Scenario Analyses for IURC Report to the 21st Century Energy Policy Task Force

Staff Report

State Utility Forecasting Group

May 2020

PURDUE UNIVERSITY | State Utility Forecasting Group

Executive Summary

This report is intended to provide information regarding the implications of different future outcomes of a variety of parameters, including the timing of retirement of coal-fired generators, natural gas prices, energy efficiency and customer self-generation.

Resource Selection

Future resource selections in all scenarios and sensitivities are a combination of natural gas-fired generation (combustion turbines and combined cycle units), wind, and solar. Coal and nuclear options were never chosen, even in the high natural gas price scenario. The various factors defining the scenarios altered the mix and timing of the resource additions in largely predictable fashion. For instance, low renewables costs, high natural gas prices, and the imposition of carbon prices all resulted in more renewables being chosen and less natural gas.

Renewable Resources

Model results were highly sensitive to the price assumptions for renewable resources. While 13% of total energy in 2035 was provided by renewables in the reference scenario, that number increased to 29% in the low renewables cost scenario.

Energy from Coal

Energy derived from coal decreases over time in all scenarios, which is driven by a combination of retirements of existing generators and economic competition from natural gas and renewables. The imposition of retirement moratoria provides a boost to coal while they are in place, but energy from coal drops to roughly the same level in all non-carbon price scenarios (23-29% of total in 2035). The imposition of a carbon price results in large additional decreases in coal utilization. Energy from coal represents 6-9% of total in 2035 for the three carbon price sensitivities.

Effect of Carbon Prices

In general, the lower carbon prices imposed in the earlier years, tend to cause a shift from coal to natural gas-fired generation. In 2030 for the reference scenario, energy from coal drops from 35% to 22% with the imposition of the carbon price, while energy from natural gas increases from 33% to 46%. Similarly, for the 2030 retirement moratorium scenario, coal decreases from 61% to 47% and natural gas increases from 16% to 30%. In the low renewables cost scenario, however, the shift is from coal to wind rather than coal to natural gas. Energy from coal is cut in half (from 35% to 17%) while energy from wind doubles (from 16% to 33%).

The higher carbon prices in the later years show renewables displacing both coal and natural gas. In 2035 in the reference scenario, the carbon price causes coal-fired energy to drop from 28% to 9% and for natural gas-fired energy to fall from 47% to 40%. Meanwhile, energy from renewables triples from 13% to 39%. In the 2030 retirement moratorium scenario, coal (29% to 9%) and natural gas (55% to 41%) decreases while renewables (5% to 38%) increases. For the low renewables cost scenario, the effect is more pronounced, with coal falling from 27% to 6%, natural gas dropping from 33% to 18%, and renewables increasing from 29% to 64%. Interestingly, the increase is coming from wind, with energy from solar actually decreasing from the non-carbon price scenario.

PURDUE UNIVERSITY | State Utility Forecasting Group

Table of Contents

Page

List of Figures

List of Tables

Acronyms and Abbreviations

CO2	Carbon dioxide
EE	Energy Efficiency
EIA	Energy Information Administration, U.S. Department of Energy
GW	Gigawatt
GWh	Gigawatthour
IOU	Investor-Owned Utility
IPL	Indianapolis Power and Light Company
IRP	Integrated Resource Plan
IURC	Indiana Utility Regulatory Commission
I&M	Indiana Michigan Power Company
kWh	Kilowatthour
mmBtu	Million British thermal unit
MW	Megawatt
NREL	National Renewable Energy Laboratory, U.S. Department of Energy
NIPSCO	Northern Indiana Public Service Company
O&M	Operation and maintenance
SUFG	State Utility Forecasting Group

Foreword

This document summarizes modeling work performed by the State Utility Forecasting Group (SUFG) in support of the Indiana Utility Regulatory Commission (IURC) for their report to the 21st Century Energy Policy Task Force. While SUFG consulted with and took direction from the IURC regarding the modeling of various scenarios and sensitivities, the modeling work is solely the responsibility of the SUFG.

The work was performed using SUFG's forecasting modeling system, which was developed to produce long-term projections of electricity usage in the state of Indiana, in fulfillment of the requirements of Indiana Code 8-1-8.5. In addition to forecasts of electricity demand, the modeling system develops projections of electricity prices and determines the least-cost mix of future resource additions, given a specified set of options. The electricity price projections and resource selections are the primary focus of this effort.

Further information on the SUFG forecasting modeling system can be found in various forecast reports, which are available for free download at the SUFG website.

https://www.purdue.edu/discoverypark/sufg/

Questions should be directed to SUFG at:

State Utility Forecasting Group
Purdue University
Mann Hall, Room 160
203 S. Martin Jischke Drive
West Lafayette, IN 47907-1971
Phone: 765-494-4223
e-mail: sufg@purdue.edu

Introduction

This report is intended to provide information regarding the implications of different future outcomes of a variety of parameters, including the timing of retirement of coal-fired generators, natural gas prices, energy efficiency and customer self-generation. It does not represent a statewide integrated resource plan (IRP), since SUFG lacks sufficient information to produce such a plan. The results of various scenarios and sensitivities are meant to be informational rather than actionable. Furthermore, the scenarios modeled are not intended to represent specific realistic futures, but instead to move the needle sufficiently to see the impacts of different factors.

First, SUFG developed a reference scenario that forms the basis of comparison to other scenarios. Each of the scenarios then represents a change to a set of inputs from the reference scenario. Furthermore, sensitivities that include a price on carbon dioxide (CO2) emissions were performed on three of the scenarios.

It should be noted that some of the scenarios and sensitivities result in a large portion of the state's energy coming from intermittent, low inertia sources like wind and solar. The analysis does not address the operational challenges of very high reliance on these sources.

Process Description

SUFG Modeling System

The SUFG modeling system explicitly links electricity costs, prices and sales on a utility-by-utility basis under each scenario. Econometric and end-use models are used to project electricity use for each major customer group — residential, commercial and industrial — using fuel prices and economic drivers to simulate growth in electric energy use. The projections for each utility are developed from a consistent set of statewide economic, demographic and fossil fuel price projections. Detailed information for the economic, demographic and fuel price inputs are provided in Chapter 4 of SUFG's 2019 forecast report.[1]

In order to project electricity costs and prices, generation resource plans are developed for each utility and the operation of the generation system is simulated. This is done using the Aurora model from Energy Exemplar. These resource plans reflect "need" from both a statewide and utility perspective. It should be noted that energy storage is not included as an option for future resources due to resource limitations. SUFG has not had sufficient time to learn Aurora's energy storage modeling capabilities.

Retirements of existing generation resources are taken from currently filed utility IRPs. For the reference scenario included here, SUFG updated the retirements from the 2019 forecast to reflect the retirements included in the Indianapolis Power & Light (IPL) IRP filed in December 2019. The retirement of Hoosier Energy's Merom units are not included, since the announcement occurred too late in the process for this report.

Future electricity prices by utility and customer class are determined within the modeling system based on the cost of supplying electricity and the amount of electricity sales. These prices are then used as an input to the forecasting model. Prices affect the electricity demand, which in turn affects future resource needs, which affects costs, which affects price. Thus, SUFG solves the modeling system

[1] https://www.purdue.edu/discoverypark/sufg/docs/publications/2019%20forecast%20final.pdf

iteratively until equilibrium is reached. This means that each scenario will have its own unique set of demand and prices, even if no exogeneous inputs to the forecasting models were changed.

Utility-sponsored energy efficiency (EE) program and demand response information were estimated from utility IRP filings and from information collected directly from the utilities by SUFG. Note that the EE and DR estimates were not changed to include the IPL IRP. See Chapter 4 of the SUFG 2019 forecast report for more information on EE and demand response modeling.

Scenario Development

The various scenarios modeled for this report were determined by IURC staff with some stakeholder and SUFG input. SUFG worked with IURC staff to come up with modeling approaches to each scenario. The following scenarios were modeled and run through the SUFG modeling system.

- Reference
- Low renewables cost
- 2025 coal retirement moratorium
- 2030 coal retirement moratorium
- Additional EE
- Industrial self-generation
- High natural gas price

In addition, sensitivities were run incorporating a price on CO2 emissions for the reference, low renewables cost, and 2030 coal retirement moratorium scenarios.

Reference Scenario

Scenario description

The reference scenario uses the base scenario from the 2019 SUFG forecast as a starting point, with a few changes to the inputs. The description here will focus on those changes with the reader directed to the forecast report for more specific information on the 2019 base scenario.

The primary change between the 2019 base scenario is the update to unit retirements from the 2019 IPL IRP. Since the IRP was released after the forecast report was published, IPL unit retirements in the 2019 base scenario were based on the most recent IPL IRP at the time, which was released in 2016. Of particular interest are the retirements of Petersburg Unit 1 in 2021 and Petersburg Unit 2 in 2023. SUFG adjusted future capital and operating expenses associated with the retiring units based on utility-provided information. Additional adjustments were made to some modeling considerations to allow comparison across scenarios (e.g., annual maximum build constraints by utility and technology were relaxed).

The reference scenario serves as the primary point of comparison for the other scenarios.

Results

The resources selected by the Aurora model are shown in Table 1. The first significant resource needs occur in 2024. The Aurora model selects a balanced mix of natural gas combustion turbine, natural gas combined cycle, and wind capacity. Solar photovoltaic capacity is added in the last two years. While new coal-fired and nuclear-powered options were available, they were not selected in any of the scenarios.

Table 1. Indiana Resource Plan for Reference Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,313	25,175	-96	0	0	0	0	0	0
2020	19,325	25,429	254	0	0	0	0	0	0
2021	19,180	25,288	-141	0	0	0	0	0	0
2022	19,135	25,433	145	0	0	0	0	0	0
2023	19,100	23,688	-1,744	0	0	23	0	0	23
2024	19,210	21,347	-2,341	1,534	389	1,726	0	0	2,114
2025	19,305	21,348	1	1,646	411	1,818	2,884	0	5,113
2026	19,242	20,522	-826	2,397	787	2,089	5,449	0	8,324
2027	19,297	20,523	0	2,462	884	2,126	5,696	0	8,705
2028	19,342	19,398	-1,124	3,640	1,505	2,136	5,696	0	9,337
2029	19,415	17,775	-1,623	5,349	1,810	2,970	5,696	0	10,476
2030	19,659	17,370	-405	6,046	2,363	3,113	5,696	0	11,173
2031	19,831	17,258	-112	6,362	2,594	3,199	5,696	0	11,489
2032	20,015	16,846	-412	6,994	3,191	3,233	5,696	0	12,120
2033	20,209	15,136	-1,710	8,935	4,209	4,157	5,696	0	14,062
2034	20,399	13,496	-1,640	10,801	4,971	5,261	5,696	0	15,928
2035	20,688	13,286	-210	11,355	4,971	5,815	5,696	0	16,482
2036	20,904	13,236	-50	11,662	4,971	5,880	5,696	347	16,893
2037	21,149	13,211	-25	11,979	4,971	6,034	5,696	579	17,280

Figure 1 shows the energy mix by fuel source through the 20-year forecast horizon while Figure 2 shows the same information on a percentage basis for 2020, 2025, 2030, and 2035. Generation from coal declines by roughly 50% over time, with natural gas generation tripling. It should be noted that these figures exclude energy acquired through purchased power agreements, which is presently the manner in which Indiana utilities acquire wind energy. Thus, no wind energy is shown until the first Aurora-selected wind addition in 2025.

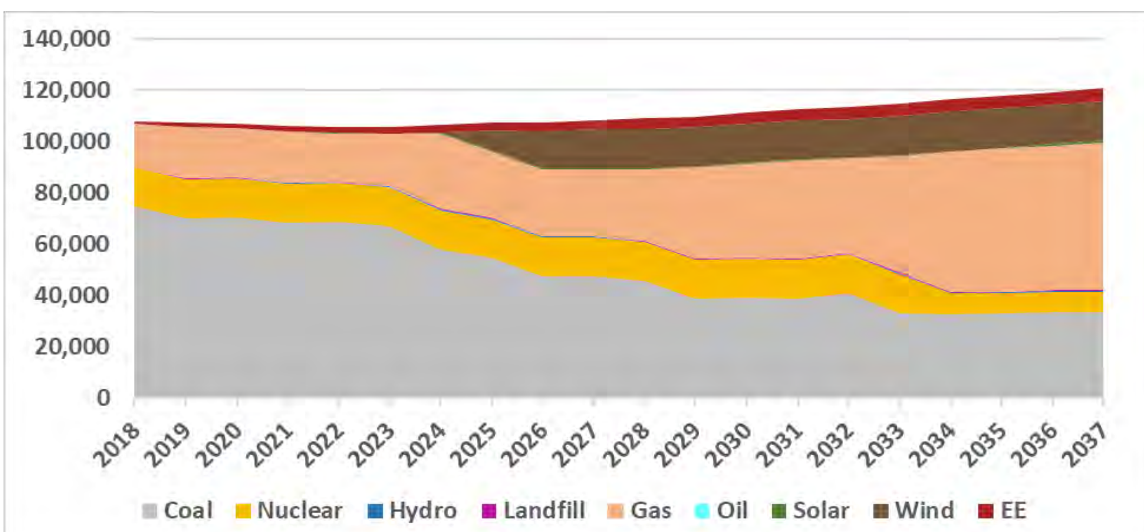

Figure 1. Electricity Supply by Resource for Reference Scenario (GWh)

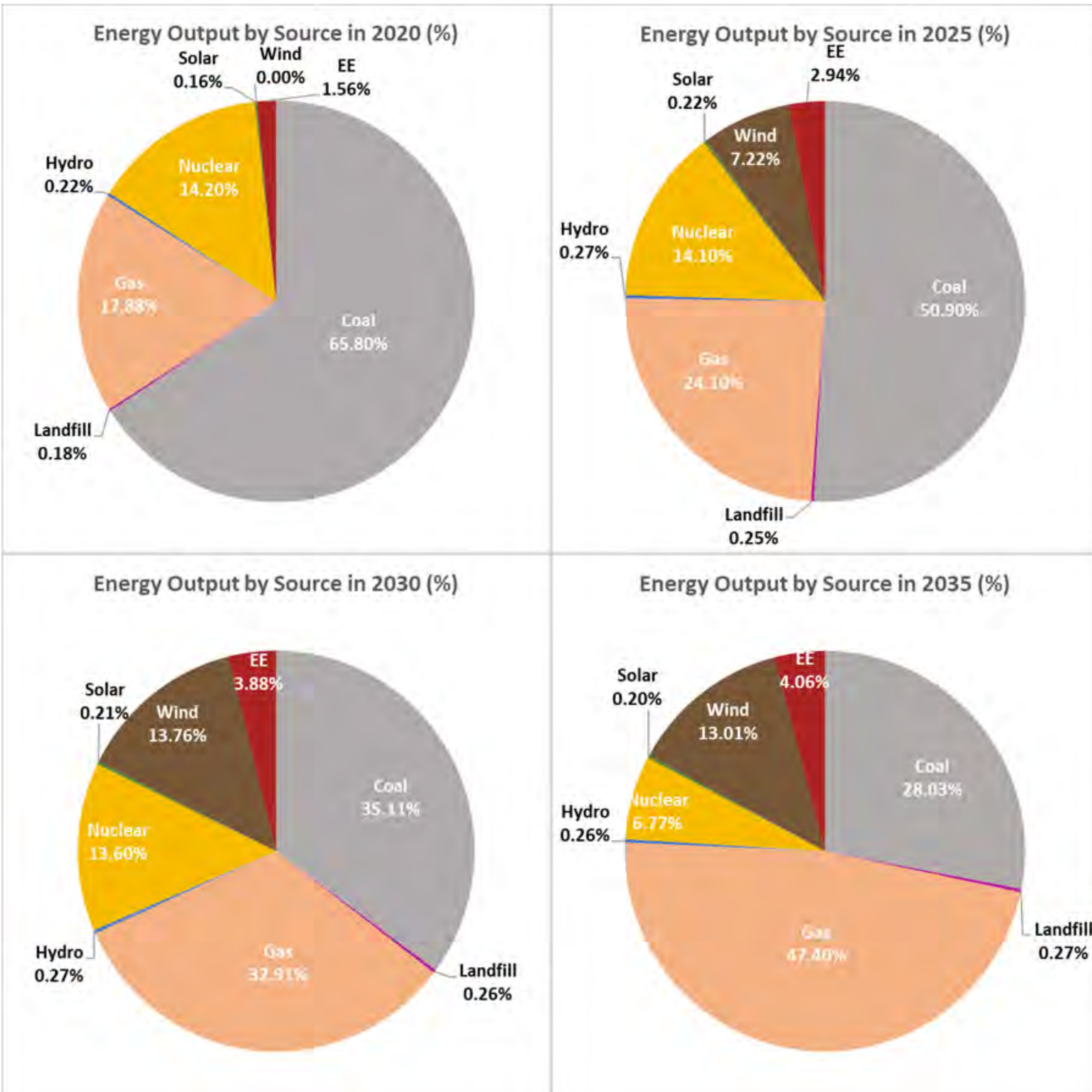

Figure 2. Energy Output by Source by Year for Reference Scenario (%)

Figure 3 shows the price trajectory for the reference scenario. Prices provided are an energy-weighted average across customer classes for the five investor-owned utilities.

