirement of the Dynegy-Vistra plants and the transition to cleaner resources do not require any major transmission expansion. The WIS:dom model simultaneously computes the capacity and transmission needs to maintain resource adequacy and meet electricity demand, and results under both scenarios show that no large-scale transmission buildout in Illinois is necessary to replace the Dynegy-Vistra coal

[17] In Scenario 2, the coal generation in the first investment period (2020- 2025) is lower compared to Scenario 1, due to the different fuel cost assumptions. In Scenario 2, the regionally aligned fuel costs make coal plants less competitive compared to gas in Illinois and other resources in neighboring states, and thus coal plants are dispatched less compared to Scenario 1. Despite these differences in the initial investment period, both scenarios show very similar results in 2030.

plants with other cheaper resources (refer to Appendix A.2 for detailed transmission results). Of course, any transmission projects that may be built will only further enable the economic transition of Illinois away from Dynegy-Vistra's retiring coal fleet[18].

3. The Mix of Renewables, Gas, and Nuclear Generation Reliably Meets Electricity Demand Without the Dynegy-Vistra Coal Fleet

In both scenarios, electricity demand is ***reliably met every hour*** in Illinois with a mix of renewables, gas, and nuclear generation.[19] Figures 4a and 4b below show how power plants in Illinois are dispatched to meet electricity demand in summer and winter in 2017 and in 2030 under Scenario 1. (Note: The dispatch curves for both scenarios are very similar. Summer and winter dispatch curves under Scenario 2 are available in Appendix A.3). In 2017, coal, gas, and nuclear resources make up the bulk of the generation mix and meet most of the electricity demand in Illinois in both summer and winter (Figure 4a).[20] In the summer months, natural gas generation increases to meet the higher electricity demand.[21] Additionally, Illinois is a net exporter of power in 2017, as generation exceeds demand (illustrated by the yellow curve in Figure 4a).[22]

As discussed in Section III.1 above, all of the Dynegy-Vistra plants are retired by 2025 in both scenarios and replaced with a mix of cost-effective wind, solar and gas resources. In 2030, electricity demand in Illinois is met with a combination of renewable, gas, and nuclear resources (Figure 4b).

In the winter months, wind generation is plentiful and meets a large part of the demand, alongside solar, gas, and nuclear resources. In the summer season, gas plants are ramped up to compensate for the lower wind output, and solar generation increases to meet a larger portion of demand compared to the winter months. Gas combustion turbine plants and some storage are also flexibly utilized to help meet the summer peak demand. (Note: Figure

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[18] For more discussion of how the existing rich transmission in Illinois as well as the planned transmission infrastructure in the region can help Southern Illinois reliably replace the Dynegy-Vistra fleet, refer to the comments submitted to the Illinois Commerce Commission (ICC) by the Natural Resources Defense Council, Environmental Defense Fund, Sierra Club and Environmental Law and Policy Center, Available in the ICC's 2018 Summary Report https://www.icc.illinois.gov/Electricity/workshops/MISOZone4.aspx

[19] The WIS:dom optimization model ensures that electricity is provided where it is needed every hour through its dispatch module, which is performed simultaneously with the capacity and transmission expansion.

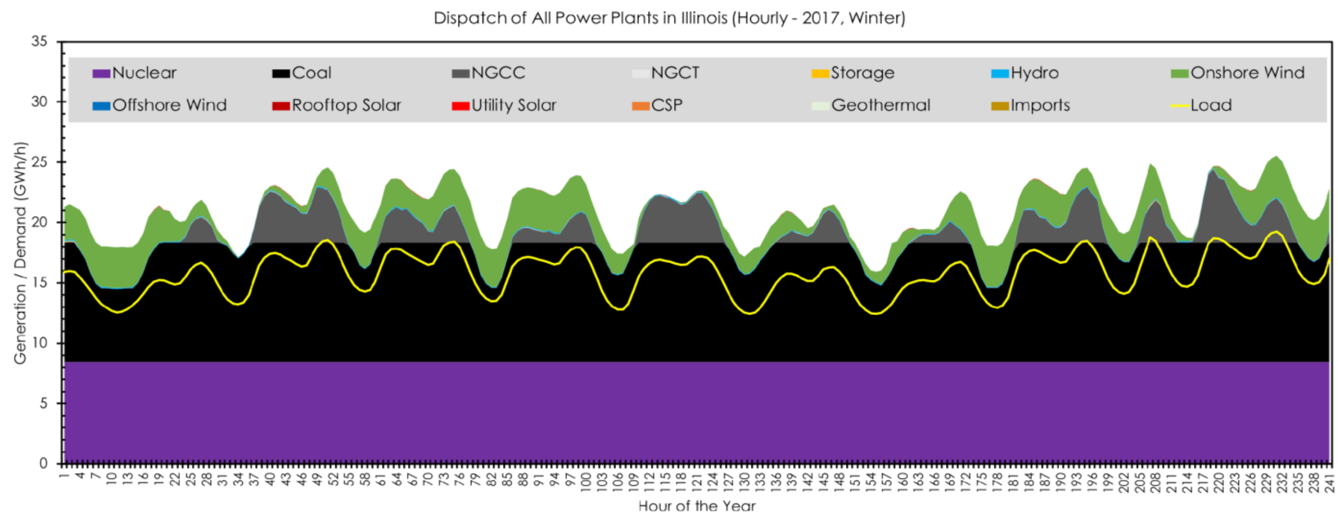
[20] WIS:dom dispatches generation based on the marginal cost of generation, transmission constraints, demand, and available resources.

[21] Electricity demand in the summer months increases due to the use of air conditioning in households and businesses.

[22] The model dispatches those resources to supply capacity and energy to other regions than Zone 4 in MISO and PJM.

4b shows how Illinois continues to be a net exporter as generation exceeds demand.) It is worth noting that in both scenarios reliability attributes like operating reserves were maintained throughout the study period of 2030.

The modeling demonstrates how flexible resources like combined cycle and combustion turbine gas plants and storage can complement the variable wind and solar generation in an efficient and cost-effective manner to reliably meet electricity demand. This is in no small part the product of good grid operation and planning, as well as efficient siting of new resources based on existing capacity and demand. For example, WIS:dom leverages geographic diversity to optimally site wind and solar resources to enhance their ability to reliably meet demand. Similarly, the model sites gas capacity and other flexible resources in a manner to complement wind and solar resources. These model functions reflect how grid operators and developers are increasingly, and reliably, integrating large amounts of renewable energy resources on the grid.



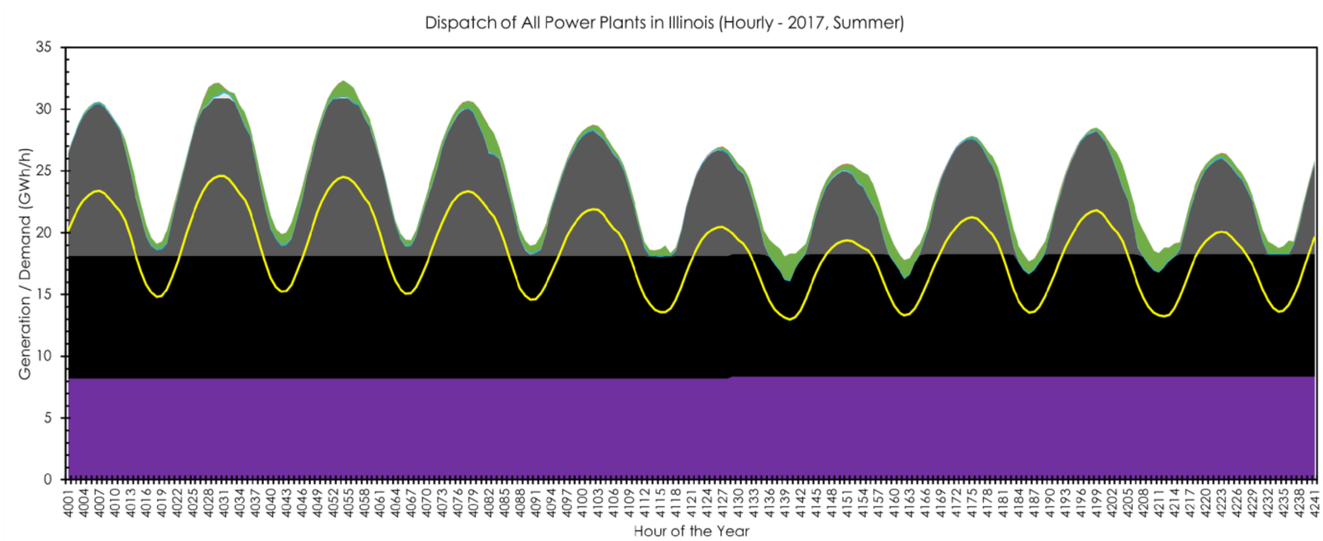
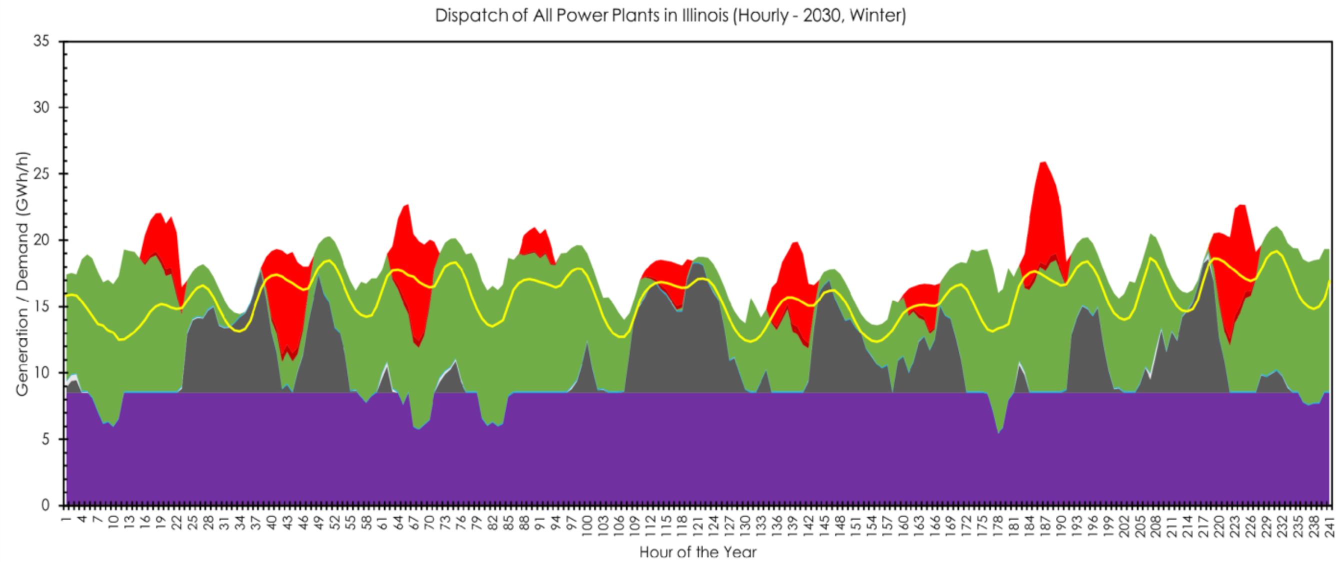


Figure 4a: 2017 winter (top) and summer (bottom) dispatch curves for Illinois under Scenario 1. In Figures 4a and 4b, the yellow curve represents electricity demand, NGCC refers to natural gas combined cycle and NGCT refers to natural gas combustion turbines.