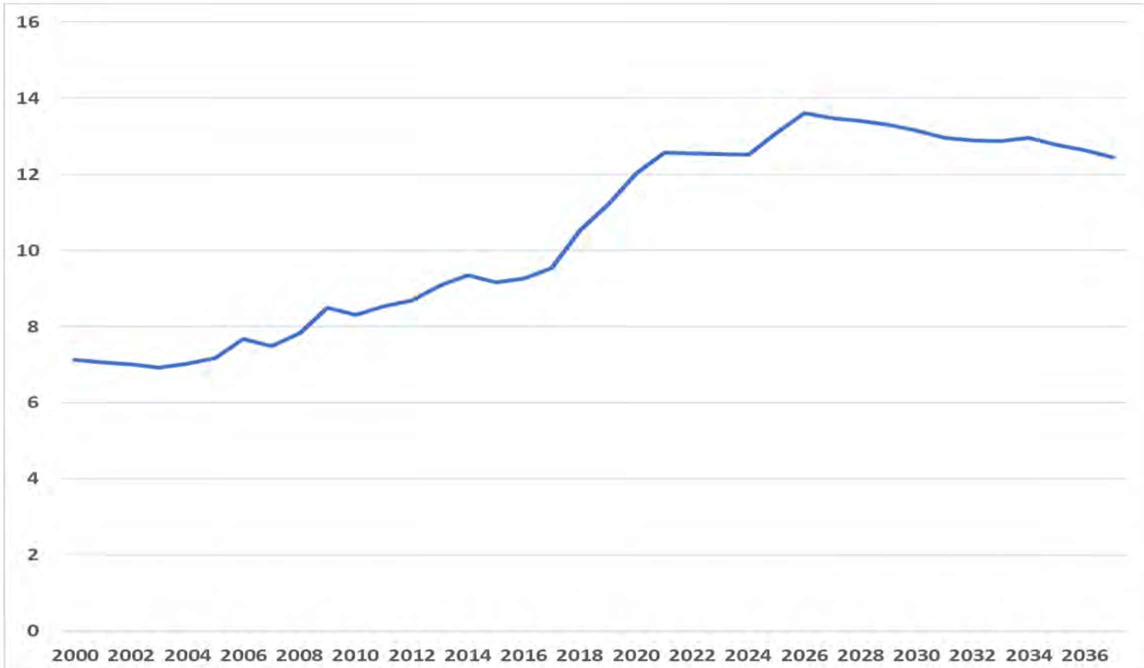

Figure 3. Indiana Electricity Price Projection for Reference Scenario (2017 cents/kWh)

Low Renewables Cost Scenario

Scenario description

As was the case with the 2019 base scenario, the reference scenario uses capital cost data from the Energy Information Association (EIA). There was some concern expressed by stakeholders that EIA's capital costs for wind and solar were higher than the levels indicated in other studies and in responses to utility requests for proposals. In order to see the impact of lower capital cost assumptions for renewable generation, this scenario was developed using cost assumptions from the National Renewable Energy Laboratory (NREL). In addition to using the lower starting costs values from NREL, the more aggressive cost reduction trajectory from NREL was used (the reference scenario used NREL's medium cost reduction rate).[2]

Results

As expected, lower capital costs for renewables resulted in more wind and solar being selected. Table 2 shows that more than 8,200 MW of solar is selected (as compared to 579 MW in the reference scenario), with solar being added much earlier (2024 vs. 2036). Wind capacity is also higher (9.5 GW vs. 5.7 GW). Between the natural gas-fired options, combined cycle additions were down significantly (3.7 GW vs. 6.0 GW), while combustion turbine additions were largely unaffected (5.1 GW vs. 5.0 GW).

[2] https://atb.nrel.gov/

Table 2. Indiana Resource Plan for Low Renewables Cost Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,316	25,175	-96	0	0	0	0	0	0
2020	19,329	25,429	254	0	0	0	0	0	0
2021	19,193	25,288	-141	0	0	0	0	0	0
2022	19,151	25,433	145	0	0	0	0	0	0
2023	19,119	23,688	-1,744	0	0	23	0	0	23
2024	19,258	21,347	-2,341	1,591	836	1,222	0	131	2,189
2025	19,359	21,348	1	1,710	915	1,267	2,975	170	5,327
2026	19,332	20,522	-826	2,504	1,618	1,292	6,255	432	9,597
2027	19,428	20,523	0	2,618	1,698	1,470	6,255	504	9,926
2028	19,509	19,398	-1,124	3,839	2,046	1,478	6,255	849	10,627
2029	19,609	17,775	-1,623	5,580	2,900	1,878	6,582	933	12,292
2030	19,869	17,370	-405	6,296	2,900	1,878	6,608	4,330	15,716
2031	20,076	17,258	-112	6,655	2,900	1,878	6,608	4,872	16,258
2032	20,283	16,846	-412	7,313	3,353	1,878	7,350	5,005	17,585
2033	20,517	15,136	-1,710	9,302	3,950	2,462	7,350	6,093	19,853
2034	20,732	13,496	-1,640	11,198	4,636	3,351	7,434	7,451	22,872
2035	21,050	13,286	-210	11,787	4,636	3,377	8,511	7,719	24,244
2036	21,327	13,236	-50	12,167	4,952	3,663	8,979	7,872	25,467
2037	21,641	13,211	-25	12,566	5,075	3,663	9,530	8,257	26,525

Figures 4 and 5 show the energy mix by fuel source for the low renewables cost scenario. In comparison to the reference scenario, the low renewables cost scenario gets much more of its energy from wind and solar (about 30% vs. 13% by the end of the analysis period). Renewables primarily displace natural gas as an energy source, with coal largely unchanged. This scenario achieves the most balanced blend of energy sources, with 27% coal, 33 % natural gas, and 29% wind and solar in 2035.

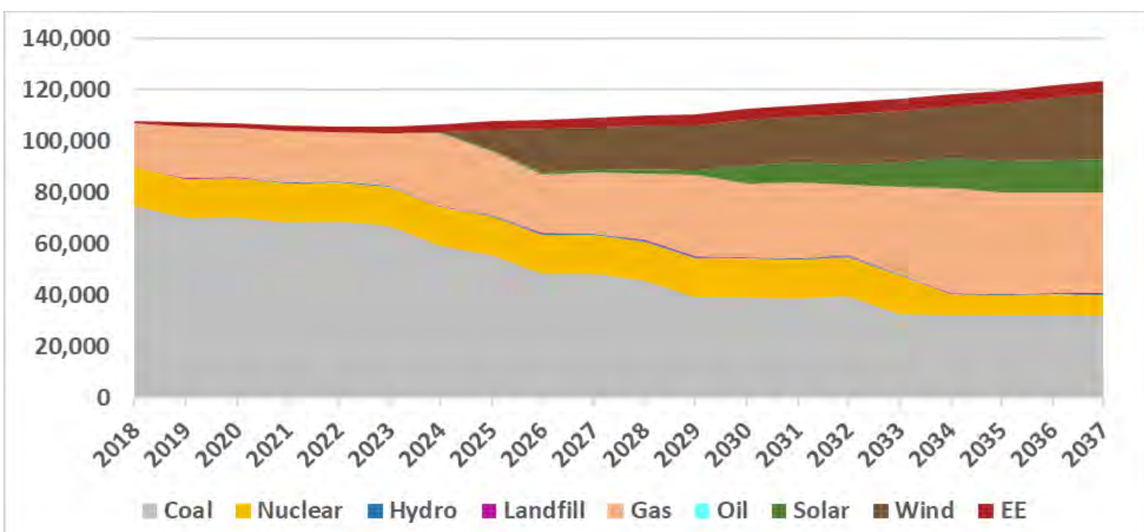

Figure 4. Electricity Supply by Resource for Low Renewables Cost Scenario (GWh)

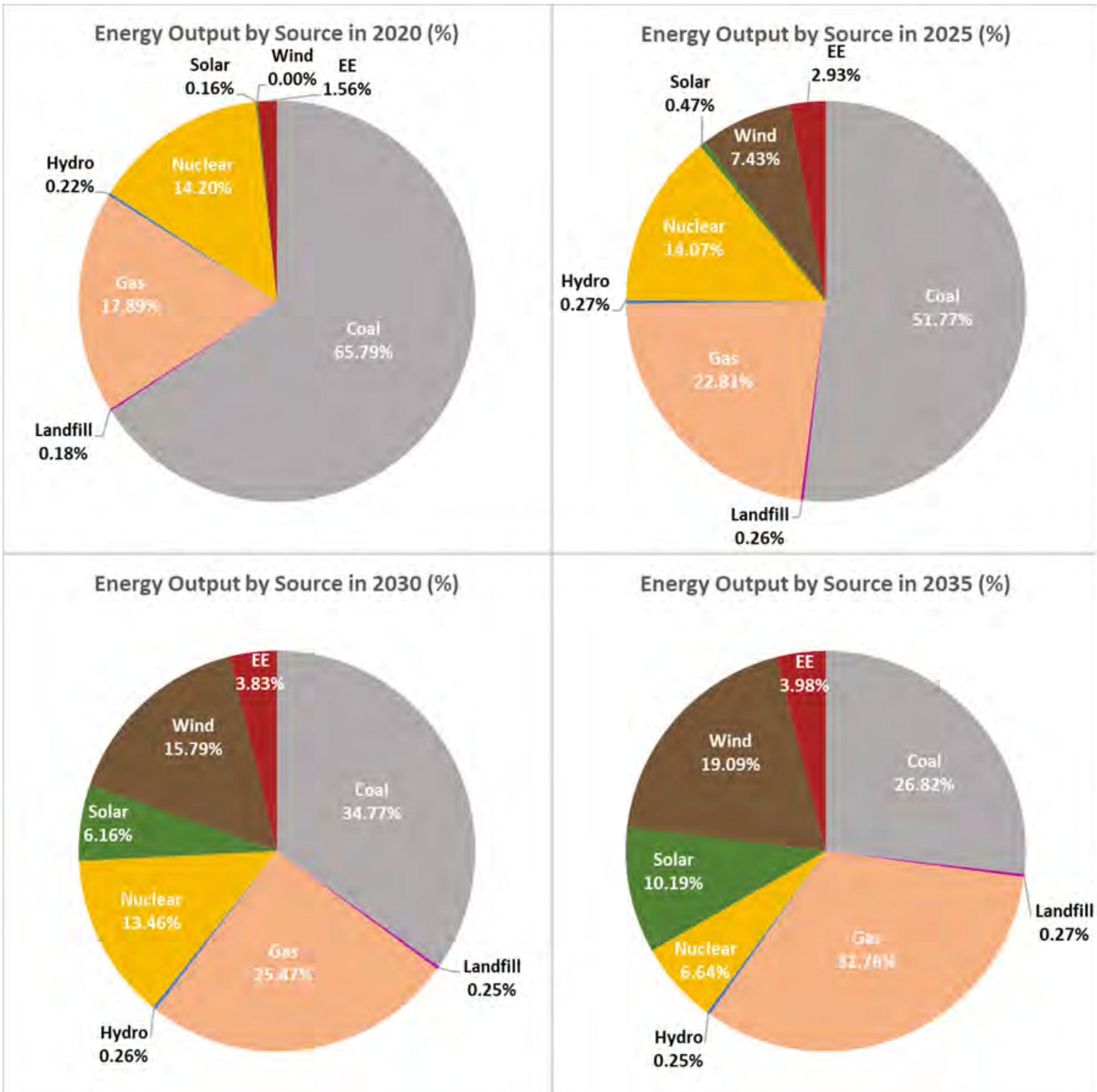

Figure 5. Energy Output by Source by Year for Low Renewables Cost Scenario (%)

Figure 6 shows the price trajectory for the low renewables cost and reference scenarios. As expected, lower capital costs for some options result in lower electricity prices.