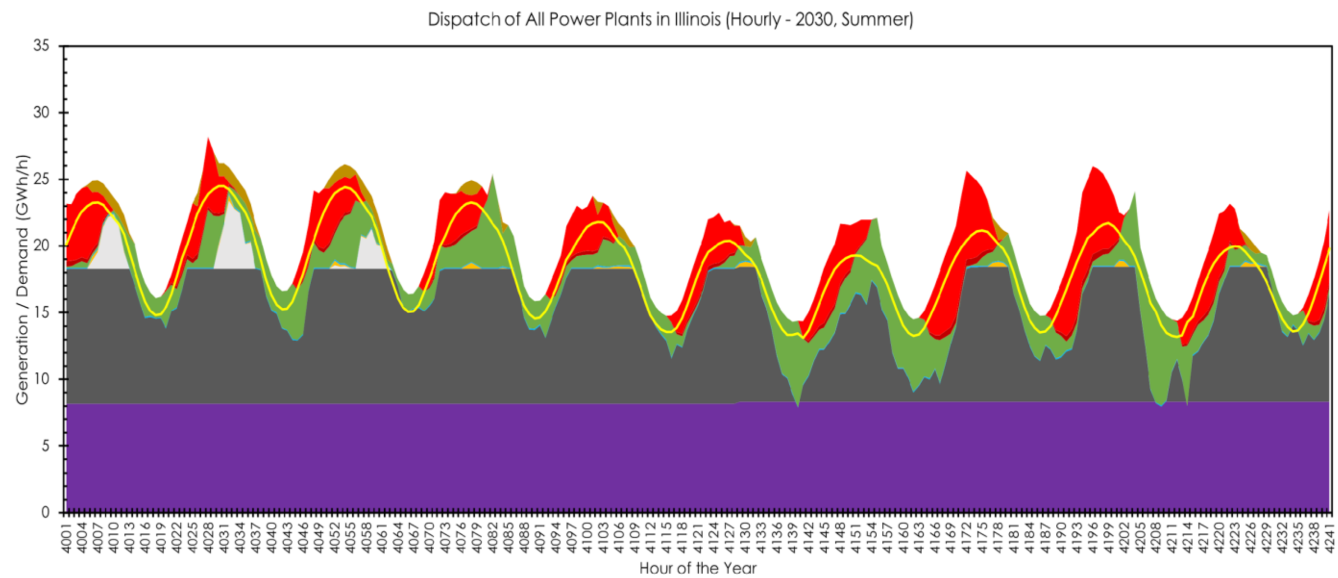


Figure 4b: 2030 winter (top) and summer (bottom) dispatch curves for Illinois under Scenario 1. The graph legend is similar to Figure 4a.

4. Replacing the Dynegy-Vistra Coal Plants with Cheaper [or Less Costly] Resources Lowers Electricity Prices

In both scenarios, replacing the Dynegy-Vistra coal plants with wind and solar resources lowers the cost of electricity for Illinois customers compared to today's prices (Figure 5).

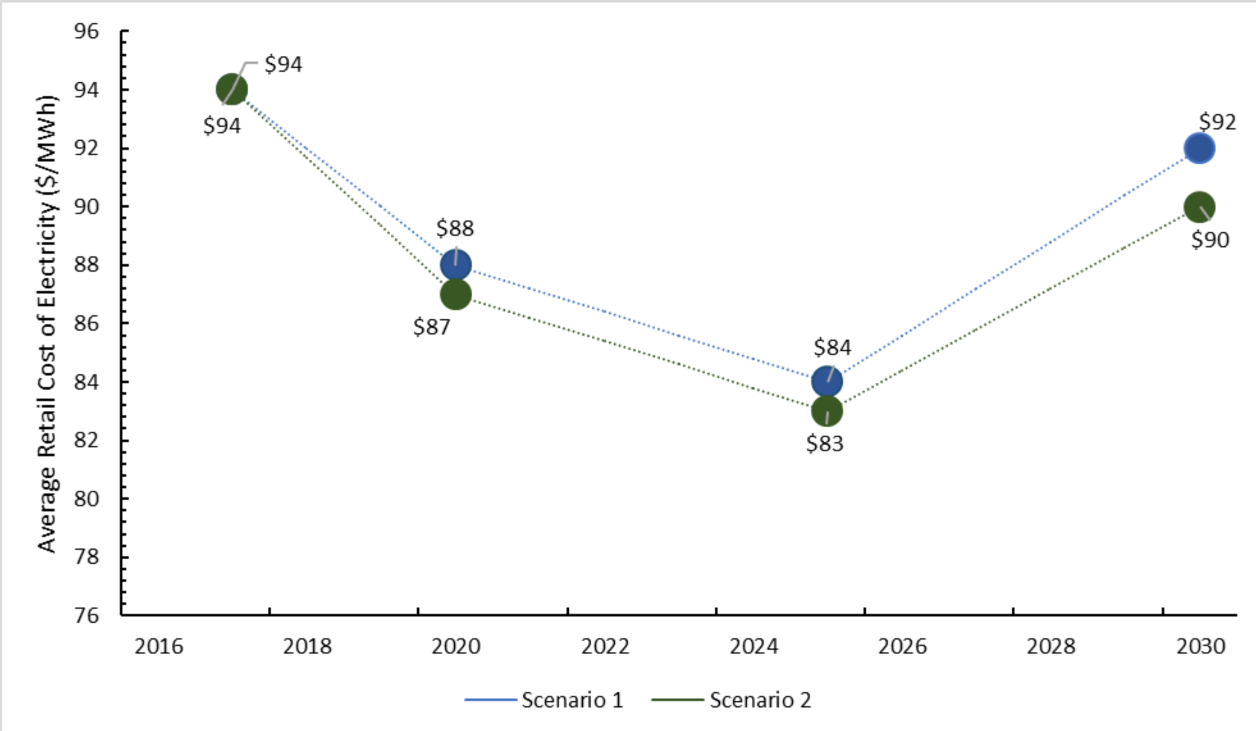


Figure 5: Estimated retail cost of electricity in Illinois under the two scenarios (prices account for inflation, and are expressed in 2016 dollars)

By 2030, the cost of electricity is 2 to 3.5 percent lower compared to 2017, and between 2018 and 2030, Illinoisans would save between ***$12.5 and $14 billion*** on their electricity bills compared to the current generation mix.

The reduction in electricity costs over time is mainly due to the very low operating costs of renewable resources. Fuel is the largest component of operating costs for fossil resources. Because wind and solar resources do not require buying fuel for operation, they have very low operating costs. These cost savings outweigh their initial construction cost and translate into lower electricity prices for Illinoisans over time. In addition, Illinois enjoys good-quality wind and solar resources (good wind speeds and good solar radiance), which enables the construction of well-performing projects[23]. These two factors—low operating costs and well-performing resources—enhance the cost-effectiveness of wind and solar investments compared to keeping the aging Dynegy-Vistra power plants in operation. Thus, the replacement of the Dynegy-Vistra plants with more cost-effective resources delivers savings to Illinoisans over time.

[23] National Renewable Energy Laboratory, National Wind Resource Assessment, https://www.nrel.gov/gis/wind.html

It is important to note that the projected electricity cost savings shown in Table 1 can reasonably be considered conservative for two main reasons. One is that, as explained above (under Section II- Scenarios evaluated), the model used conservative cost assumptions for the Dynegy-Vistra coal plants that are likely to be lower than what the costs are in reality. Further, solar and wind projects could become cheaper and better performing than what our analysis shows due to the rapid rate of technological advancement.

5. Retirement of the Dynegy-Vistra Coal Plants Would Dramatically Lower Emissions of Harmful Pollutants

The retirement of the Dynegy-Vistra coal plants would also deliver large climate and public health benefits to Illinoisans. Replacing the Dynegy-Vistra plants with clean renewable generation reduces carbon dioxide (CO_2) emissions by 70 to 80 percent in 2030, compared to 2017 (Figure 7), as electricity generation in Illinois becomes significantly cleaner (Figure 6). Given CO_2 is the main driver of climate change, these substantial reductions in its emissions from the electricity sector in Illinois would deliver important climate benefits and position the state well to comply with any potential future federal and/or state policies limiting carbon emissions[24].

[24] Intergovernmental Panel on Climate Change, "Climate Change 2014 Synthesis Report Summary for Policymakers.", 2014, https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

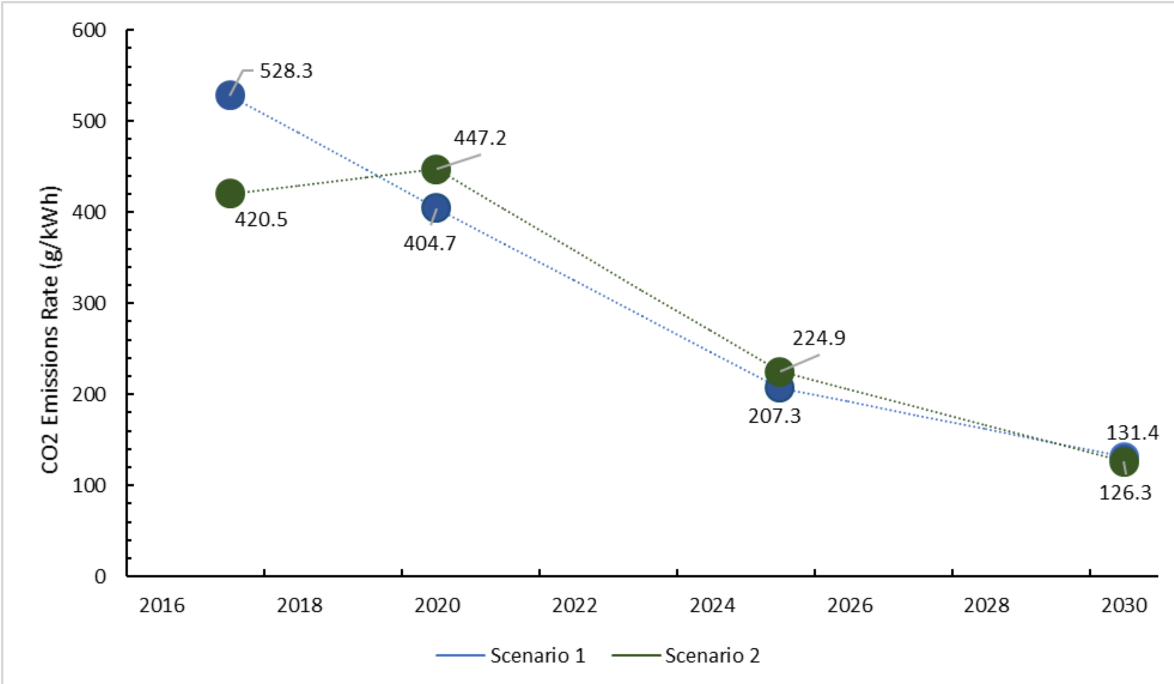


Figure 6: Estimated carbon dioxide (CO_2) emission rates for the Illinois electricity sector under Scenarios 1 and 2.

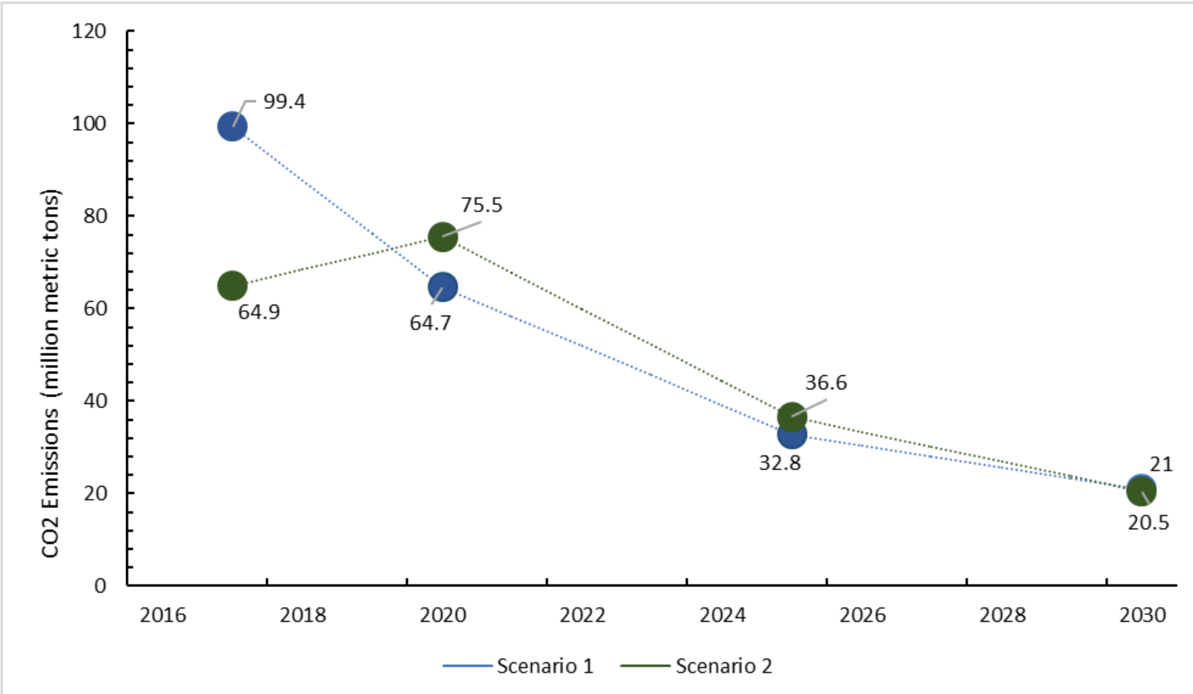


Figure 7: Total carbon dioxide (CO_2) emissions from electricity generation in Illinois under Scenarios 1 and 2. CO2 emissions for Scenario 2 are lower than Scenario 1 in 2017 due to the higher fuel costs assumed under Scenario 2 for the Dynegy-Vistra plants. The higher fuel costs result in the Dynegy-Vistra fleet being dispatched less in Scenario 2.