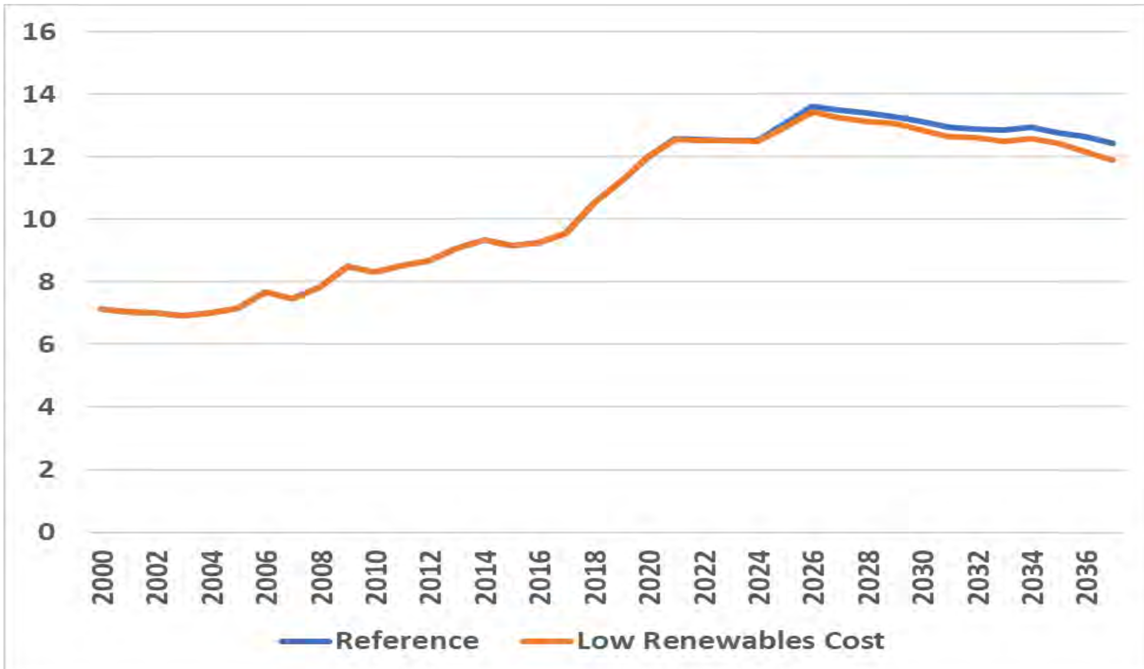

Figure 6. Indiana Electricity Price Projection for Reference and Low Renewables Cost Scenarios (2017 cents/kWh)

2025 Moratorium Scenario

Scenario description

The 2025 moratorium scenario is one of two scenarios that examine the impacts of delaying the scheduled retirement of coal-fired generators. For this scenario, coal retirements are not allowed to retire prior to the end of 2025. Exceptions to this are Duke Energy's Gallagher units 2 & 4 which cannot continue operation past the date of the Consent Decree and I&M's Rockport Unit 2 due the expiration of the lease agreement. The units affected by the moratorium are retired in the model as of the start of 2026.

A key input to this scenario is the necessary capital investments and operating and maintenance (O&M) costs necessary to keep a unit with a planned or projected retirement prior to 2025 in commercial operation through 2025. This data was provided by all five investor-owned utilities.

Results

While the moratorium pushes back the need for new resources from 2024 to 2026, it has little long-term influence on the mix of resources selected. As can be seen in Table 3, the Aurora model selects a balanced mix of natural gas combustion turbine, natural gas combined cycle, and wind capacity. Solar capacity is added in the last two years. These are all similar to the reference scenario.

Table 3. Indiana Resource Plan for 2025 Moratorium Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,316	25,175	-96	0	0	0	0	0	0
2020	19,324	25,429	254	0	0	0	0	0	0
2021	19,169	25,500	71	0	0	0	0	0	0
2022	19,106	25,645	145	0	0	0	0	0	0
2023	19,057	24,315	-1,329	0	0	23	0	0	23
2024	19,111	24,126	-189	0	0	23	0	0	23
2025	19,250	24,127	1	0	0	46	0	0	46
2026	19,260	20,522	-3,605	2,419	1,003	1,840	5,917	0	8,760
2027	19,316	20,523	0	2,485	1,089	1,903	6,082	0	9,074
2028	19,370	19,398	-1,124	3,674	1,712	1,917	6,082	0	9,711
2029	19,448	17,775	-1,623	5,389	2,035	2,746	6,082	0	10,863
2030	19,686	17,370	-405	6,078	2,661	2,808	6,082	0	11,551
2031	19,860	17,258	-112	6,397	2,943	2,846	6,082	0	11,871
2032	20,053	16,846	-412	7,039	3,578	2,853	6,082	0	12,512
2033	20,259	15,136	-1,710	8,995	4,516	3,870	6,082	0	14,468
2034	20,465	13,496	-1,640	10,880	5,096	5,176	6,082	0	16,354
2035	20,769	13,286	-210	11,452	5,096	5,747	6,082	0	16,925
2036	20,999	13,236	-50	11,776	5,096	5,831	6,082	343	17,352
2037	21,259	13,211	-25	12,111	5,096	5,831	6,082	823	17,832

Figures 7 and 8 show the energy mix by fuel source for the 2025 moratorium scenario. The energy picture follows a similar path as the resource additions. Energy from various sources is stable through 2025. As coal units begin retiring in 2026, coal-fired generation drops and energy from wind and natural gas increases. The long-term mix is quite similar to the reference scenario.

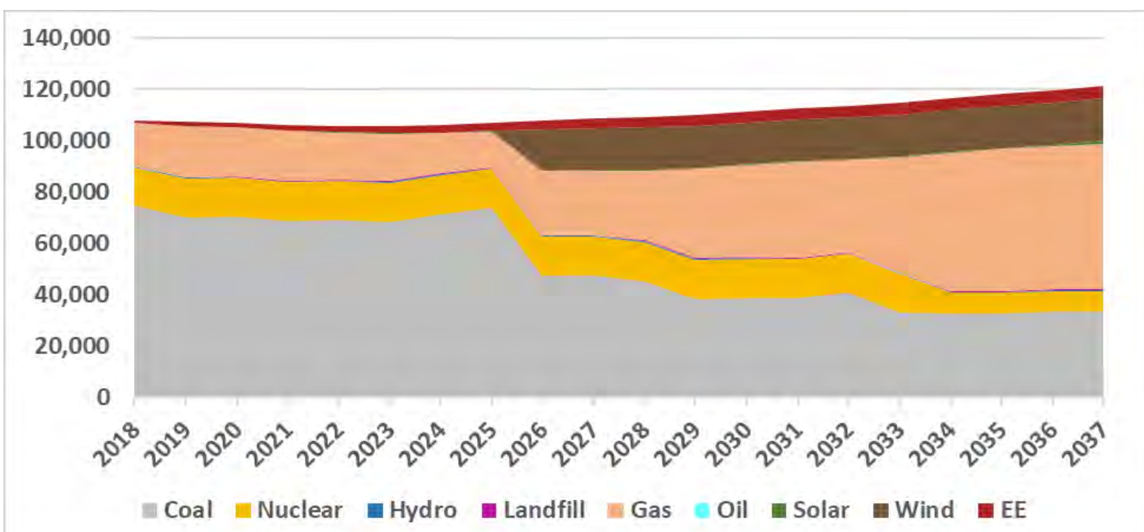

Figure 7. Electricity Supply by Resource for 2025 Moratorium Scenario (GWh)

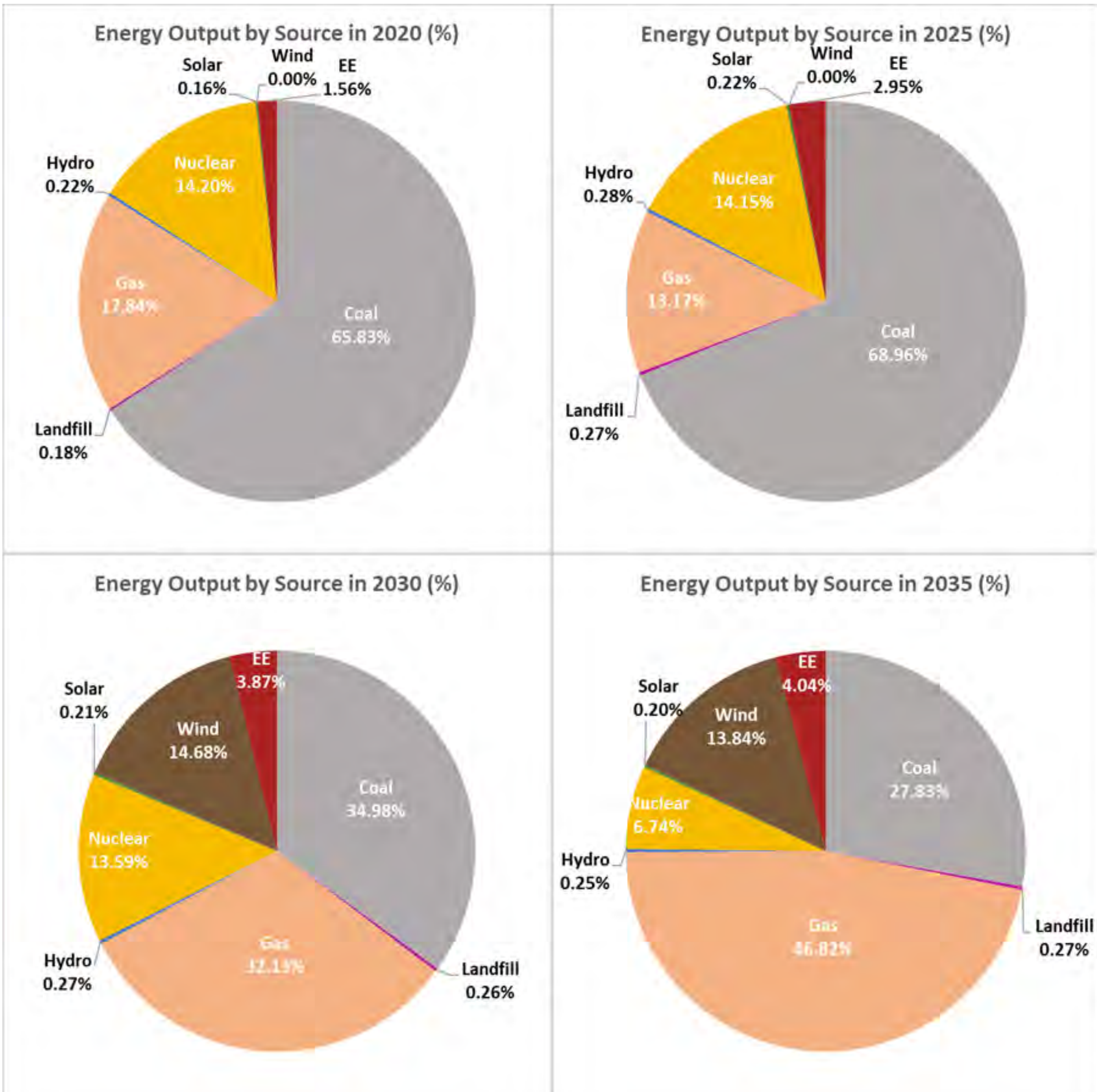

Figure 8. Energy Output by Source by Year for 2025 Moratorium Scenario (%)

Figure 9 shows the price trajectory for the 2025 moratorium and reference scenarios. Electricity prices are generally slightly (1-2%) higher in the 2025 moratorium scenario, as the costs associated with extending the life of the affected units offset the cost of replacement capacity.

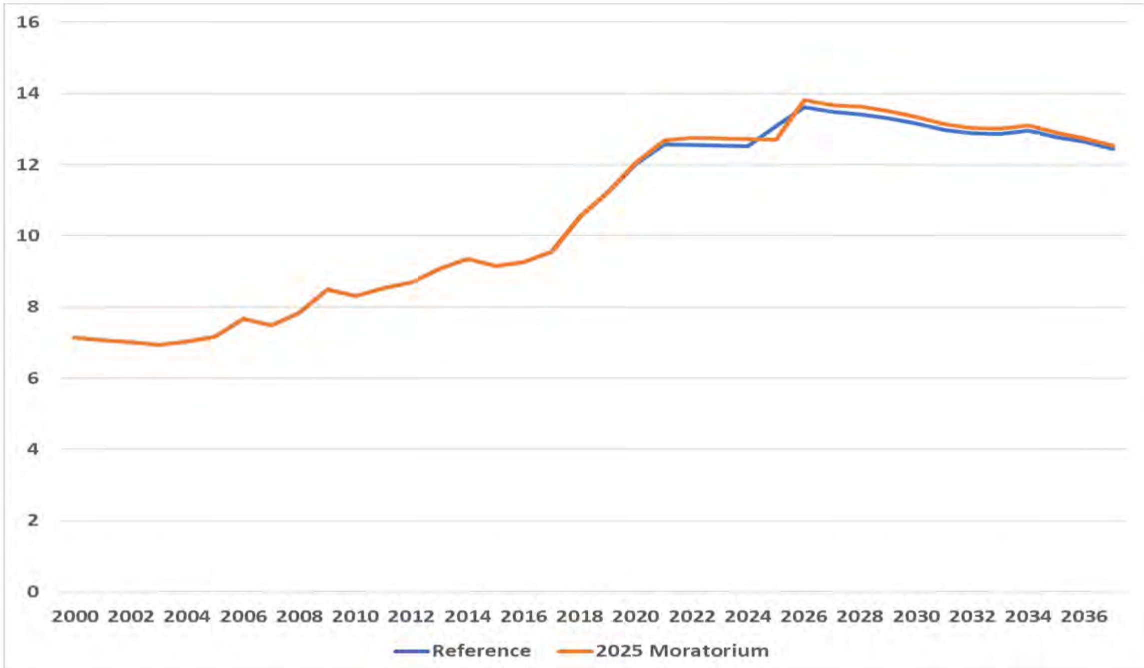

Figure 9. Indiana Electricity Price Projection for Reference and 2025 Moratorium Scenarios (2017 cents/kWh)

2030 Moratorium Scenario

Scenario description

This scenario is similar to the 2025 moratorium scenario but extends the restrictions to coal unit retirements through the end of 2030. In addition to the three exceptions in 2025 moratorium scenario, Rockport Unit 1 cannot operate beyond 2028 given it is subject to a Consent Decree. For this scenario, utilities provided capital and O&M costs associated with keeping the affected plants operational through 2030. Affected units were retired in the model at the start of 2031.

Results

The moratorium delays resource needs to 2026, with significant new resources in 2031 when the deferred retirements occur. The mix of resources change relative to the reference scenario, with less wind (2.1 GW vs. 5.7 GW) and combustion turbines (4.3 GW vs. 5.0 GW) and more combined cycle generators (7.4 GW vs. 6.0 GW). Solar is similar to the reference case with additions occurring in the last two years. Table 4 provides the resource mix selected by the model.

Table 4. Indiana Resource Plan for 2030 Moratorium Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,316	25,175	-96	0	0	0	0	0	0
2020	19,321	25,429	254	0	0	0	0	0	0
2021	19,161	25,500	71	0	0	0	0	0	0
2022	19,084	25,645	145	0	0	0	0	0	0
2023	19,021	24,315	-1,329	0	0	23	0	0	23
2024	19,041	24,126	-189	0	0	23	0	0	23
2025	19,134	24,127	1	0	0	46	0	0	46
2026	19,196	23,923	-204	0	21	140	2,115	0	2,276
2027	19,302	23,924	0	0	330	162	2,115	0	2,607
2028	19,394	23,774	-149	0	330	176	2,115	0	2,621
2029	19,511	22,600	-1,174	639	735	577	2,115	0	3,426
2030	19,777	22,195	-405	1,361	806	669	2,115	0	3,590
2031	19,973	17,258	-4,937	6,531	3,279	3,041	2,115	0	8,435
2032	20,184	16,846	-412	7,195	3,731	3,253	2,115	0	9,098
2033	20,404	15,136	-1,710	9,167	3,731	5,225	2,115	0	11,071
2034	20,614	13,496	-1,640	11,057	4,329	6,517	2,115	0	12,960
2035	20,919	13,286	-210	11,631	4,329	7,091	2,115	0	13,534
2036	21,155	13,236	-50	11,962	4,329	7,244	2,115	253	13,941
2037	21,428	13,211	-25	12,312	4,329	7,403	2,115	528	14,374

Figures 10 and 11 show the energy mix by fuel source for the 2030 moratorium scenario. As expected, energy from coal does not begin to decrease significantly until after the moratorium ends, with over 60% of energy coming from coal in 2030 (as compared to 35% in the reference case). At the end of the analysis period, over half of the energy is coming from natural gas.