The retirement of the Dynegy-Vistra coal plants would also deliver important local public health benefits to Illinoisans. Figure 8 displays the change in emissions of harmful air pollutants from electricity generation in Illinois under Scenario 1. Scenario 2 (not shown below) shows a very similar pattern. Most notably, particulate matter emissions from the power sector would zero out by 2030, while emissions of other harmful pollutants like nitrogen oxides (NO_x) and sulfur dioxide (SO_2) would reduce by 80 to 90 percent (respectively) by 2030 compared to 2017. These pollutants are known to cause severe health impacts, including asthma, cancer, and heart and lung disease. Thus, replacing the Dynegy-Vistra coal plants—four of which lack crucial emissions controls—with clean resources would significantly improve air quality and public health in both Northern and Southern Illinois.[25,26]

[25] U.S. Environmental Protection Agency, "Overview of the Human Health and Environmental Effects of Power Generation: Focus on Sulfur Dioxide (SO2), Nitrogen Oxides (NOX) and Mercury (Hg)," June 2002, https://archive.epa.gov/clearskies/web/pdf/overview.pdf.

[26] Notably, E.D. Edwards, Hennepin, Joppa Steam and Newton all lack flue gas desulfurization (FGD) controls and had 2016 sulfur dioxide (SO2) emissions rates more than 1.5, 2, 1.8, and 1.6 times higher than the state SO2 emissions rate limit, respectively.

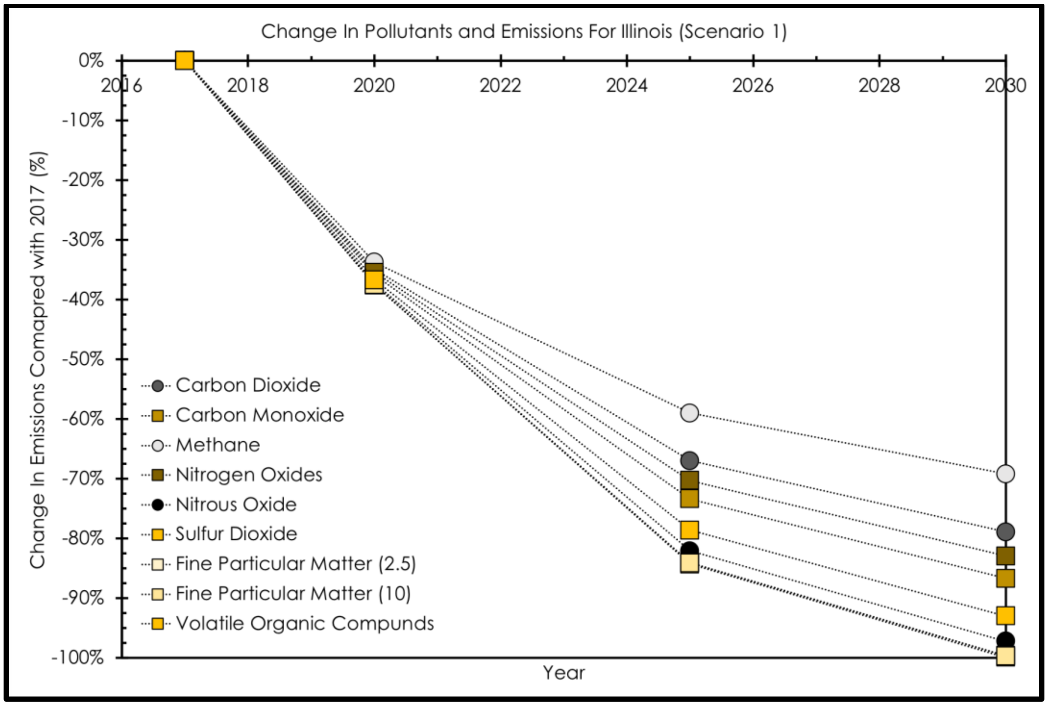


Figure 8: The change in emissions of harmful air pollutants from electricity generation in Illinois under Scenario 1.

IV. Conclusions

The modeling conducted by VCE confirms that the eight (8) Dynegy-Vistra coal plants in Southern Illinois are less competitive compared to other resources and can be retired in the near term with no impact on Zone 4 resource adequacy or reliability. In addition, resource adequacy in both the wider MISO footprint and PJM are not impacted by the near-term retirement of the Dynegy-Vistra coal plants.

The output from the Dynegy-Vistra plants can be feasibly and reliably replaced with a cost-effective mix of wind, solar, gas and nuclear, without the need for transmission expansion. The cleaner generation mix lowers the cost of electricity for Illinoisans compared to what they pay today. In fact, Illinoisans would save between $12.5 and 14 billion on their electricity bills between 2018 and 2030 under the cleaner generation mix compared to the current coal-dominant mix. Further, Illinois remains a net exporter of power throughout the study period despite the near-term retirement of the Dynegy-Vistra coal plants owing in no small part to the projected flat demand growth driven by the energy efficiency mandates under FEJA.

And finally, replacing the Dynegy-Vistra plants with cleaner resources would significantly reduce emissions of harmful pollutants, and thus improve air quality and public health in Southern Illinois. It would also deliver important climate benefits and position Illinois well for potential future carbon regulations.

Appendix A: Additional Results

a. Transmission Investments

WIS:dom also computes the transmission expansion necessary to accommodate new capacity additions. None of the modeling performed by VCE indicates that transmission expansion is needed in Illinois to replace the Dynegy-Vistra coal plants with cleaner, more flexible generation. Figure 12 shows the transmission expansion aggregated by state. In both scenarios, Illinois does not need to invest in transmission expansion to make up for the Dynegy-Vistra coal power plants. Some small amount of additional export capacity is built by 2025 in Scenario 2 to ramp up exports to other states, but this could easily be avoided with some additional storage capacity.

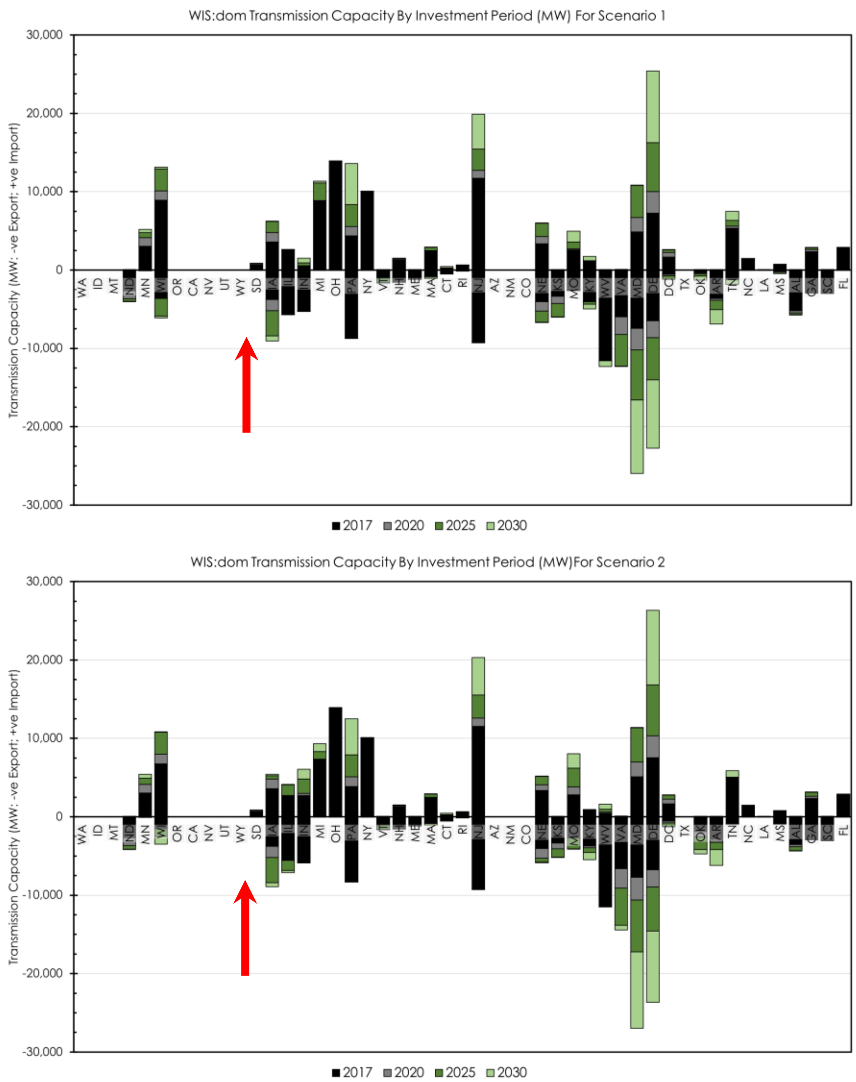


Figure 11: The transmission capacity (import and export) for each state in the Eastern Interconnection. The black bars show existing capacity, the grey bars show additional capacity added by 2020, the dark green bars show added capacity by 2025, and the light green bars show added capacity by 2030. The red arrow points to Illinois.