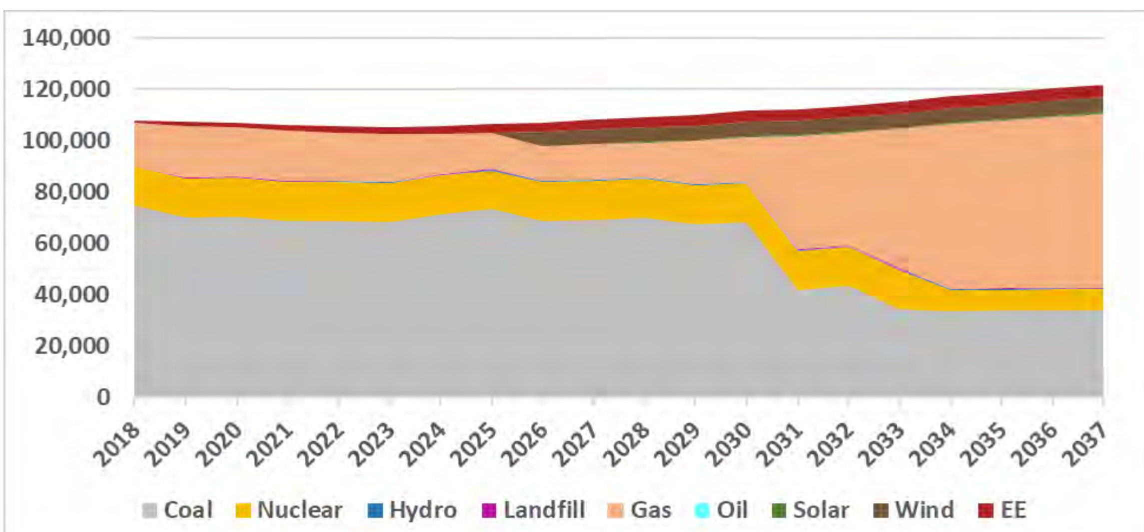

Figure 10. Electricity Supply by Resource for 2030 Moratorium Scenario (GWh)

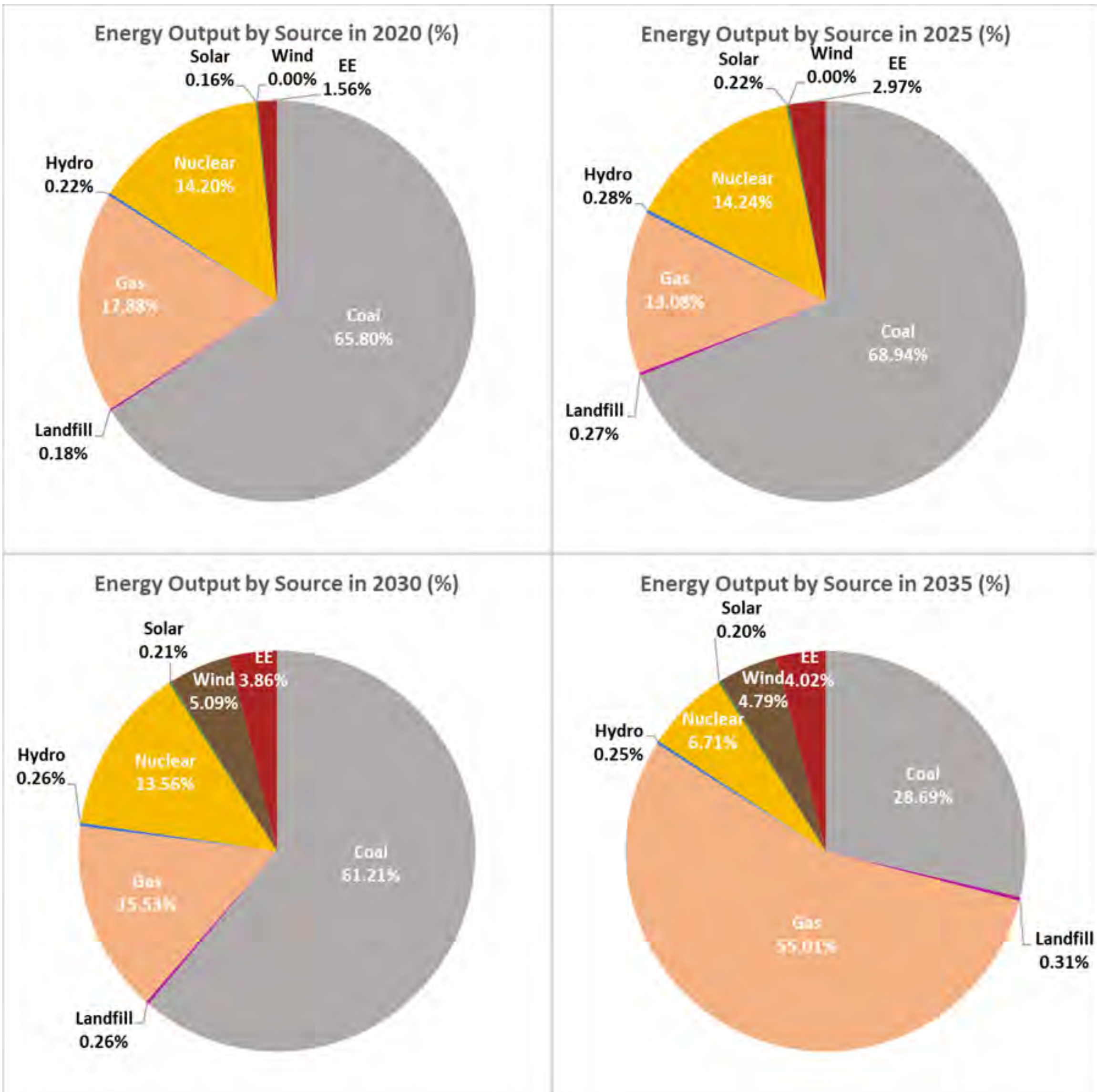

Figure 11. Energy Output by Source by Year for 2030 Moratorium Scenario (%)

Figure 12 shows the price trajectory for the 2030 moratorium and reference scenarios. Electricity prices are 1-4% higher in the short term (2021-2024) under the 2030 moratorium scenario and virtually unchanged in the long term.

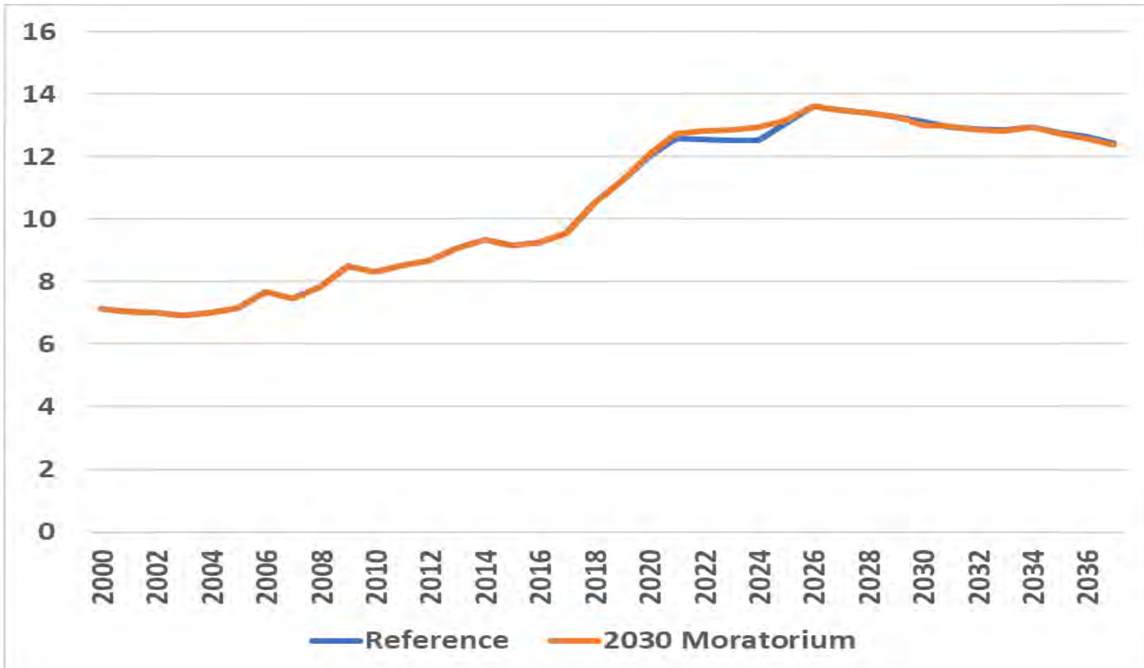

Figure 12. Indiana Electricity Price Projection for Reference and 2030 Moratorium Scenarios (2017 cents/kWh)

Additional EE Scenario

Scenario description

This scenario examines the impacts of more aggressive EE efforts by the utilities. Since SUFG lacks information on the potential for and costs of higher levels of utility-sponsored efficiency, a simplified approach was used. SUFG doubled the amount of EE identified in the IRPs at double the total cost, with the exception of NIPSCO.[3] It should be noted that this likely results in an understatement of EE program costs, since it is probable that the incremental EE (which was not selected in the IRP process) would be more expensive than the EE programs that were selected. Rather than arbitrarily choose a higher cost that could be either too high or too low, SUFG opted to use a cost where the direction of the likely error was known, even if the magnitude was not.

Results

Table 5 shows the resources selected by the model. Total resources are lower than in the reference scenario due to the reduction in demand from the higher EE. While wind (3.3 GW vs. 5.7 GW) and combustion turbine (3.8 GW vs. 5.0 GW) additions are lower, combined cycle (6.3 GW vs. 6.0 GW) and solar (1.4 GW vs. 0.6 GW) are higher.

---

[3] SUFG originally modeled double EE in NIPSCO, but found that this caused net sales to approach zero (EE savings roughly equal to pre-EE sales) in the residential and commercial sectors. This caused prices to rise to an unreasonably high level. Thus, NIPSCO's EE levels and costs were kept the same as in the reference scenario.

Table 5. Indiana Resource Plan for Additional EE Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,302	25,271		0	0	0	0	0	0
2019	19,077	25,175	-96	0	0	0	0	0	0
2020	19,047	25,429	254	0	0	0	0	0	0
2021	18,855	25,288	-141	0	0	0	0	0	0
2022	18,754	25,433	145	0	0	0	0	0	0
2023	18,672	23,688	-1,744	0	0	23	0	0	23
2024	18,705	21,347	-2,341	933	228	1,371	0	0	1,600
2025	18,802	21,348	1	1,047	256	1,789	1,484	0	3,529
2026	18,774	20,522	-826	1,840	600	2,019	2,999	0	5,618
2027	18,837	20,523	0	1,914	741	2,071	3,330	0	6,141
2028	18,889	19,398	-1,124	3,101	741	2,563	3,330	407	7,040
2029	18,962	17,775	-1,623	4,810	1,036	3,157	3,330	407	7,929
2030	19,220	17,370	-405	5,523	1,457	3,339	3,330	562	8,688
2031	19,392	17,258	-112	5,839	1,834	3,339	3,347	734	9,254
2032	19,563	16,846	-412	6,456	2,052	3,555	3,347	734	9,688
2033	19,755	15,136	-1,710	8,394	2,888	4,657	3,347	734	11,627
2034	19,947	13,496	-1,640	10,263	3,842	5,573	3,347	734	13,496
2035	20,246	13,286	-210	10,829	3,842	6,139	3,347	734	14,062
2036	20,464	13,236	-50	11,138	3,842	6,209	3,347	1,077	14,474
2037	20,716	13,211	-25	11,464	3,842	6,334	3,347	1,363	14,885

Figures 13 and 14 show the energy mix by fuel source for the additional EE scenario. The major differences between this scenario and the reference scenario are increased energy from EE programs and solar, with energy from wind roughly halved.

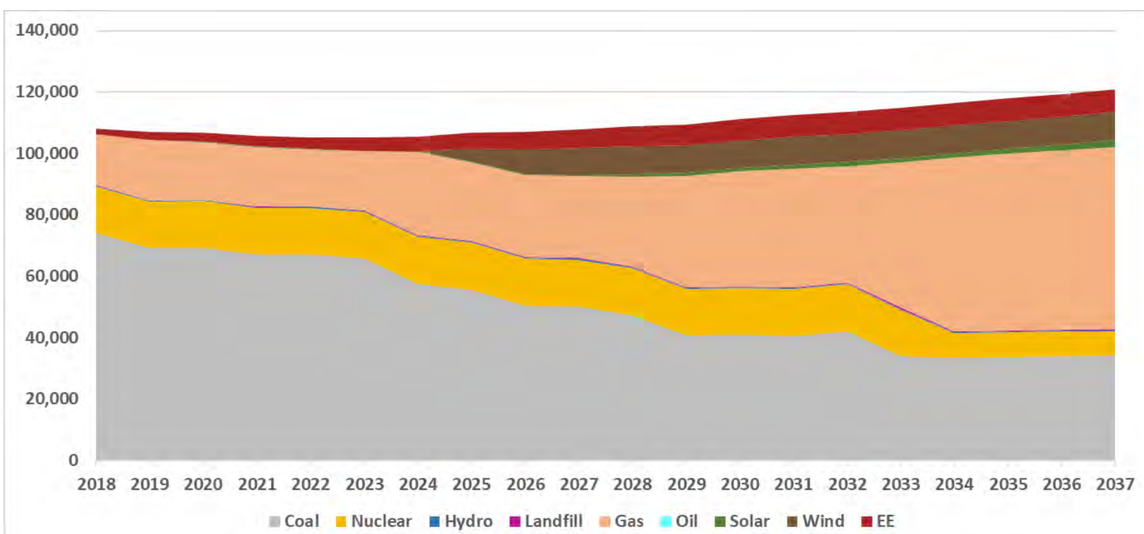

Figure 13. Electricity Supply by Resource for Additional EE Scenario (GWh)

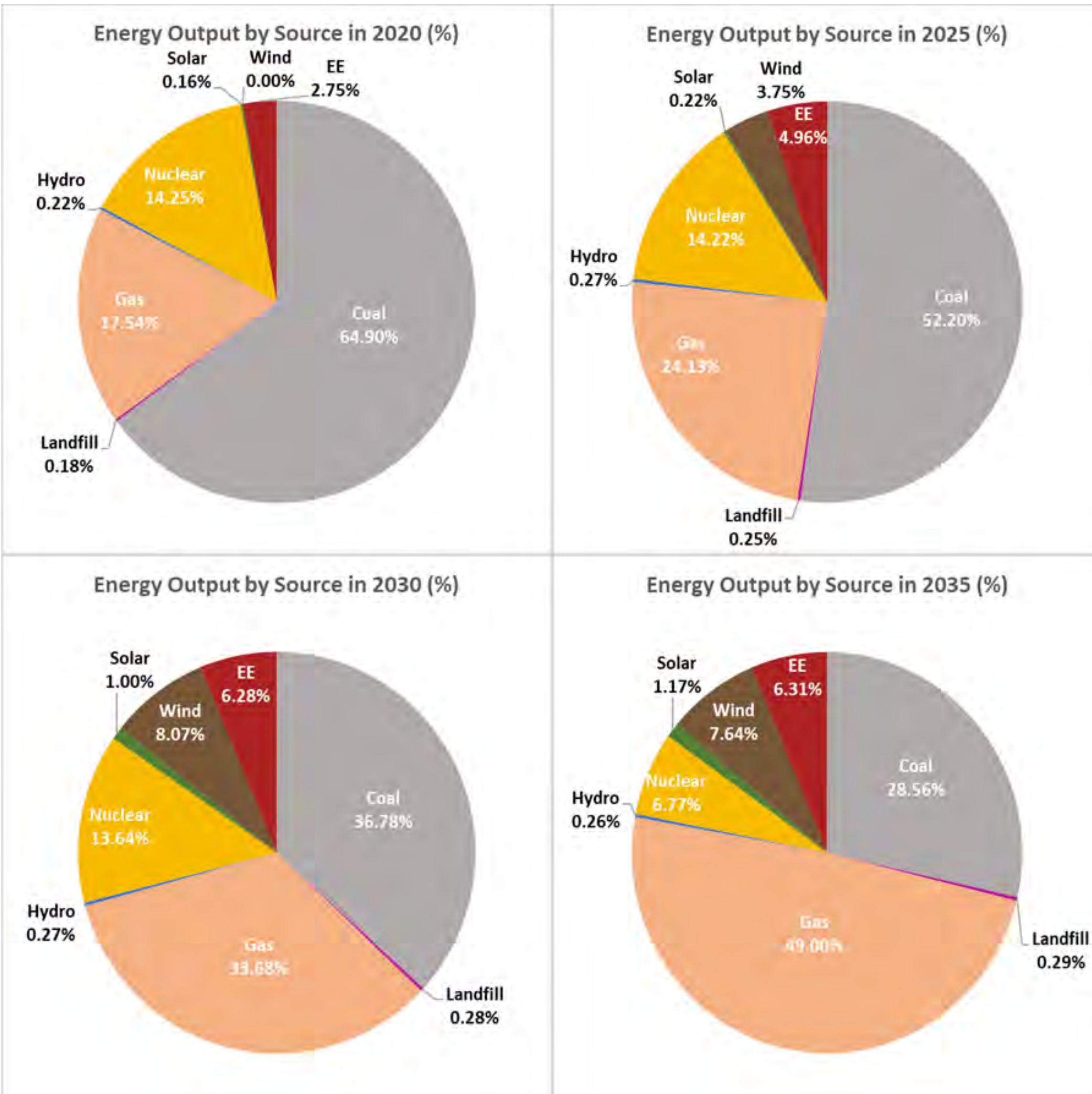

Figure 14. Energy Output by Source by Year for Additional EE Scenario (%)

Figure 15 shows the price trajectory for the additional EE and reference scenarios. Electricity prices are 2-3% higher through 2024 as there is little avoided cost of new resources and less than 1% higher in the long term under the additional EE scenario. It should be noted that while electricity prices may be higher in this scenario, energy usage is lower for the average customer. Thus, customer bills may be lower.

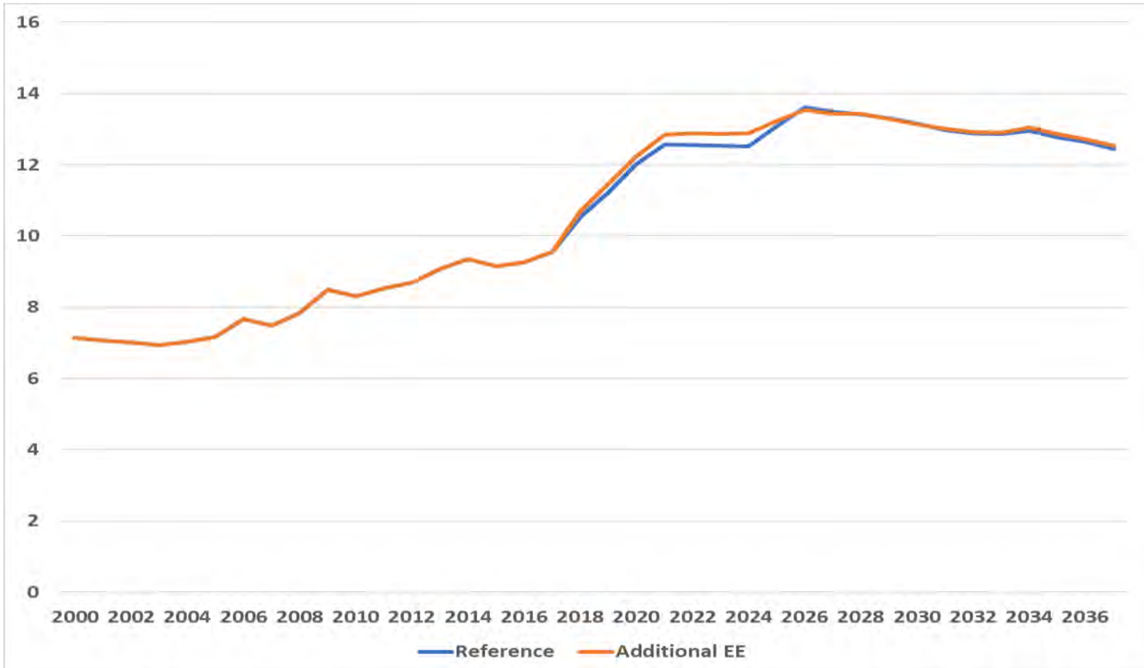

Figure 15. Indiana Electricity Price Projection for Reference and Additional EE Scenarios (2017 cents/kWh)

Industrial Self-Generation Scenario

Scenario description

This scenario examines the impact of the development of significant levels of self-generation, co-generation, and combined heat and power in the industrial sector. Since future industrial self and co-generation is highly uncertain and SUFG lacks the capability to credibly forecast these developments, a proxy was used such that self-generation completely offsets future growth in industrial electricity consumption. This was modeled by keeping the industrial load forecast flat across the state's IOUs. Note that SUFG's not-for-profit models are not at the sectoral level, so determining a flat industrial forecast for them is problematic. Also, since industrial sales in the reference scenario are declining through 2021, industrial sales are held constant at that level rather than from the beginning of the forecast period.

Results

Table 6 shows the resources selected by the model. While overall resource needs are lower than in the reference scenario due to the reduction in demand in the industrial sector, wind capacity additions are actually higher (6.3 GW vs. 5.7 GW). Combined cycle additions are significantly lower (4.9 GW vs. 6.0 GW), while combustion turbines (4.7 GW vs. 5.0 GW) and solar (0.4 GW vs. 0.6 GW) are slightly lower.

Table 6. Indiana Resource Plan for Industrial Self-Generation Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,317	25,175	-96	0	0	0	0	0	0
2020	19,331	25,429	254	0	0	0	0	0	0
2021	19,192	25,288	-141	0	0	0	0	0	0
2022	19,145	25,433	145	0	0	0	0	0	0
2023	19,111	23,688	-1,744	0	0	23	0	0	23
2024	19,192	21,347	-2,341	1,513	677	1,288	0	0	1,965
2025	19,246	21,348	1	1,576	699	1,367	2,570	0	4,636
2026	19,202	20,522	-826	2,349	1,075	1,638	5,982	0	8,695
2027	19,220	20,523	0	2,370	1,247	1,681	6,293	0	9,221
2028	19,209	19,398	-1,124	3,482	1,815	1,690	6,293	0	9,798
2029	19,214	17,775	-1,623	5,110	2,184	2,297	6,293	0	10,774
2030	19,354	17,370	-405	5,683	2,654	2,400	6,293	0	11,347
2031	19,404	17,258	-112	5,854	2,825	2,400	6,293	0	11,518
2032	19,453	16,846	-412	6,324	3,295	2,400	6,293	0	11,987
2033	19,516	15,136	-1,710	8,110	4,276	3,204	6,293	0	13,773
2034	19,603	13,496	-1,640	9,853	4,747	4,477	6,293	0	15,517
2035	19,768	13,286	-210	10,260	4,747	4,884	6,293	0	15,923
2036	19,845	13,236	-50	10,401	4,747	4,893	6,293	189	16,122
2037	19,950	13,211	-25	10,551	4,747	4,893	6,293	404	16,336

Figures 16 and 17 show the energy mix by fuel source for the industrial self-generation scenario. Energy from natural gas is lower relative to the reference scenario (about 8,600 GWh lower in 2037), while wind is higher (1,500 GWh higher in 2037). Other sources are almost unchanged. Note that the percentages may increase from those in the reference case because total energy is lower.

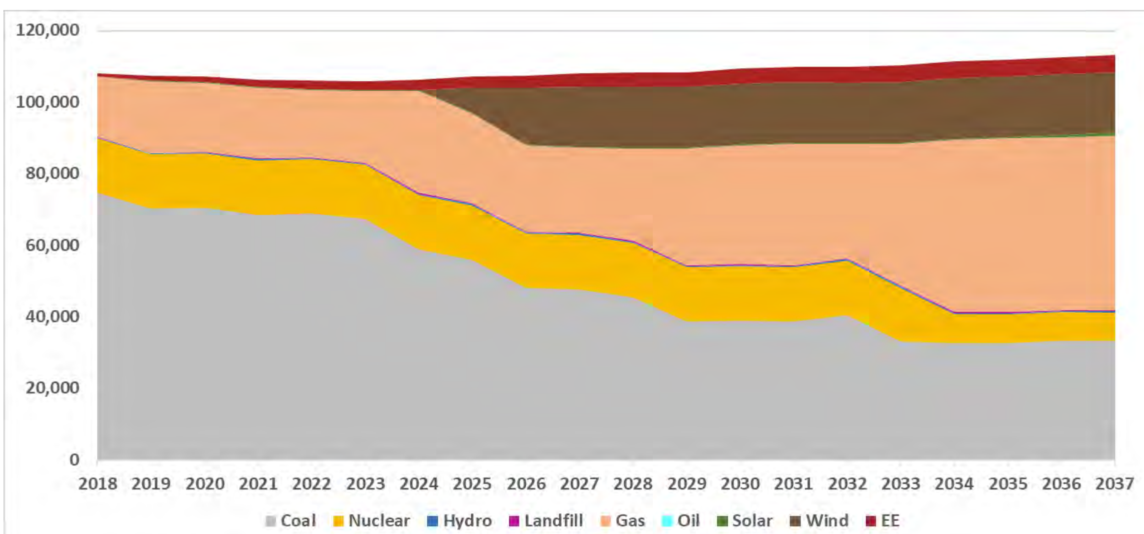

Figure 16. Electricity Supply by Resource for Industrial Self-Generation Scenario (GWh)

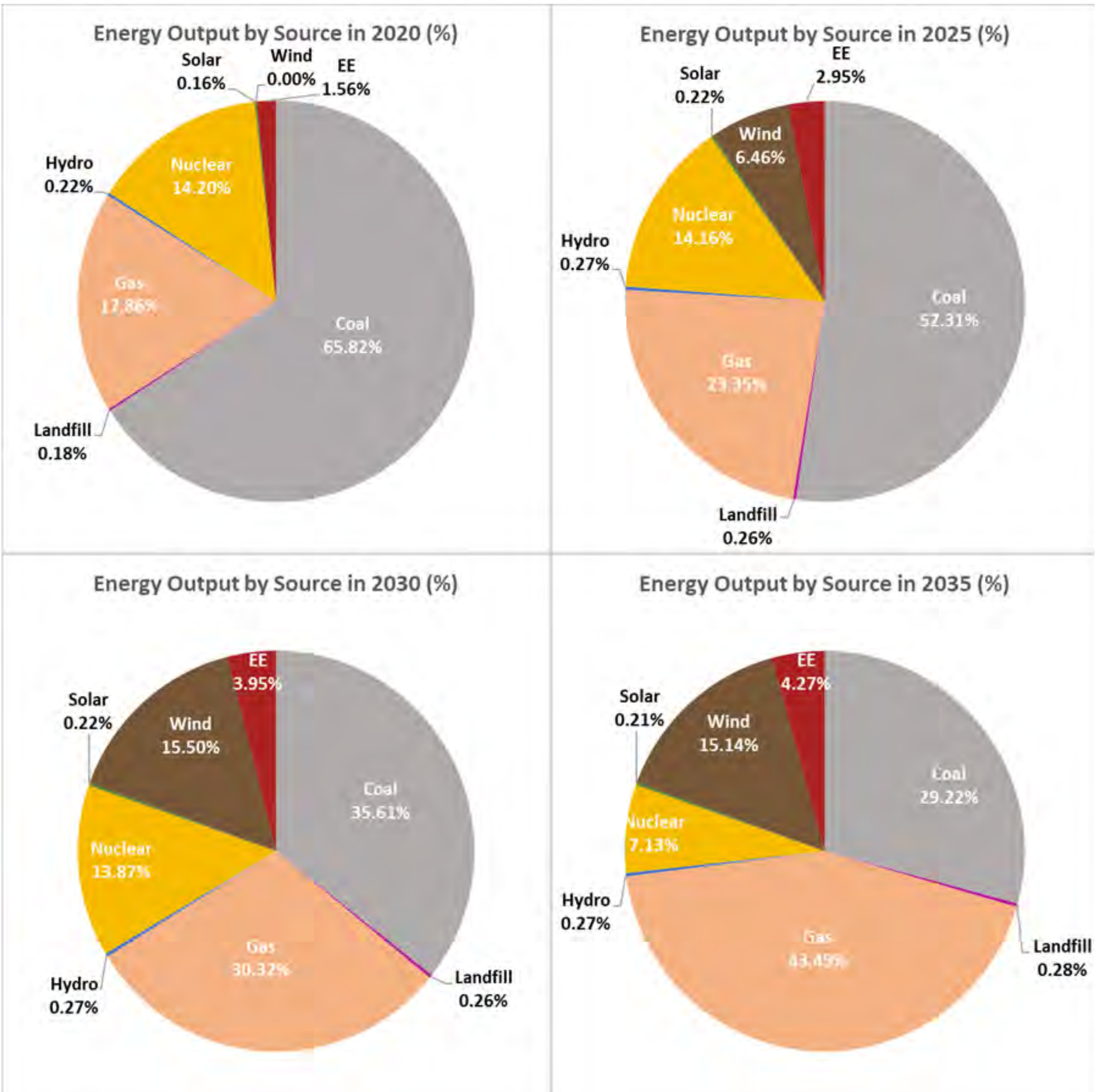

Figure 17. Energy Output by Source by Year for Industrial Self-Generation Scenario (%)

Figure 18 shows the price trajectory for the industrial self-generation and reference scenarios. Long-term prices are higher (1% in 2026 to 7% in 2037) as the reduction in sales is greater than the reduction in revenue requirements.