b. 2017 and 2030 Dispatch Curves under Scenario 2

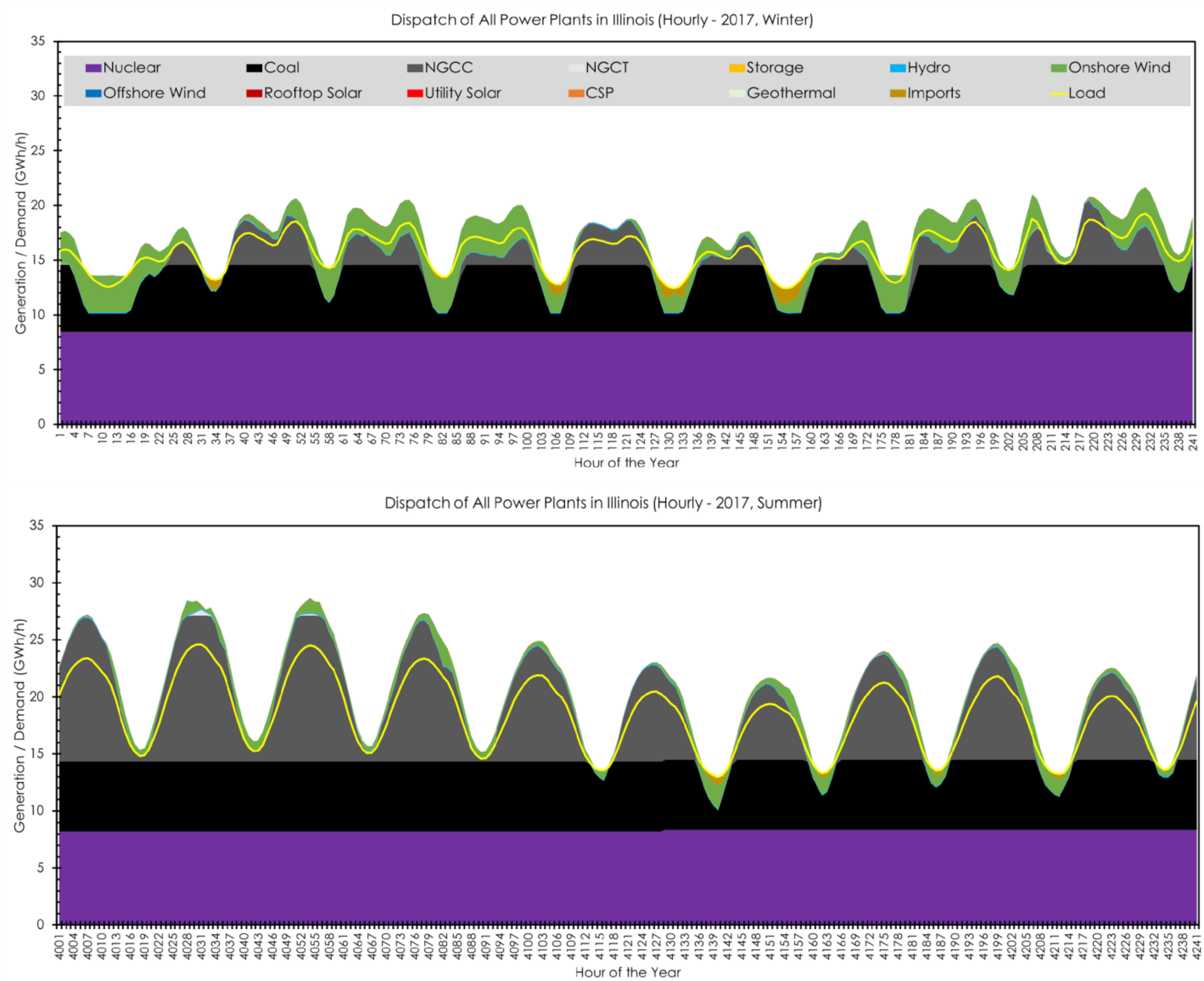
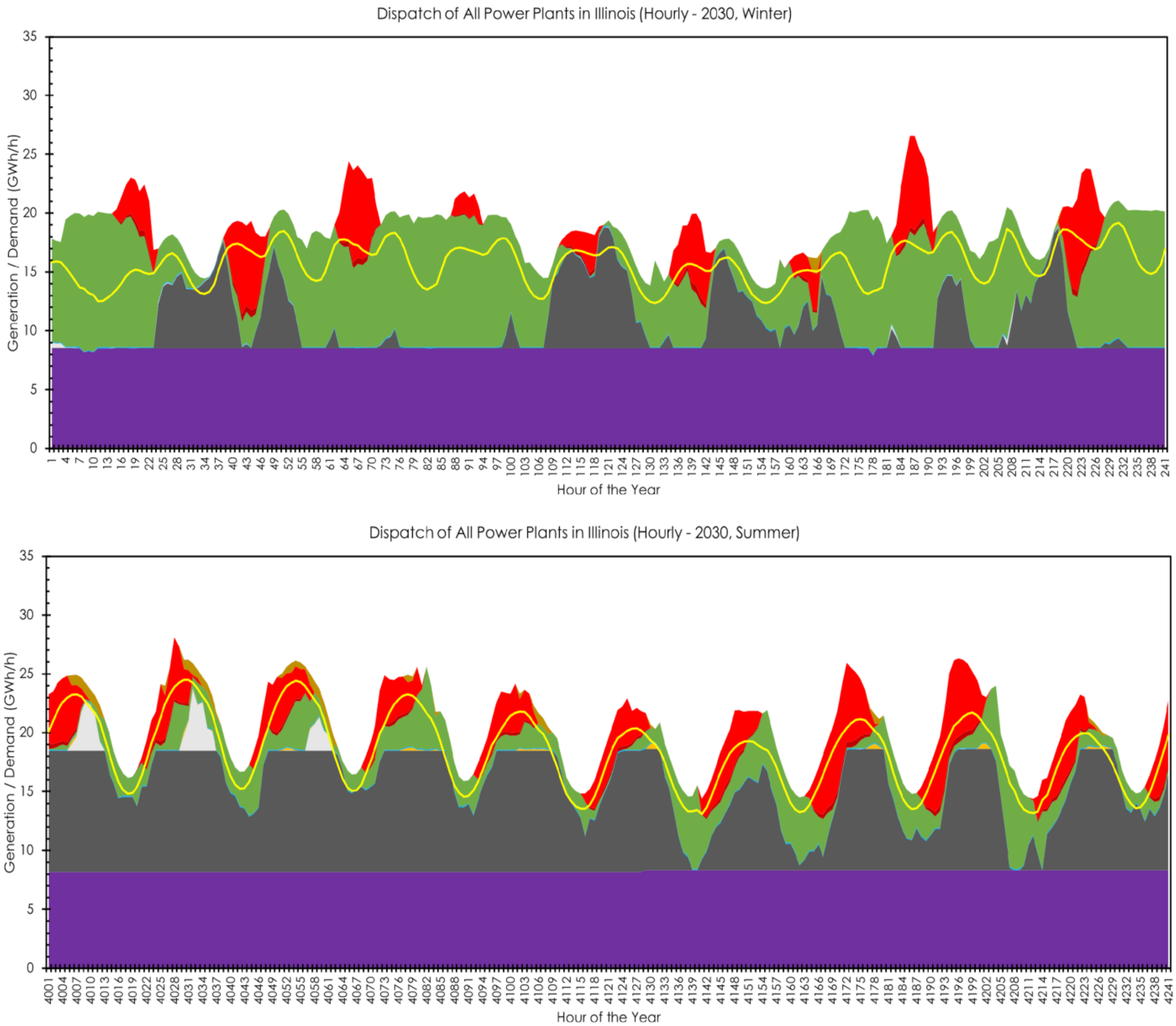


Figure 12: 2017 winter (top) and summer (bottom) dispatch curves for Illinois under Scenario 2. The yellow curve represents electricity demand.



2030 winter (top) and summer (bottom) dispatch curves for Illinois under Scenario 2. The yellow curve represents electricity demand.

Appendix B: Sources and Model Description

a. WIS:dom Model Description

The WIS:dom optimization model (Weather-Informed Systems: design, operation, markets) is a blended capacity expansion and production cost model or a synthesis model. It solves for the least-cost generation mix, taking into account all the constraints and commitments built into the initialization. The branch of WIS:dom used in the current analysis solves over the entire Eastern Interconnection. It solves for each of the markets that are in the Eastern Interconnection, while considering the transmission corridors between the markets, committed units for certain markets and some other market friction/inefficiencies.

WIS:dom uses a *minimum* of hourly data over a period of a year for a grid granularized at 13-km spatial resolution for its production cost calculations. WIS:dom handles large volumes of data, including weather data, to estimate the use of variable and conventional generation in a manner applicable to the operation of the electricity grid. It allows users to create possible alternative pathways under scenarios to formulate a picture of how the system could evolve. The differences between scenarios can be analyzed to derive conclusions regarding the cost-effectiveness of different scenario choices. As mentioned above, WIS:dom solves for the lowest-cost solution given the constraints that it must meet within a configured scenario.

WIS:dom finds "solutions" to different scenarios by minimizing the objective function, which is the sum of the total costs for each of the systems it is considering. The system costs include: capital repayments, fixed costs, variable costs, fuel costs, transmission costs, reserve payments, market clearing costs, and integration costs. There are seven (7) main market areas in the Eastern Interconnect (EI) (that reside in the US): FRCC, ISO-NE, MISO, NYISO, PJM, SERC and SRCC. One of the important constraints is enforcing a market-clearing price for each market, which is taken as the highest marginal cost of generator necessary to fulfill demand. This additional cost is added to the total system costs.