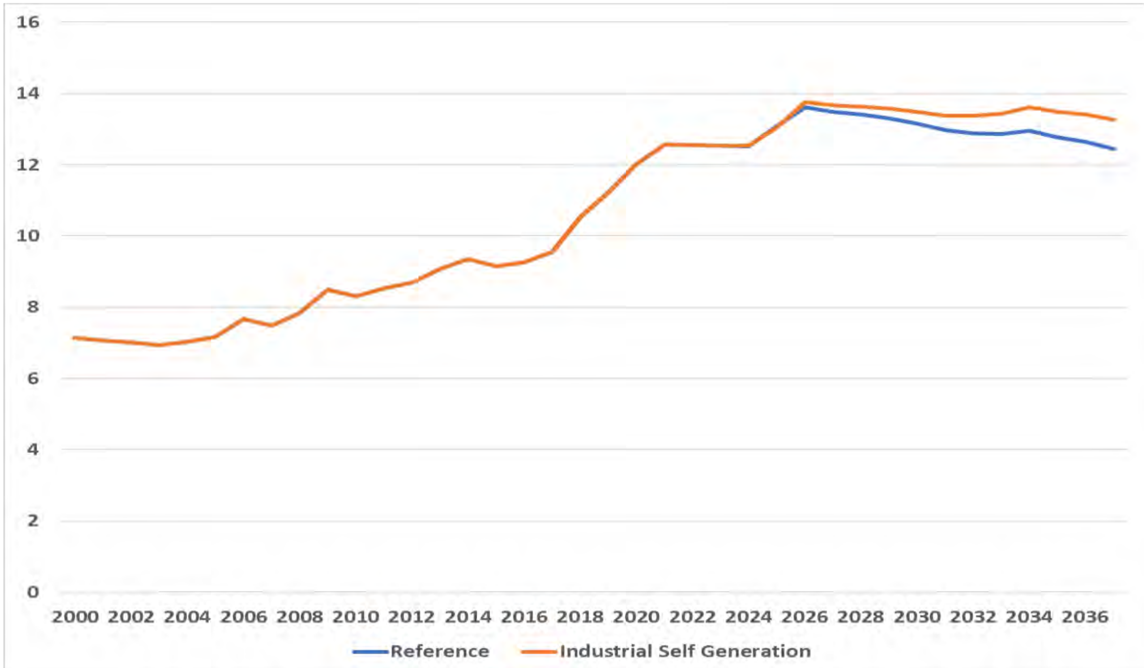

Figure 18. Indiana Electricity Price Projection for Reference and Industrial Self-Generation Scenarios (2017 cents/kWh)

High Natural Gas Price Scenario

Scenario description

This scenario models a high natural gas price future similar to that which might occur with a long-term moratorium on hydraulic fracturing (commonly referred to as fracking). Since the price of natural gas without fracking is purely speculative, an arbitrary, very high price ($10/mmBtu) was used. Since natural gas price is an input to various models within the modeling system, such as the forecasting models, the $10 price was set for the electric utility sector. Other sectors use the same price with an adjustment for typical differences in distribution costs.

Results

As shown in Table 7, the high natural gas price has a very large impact on the resources selected by the model. Natural gas combined cycle selections are dramatically lower than in the reference scenario (0.8 GW vs. 6.0 GW). Wind capacity is significantly higher (22.8 GW vs. 5.7 GW), with over 2 GW added as early as 2020 despite adequate resource capacity in place. Both solar (1.1 GW vs. 0.6 GW) and combustion turbine capacity (6.5 GW vs. 5.0 GW) are somewhat higher. Combustion turbines are used to supplement existing resources for times when wind output is low. It is possible that energy storage would have displaced the combustion turbines if that had been an option.

Table 7. Indiana Resource Plan for High Natural Gas Price Scenario (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,451	25,271		0	0	0	0	0	0
2019	19,507	25,175	-96	0	0	0	0	0	0
2020	19,597	25,429	254	0	0	0	2,304	0	2,304
2021	19,492	25,288	-141	0	0	0	2,475	0	2,475
2022	19,445	25,433	145	0	0	0	2,803	0	2,803
2023	19,311	23,688	-1,744	0	0	0	6,048	0	6,048
2024	19,153	21,347	-2,341	1,466	1,364	0	9,325	0	10,689
2025	19,144	21,348	1	1,454	1,367	0	9,698	0	11,065
2026	19,124	20,522	-826	2,256	2,018	0	11,228	0	13,245
2027	19,147	20,523	0	2,284	2,163	0	11,616	26	13,804
2028	19,113	19,398	-1,124	3,367	3,210	0	13,896	26	17,132
2029	19,069	17,775	-1,623	4,938	3,374	263	15,971	97	19,704
2030	19,217	17,370	-405	5,519	3,839	354	16,270	97	20,560
2031	19,281	17,258	-112	5,707	4,187	388	17,132	120	21,828
2032	19,371	16,846	-412	6,226	4,246	594	17,435	146	22,420
2033	19,382	15,136	-1,710	7,950	4,895	848	21,532	602	27,877
2034	19,395	13,496	-1,640	9,605	6,429	848	22,392	618	30,287
2035	19,541	13,286	-210	9,989	6,469	848	22,392	618	30,328
2036	19,644	13,236	-50	10,162	6,469	848	22,586	837	30,741
2037	19,809	13,211	-25	10,384	6,469	848	22,764	1,129	31,210

Figures 19 and 20 show the energy mix by fuel source for the high natural gas price scenario. In this scenario, wind becomes the largest source of energy, producing almost half of the energy at the end of the analysis period. Energy from natural gas is about 1/3 of the amount in the reference case. Energy from coal is also down somewhat as the units are utilized more in a cycling mode to adjust for the variability of the wind output.

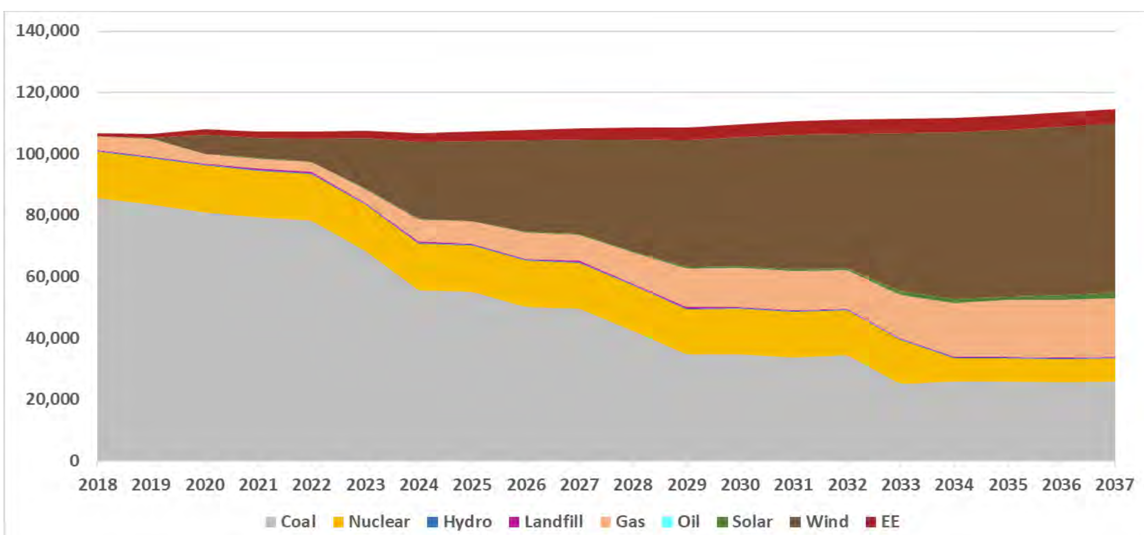

Figure 19. Electricity Supply by Resource for High Natural Gas Price Scenario (GWh)

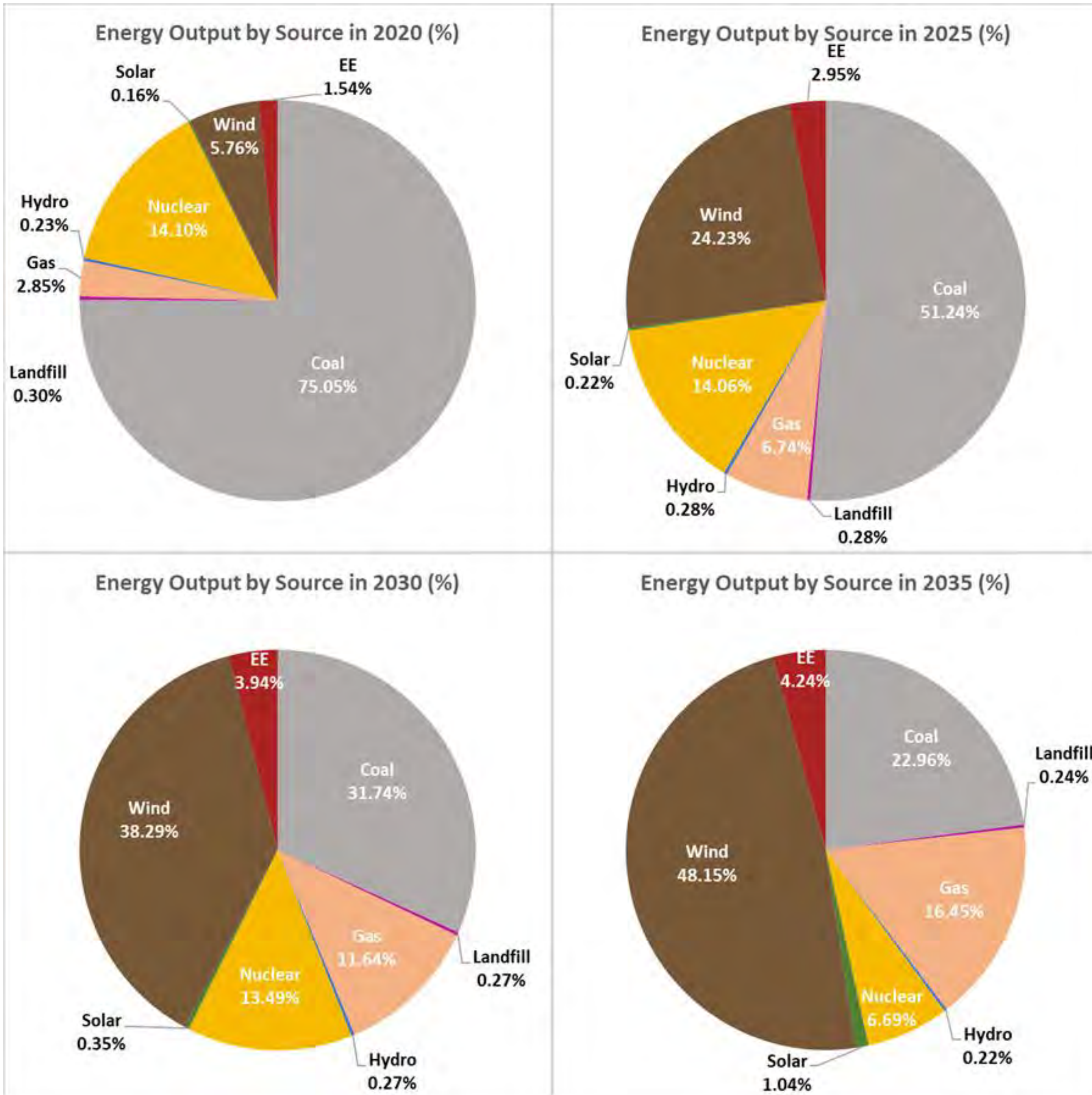

Figure 20. Energy Output by Source by Year for High Natural Gas Price Scenario (%)

Figure 21 shows the price trajectory for the high natural gas price and reference scenarios. Prices are 1-2% higher through 2022, then increase to over 20% higher late in the analysis period.

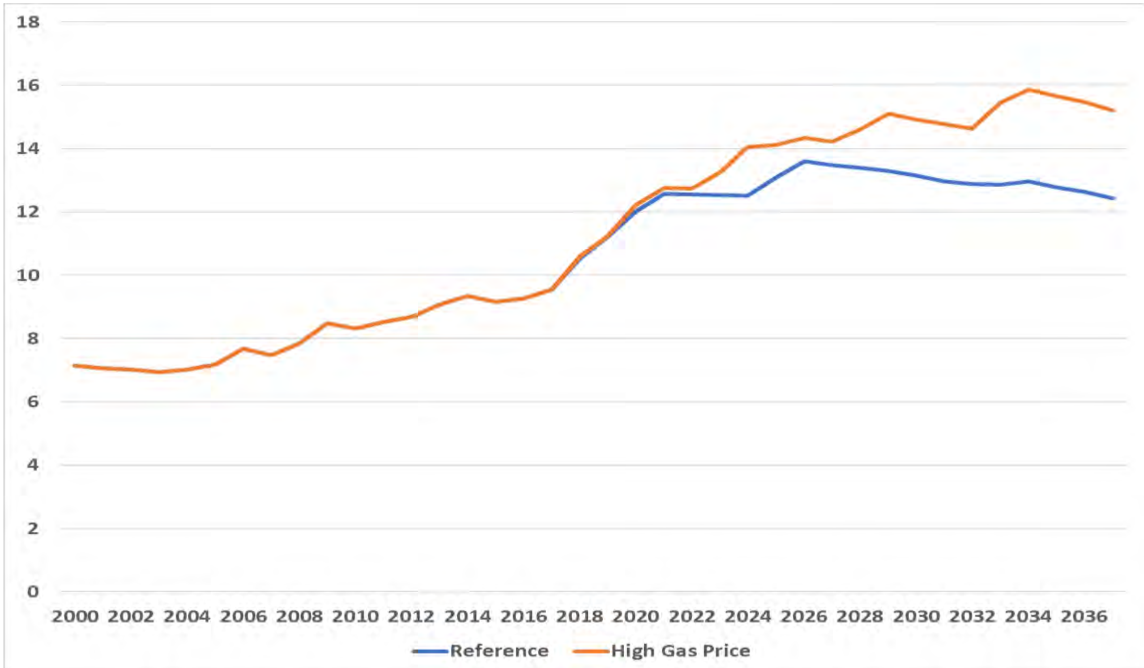

Figure 21. Indiana Electricity Price Projection for Reference and High Natural Gas Price Scenarios (2017 cents/kWh)

Comparison Across Scenarios

Figure 22 provides the total resource additions and Figure 23 provides the electricity prices across all scenarios.

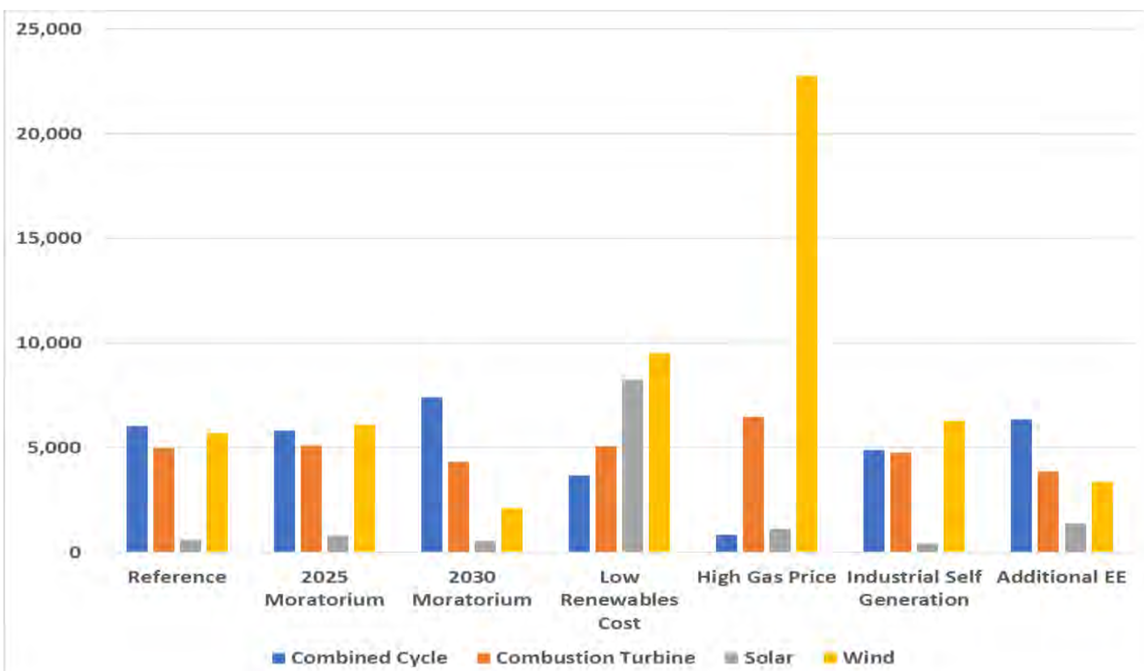

Figure 22. Resource Additions by Type through 2037 for All Scenarios (MW)

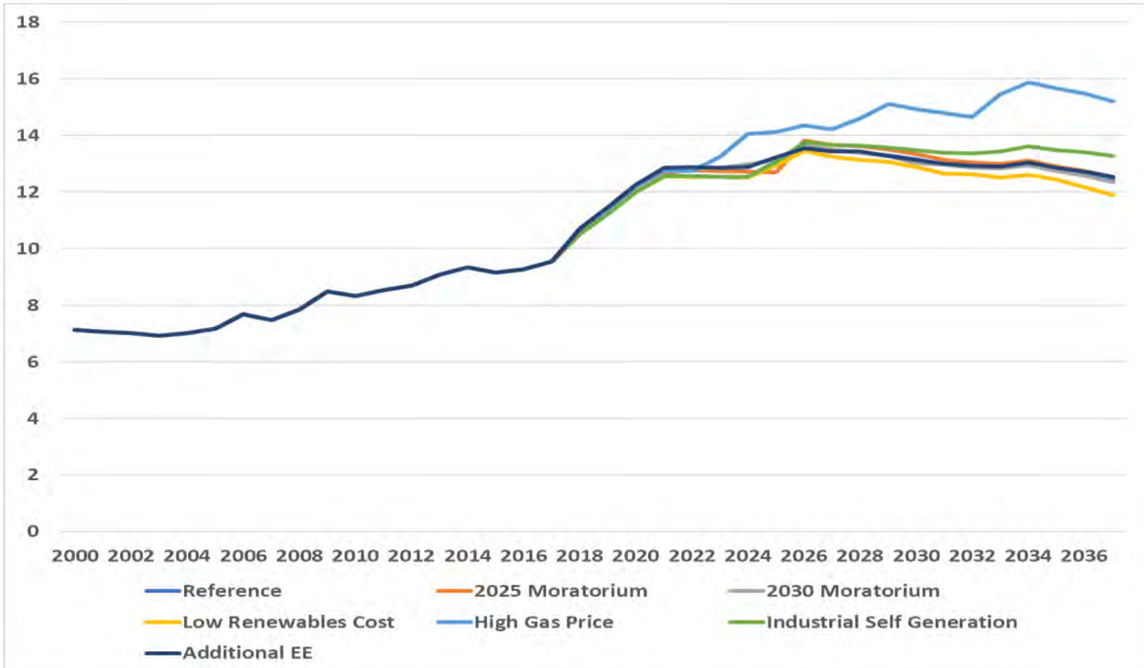

Figure 23. Indiana Electricity Price Projection for All Scenarios (2017 cents/kWh)

Carbon Price Sensitivities

Three scenarios were selected for sensitivity analysis examining the impact of a price on CO2 emissions; reference, 2030 moratorium, and low renewables cost. As with the scenarios, the purpose of the sensitivities is not to model a specific future but instead to see the broader impacts. CO2 emissions modeled are from combustion only and do not consider life cycle emissions.

The carbon prices used in the sensitivities were developed collaboratively by the SUFG and IURC. They do not represent any specific proposed legislation or the result of any detailed analysis. They are intended to be in the range of prices used by Indiana utilities in the IRP process. CO2 prices start at $2.50/ton in 2025 and increase by $2.50/ton/year every year thereafter. The same prices were used in all sensitivities.

Carbon Price Sensitivity for Reference Scenario

Table 8 shows the selected resources for the carbon price sensitivity to the reference scenario and Figure 24 compares the total resources added with and without the carbon price. The imposition of a carbon price results in a significant increase in renewable capacity, with wind generation over 10 GW higher and solar additions of 3.9 GW as opposed to just 0.6 GW without a carbon price. Far less combustion turbine capacity is selected (0.6 GW vs. 5.0 GW), while total combined cycle additions are largely unchanged.

Table 8. Indiana Resource Plan for Reference Scenario with Carbon Price (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,315	25,175	-96	0	0	0	0	0	0
2020	19,329	25,429	254	0	0	0	0	0	0
2021	19,190	25,288	-141	0	0	0	0	0	0
2022	19,145	25,433	145	0	0	0	0	0	0
2023	19,115	23,688	-1,744	0	0	23	0	0	23
2024	19,243	21,347	-2,341	1,573	0	1,842	0	0	1,842
2025	19,331	21,348	1	1,678	0	2,174	2,853	0	5,026
2026	19,233	20,522	-826	2,386	0	2,595	5,267	0	7,862
2027	19,256	20,523	0	2,413	0	2,818	5,456	0	8,274
2028	19,254	19,398	-1,124	3,535	0	3,534	5,456	0	8,990
2029	19,281	17,775	-1,623	5,190	234	4,410	5,456	0	10,100
2030	19,474	17,370	-405	5,826	317	4,948	5,456	21	10,743
2031	19,592	17,258	-112	6,078	354	5,163	5,456	21	10,995
2032	19,706	16,846	-412	6,625	354	5,535	6,830	76	12,795
2033	19,825	15,136	-1,710	8,478	354	6,065	7,543	1,862	15,825
2034	19,906	13,496	-1,640	10,214	354	6,065	13,084	3,552	23,056
2035	20,074	13,286	-210	10,625	411	6,065	14,146	3,905	24,527
2036	20,165	13,236	-50	10,782	567	6,065	15,072	3,905	25,610
2037	20,326	13,211	-25	11,000	609	6,065	15,916	3,905	26,496

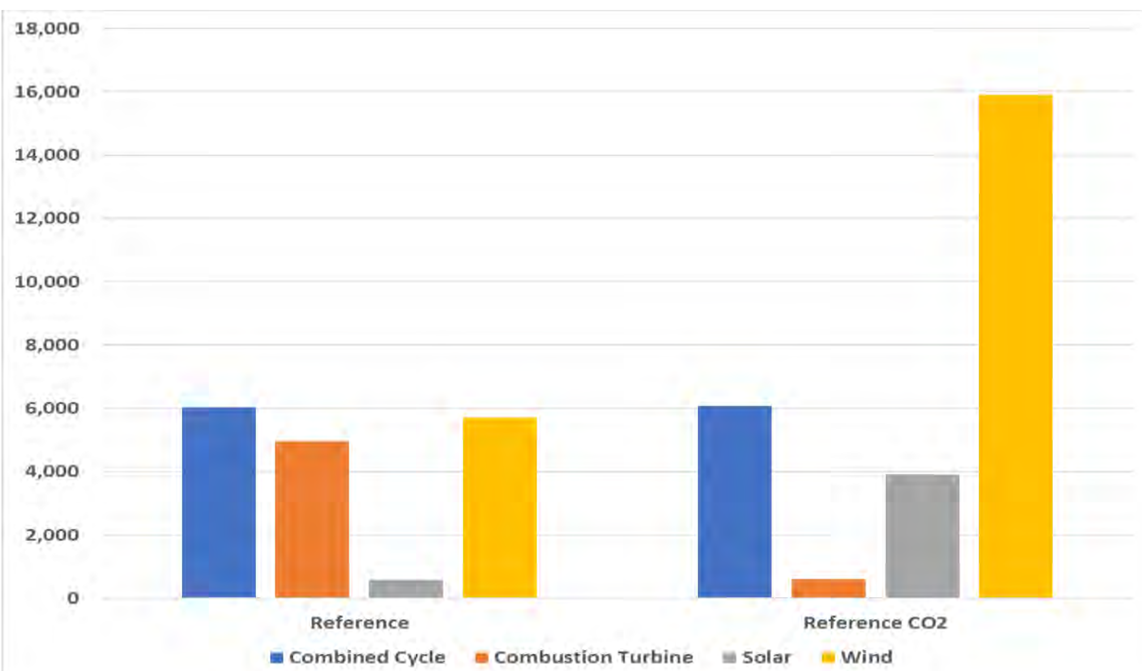

Figure 24. Resource Additions by Type through 2037 for Reference Scenario with and without Carbon Price (MW)

Figures 25 and 26 show the energy mix by fuel source for the carbon price sensitivity to the reference scenario. Energy from coal drops consistently as the carbon price grows starting in 2025. In the earlier years of the carbon price, natural gas makes up for most of the decline in coal utilization. However, as the carbon price gets higher in the later years, energy from natural gas also starts to decline, with energy from wind and solar increasing. Comparing the percentage charts with (Figure 2) and without (Figure 26) the carbon price, it can be seen that there are small differences in 2025, the first year of the CO2 costs. By 2030, energy from coal is down from 35% to less than 22%, while energy from natural gas has increased from 33% to over 45%. By 2035, coal-fired energy is down to 9% (compared to 28% without a carbon price), natural-gas fired energy has dropped (40% vs. 47%) and 1/3 of electrical energy is supplied by wind.

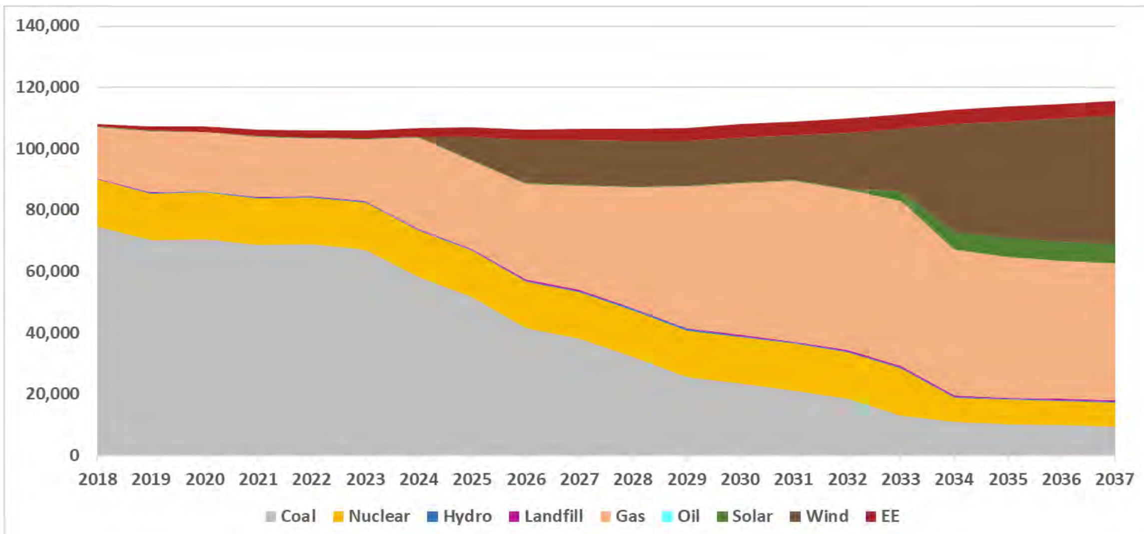

Figure 25. Electricity Supply by Resource for Reference Scenario with Carbon Price (GWh)

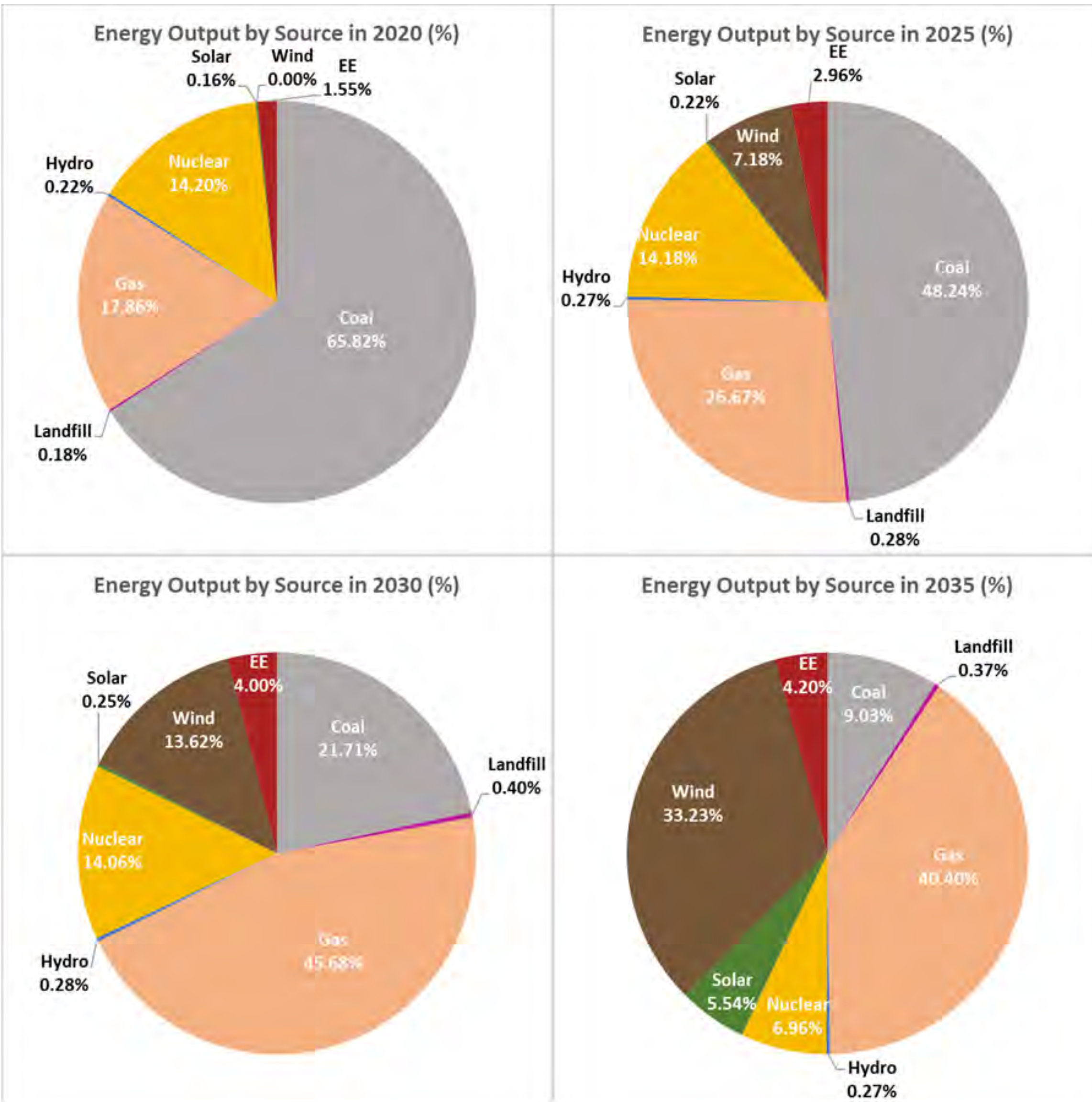

Figure 26. Energy Output by Source by Year for Reference Scenario with Carbon Price (%)

A comparison of the projected electricity prices with and without CO2 costs is provided in Figure 27. As expected, the imposition of CO2 costs causes electricity prices to be higher. Prices in the carbon price sensitivity are 1% higher in 2025 and grow to 14% higher in 2037.