In this analysis, the cost assumptions for all new investments in generation, transmission and storage remain the same between the scenarios (except those for the Dynegy-Vistra coal plants, as explained in Appendix C). We rely on costs from NREL's ATB 2017 values. The NREL values were chosen because they are reputable values; they are used by RTOs in their modeling, give high granularity, and are updated frequently. The mid-case projections are used for wind and solar technologies and coal prices, while the low-case forecast is used for gas prices, in order to be more in line with EIA's Annual Energy Outlook 2018 gas price forecast. The WIS:dom optimization model applies regional multipliers for the technology and fuel costs to take into account local economies and constraints.

b. Sources of Data

VCE utilizes publicly available data where possible, and supplements the data with a Platts purchased dataset. The publicly available data comes from the Energy Information Agency, the National Renewable Energy Laboratory, other Department of Energy sources, the Federal Energy Regulatory Commission and the National Oceanic and Atmospheric Administration.

WIS:dom relies on the above-mentioned sources to collect data on the cost and performance of different generators. The data includes: heat rates for thermal generators, minimum loading for thermal generators, fuel costs for thermal generators, fixed O&M costs for all generators, non-fuel variable O&M costs for all generators, remaining capital costs for all generators, transmission topology for all voltages above 69 kV, estimated relicense costs for nuclear generators, repowering costs for variable generators, the age and expected life of all existing generators, the power factor of all existing generators, the near-term generator interconnection queue, and electricity demand by sector. The main generator inputs are shown in Figure 13.

The current study relied on the publicly available S&P Global Market Intelligence data for assumptions on the heat rates, as well as fixed and operating costs of the Dynegy-Vistra plants. As explained in section II, the latter costs were supplemented to better reflect the costs of the Dynegy-Vistra plants.

Input ID	Input Name	Existing	New
1	Heat Rate	All Current Thermal Data	NREL ATB 2017 Value
2	Minimum Load	All Current Thermal Data	Fleet Average
3	Power Factors	All Current Generator Data	Fleet Average
4	Fuel Costs	All Current Thermal Data For Multiplier	NREL ATB 2017 Value
5	Fixed O&M Costs	All Current Generator Data	NREL ATB 2017 Value
6	Non-fuel Variable O&M Costs	All Current Generator Data	NREL ATB 2017 Value
7	Capital Costs	All Current Generator Data	NREL ATB 2017 Value
8	Relicense / Repower Costs	All Existing Nuclear, Wind, and Solar Generators	45% For VRE, N/A For Nuclear
9	Discount Rates	Uses Same Rate as "New"	5.87% Real
10	Economic Lifetimes	All Current Generator Data	NREL ATB 2017 Value
11	Transmission Costs	Uses Same Cost As "New"	ABB / Blended Existing Costs
12	Transmission Topolgy	Current Above 69 kV Aggregated To Reduced Form	New Lines Allowed Within WIS:dom; constrained by user
13	Demand	Current Demand By Sector	Growth Estimates Provided By Sector By VCE
14	Weather / Power Data	N/A	One Year Of Hourly Power Data For Wind & Solar Over El
15	Policy & Regulations	Apply All Existing Policies & Regulations	Input As Constraints On Future Scenarios
16	Locational Multiplier	N/A	Black & Veach / NREL Public Data Combined By VCE

Figure 14: Input assumptions in WIS:dom and their sources

c. Further Testing the Value of the Dynegy-Vistra Plants for Resource Adequacy

An important feature of WIS:dom is its ability to explicitly examine the need of a plant or set of plants to maintain resource adequacy. Although it is seldom the case, the model allows a plant to come back online after retirement if it is needed in the future to maintain resource adequacy.

VCE found that this (modeled) option facilitates the ability to calculate any subsidies that would be required to keep the Dynegy-Vistra coal plants in operation if those are shown to be needed to meet resource adequacy at a later date. *For the scenarios that were modeled by VCE, the Dynegy-Vistra coal plants were never brought back into operation after they were retired*, confirming once more that they are not needed to maintain resource adequacy in Zone 4.

Appendix C: Demand and Cost Assumptions

a. Load Forecast

The analysis relies on load forecasts submitted by Illinois' three investor-owned utilities- Ameren, Commonwealth Edison, and MidAmerican- to the Illinois Power Agency as part of the 2018 Renewable Energy Procurement process. The load forecasts are available here: https://www2.illinois.gov/sites/ipa/Documents/2018ProcurementPlan/LTRRPP-Filed-Appendix-B-RPS-Summaries.pdf#search=rps%20summaries

b. Cost Assumptions

As explained in Section II. Scenarios Evaluated, given that much of the cost data for the Dynegy-Vistra coal fleet is proprietary, VCE made some adjustments to reflect the capital and operating costs of the 8 Dynegy-Vistra plants in the most accurate manner possible. The publicly available capital and operating costs for the Dynegy-Vistra coal plants pulled from the S&P Global Market Intelligence database were lower than those recorded by WIS:dom and the Energy Information Administration (EIA) for the rest of the coal fleet in Illinois and the Eastern Interconnect. Thus, VCE revised these costs to make them in line with those incurred by the rest of the coal fleet in the state and the region. We further discuss these revisions below:

"Scenario 1": Regionally aligned fixed costs, low variable costs.

In this scenario, we paired the fuel costs for the Dynegy-Vistra plants reported by S&P Global Market Intelligence, which are lower than what the rest of the coal fleet in the Midwest typically pays, with fixed costs that are aligned with those incurred by the rest of the coal fleet in the Midwest region. In revising the fixed costs, WIS:dom starts off with the S&P reported fixed costs and escalates them with time. This revision is meant to capture the escalating retrofit costs that the 45+ year-old Dynegy-Vistra coal plants are expected to incur moving forward to keep operating. The applied cost escalation rates to the Dynegy-Vistra fleet are the same as those applied to all of the coal plants in the Eastern Interconnect.

"Scenario 2": Low fixed costs, regionally aligned variable costs.

In this scenario, we paired the fixed costs for the Dynegy-Vistra plants reported by S&P Global Market Intelligence, which are lower than what the rest of the coal fleet in the Midwest typically pays, with fuel costs that are aligned with those incurred by the rest of the coal fleet in Illinois and Midwest region. In revising the fuel costs, VCE increased the S&P reported coal costs for the Dynegy-Vistra fleet to be in line with what the Illinois region paid, on average, for coal in 2016 according to the EIA. The revision amounted to a 20 percent increase in the cost of coal for the Dynegy-Vistra plants compared to the S&P reported figures.