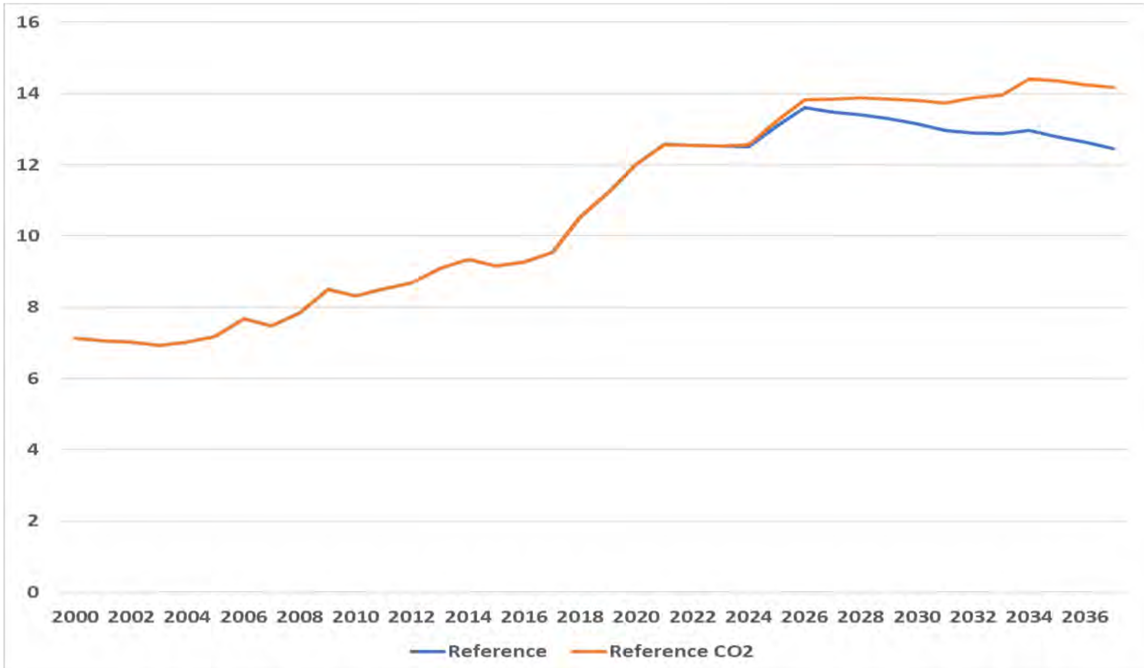

Figure 27. Indiana Electricity Price Projection for Reference Scenario with and without Carbon Price (2017 cents/kWh)

Carbon Price Sensitivity for 2030 Moratorium Scenario

Table 9 shows the selected resources for the carbon price sensitivity to the 2030 moratorium scenario and Figure 28 compares the total resources added with and without the carbon price. The overall impact of the carbon price is similar to that seen in the reference scenario; significant increases in wind and solar capacity and a severe decrease in combustion turbines. With the carbon costs, wind capacity additions were 16.6 GW, while only 2.1 GW were added without. Solar saw 3.6 GW with and 0.5 GW without. Only 0.3 GW of combustion turbines were chosen with the carbon prices, with 4.3 GW without. Combined cycle capacity additions were also down somewhat (6.2 GW vs. 7.4 GW).

Table 9. Indiana Resource Plan for 2030 Moratorium Scenario with Carbon Price (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,316	25,175	-96	0	0	0	0	0	0
2020	19,321	25,429	254	0	0	0	0	0	0
2021	19,160	25,500	71	0	0	0	0	0	0
2022	19,083	25,645	145	0	0	0	0	0	0
2023	19,021	24,315	-1,329	0	0	23	0	0	23
2024	19,041	24,126	-189	0	0	23	0	0	23
2025	19,100	24,127	1	0	0	46	0	0	46
2026	19,116	23,923	-204	0	0	157	1,556	0	1,713
2027	19,150	23,924	0	0	0	356	1,556	0	1,912
2028	19,153	23,774	-149	0	0	370	1,556	0	1,926
2029	19,158	22,600	-1,174	219	0	1,495	1,556	0	3,051
2030	19,308	22,195	-405	803	0	2,044	1,556	0	3,599
2031	19,422	17,258	-4,937	5,876	34	6,024	1,556	65	7,679
2032	19,545	16,846	-412	6,434	93	6,024	2,666	71	8,855
2033	19,661	15,136	-1,710	8,282	93	6,150	3,819	2,367	12,429
2034	19,714	13,496	-1,640	9,985	93	6,150	12,308	3,588	22,139
2035	19,858	13,286	-210	10,367	288	6,150	13,993	3,614	24,045
2036	19,930	13,236	-50	10,502	330	6,150	14,927	3,614	25,021
2037	20,051	13,211	-25	10,672	330	6,150	16,619	3,614	26,713

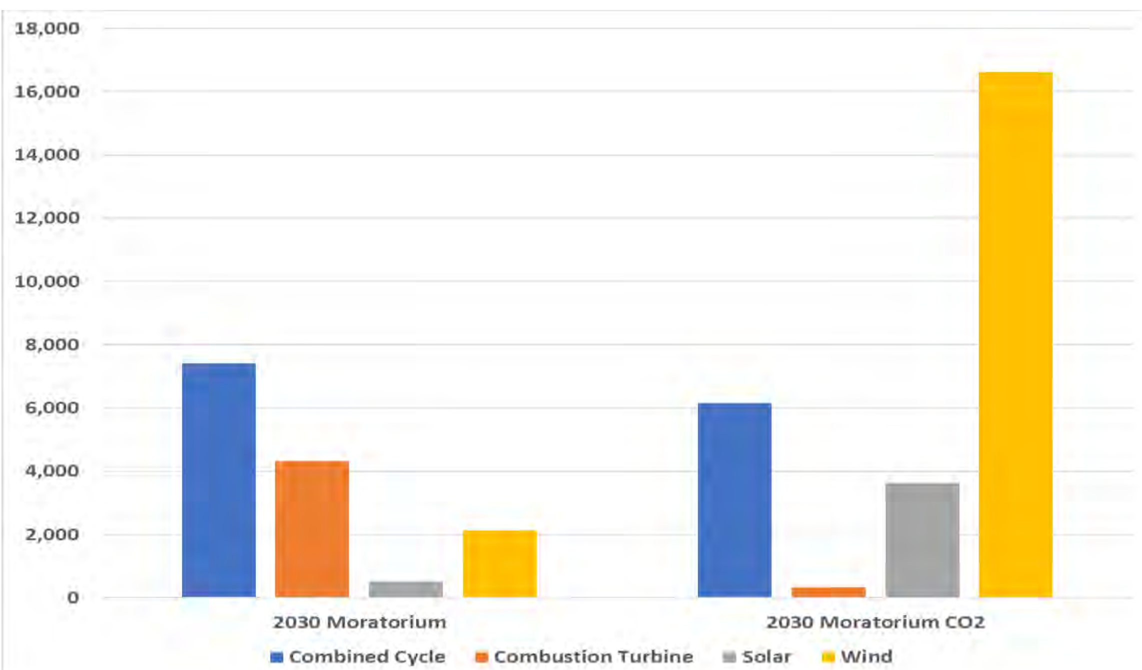

Figure 28. Resource Additions by Type through 2037 for 2030 Moratorium Scenario with and without Carbon Price (MW)

Figures 29 and 30 show the energy mix by fuel source for the carbon price sensitivity to 2030 moratorium scenario. Energy from coal declines gradually through the end of the moratorium, then decreases precipitously. A comparison of the scenario results in 2030 with (Figure 11) and without (Figure 30) a carbon price shows that natural gas has displaced some coal; energy from natural gas represents 30% of total with and 16% without and coal is 47% with and 61% without. By 2035, natural gas and wind are the major energy sources. Wind provides 33% of total energy with a carbon price vs. 5% without. Natural gas provides 41% with and 55% without. Coal, which provided 29% of energy without a carbon price, was down to 9% in the sensitivity.

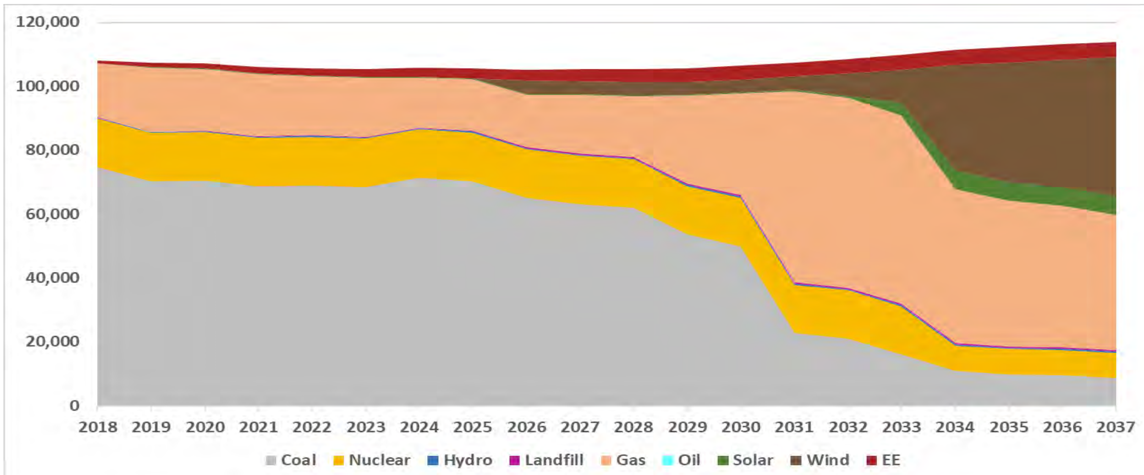

Figure 29. Electricity Supply by Resource for 2030 Moratorium Scenario with Carbon Price (GWh)

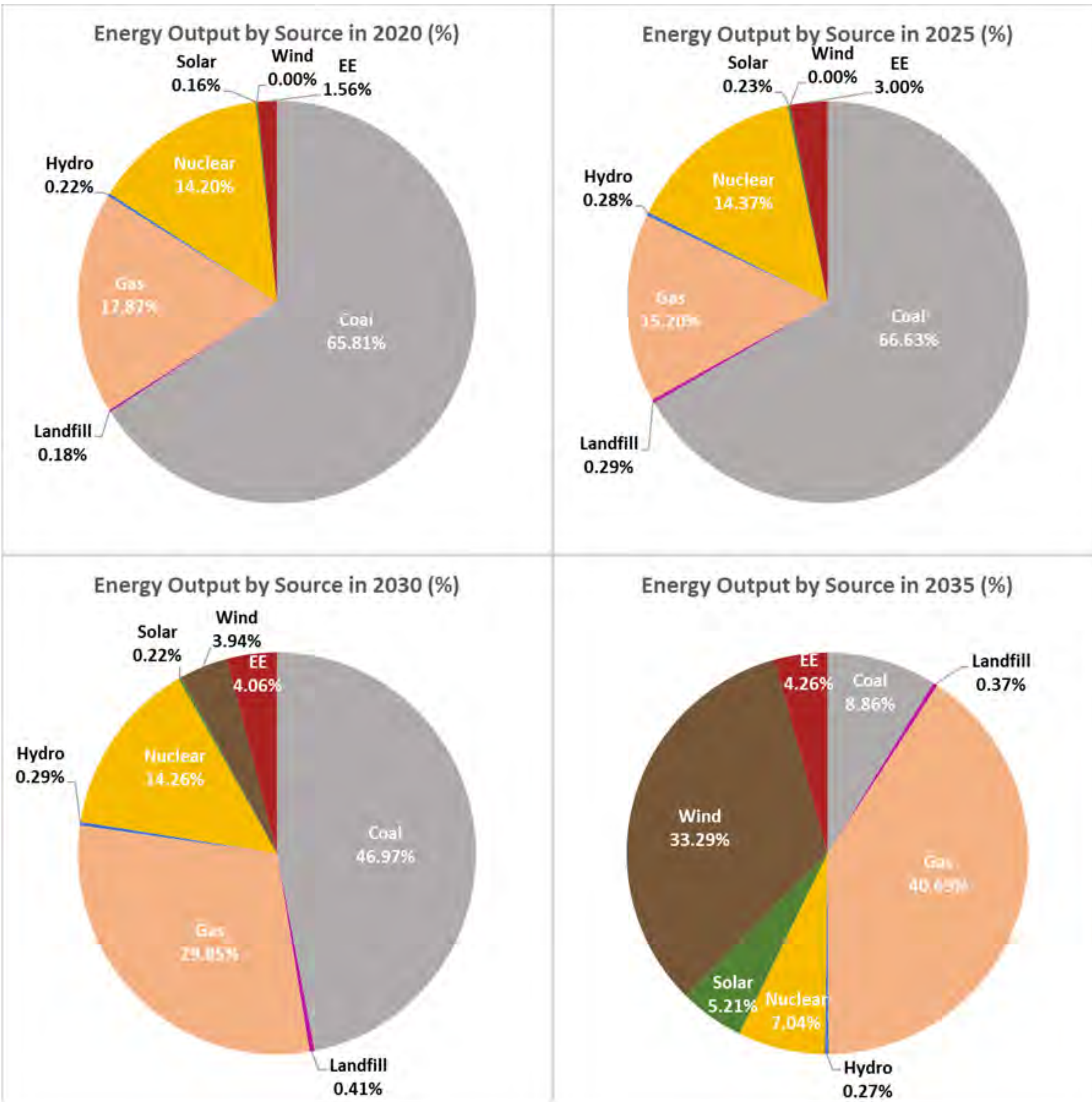

Figure 30. Energy Output by Source by Year for 2030 Moratorium Scenario with Carbon Price (%)

A comparison of the projected electricity prices with and without CO2 costs for the 2030 moratorium scenario is provided in Figure 31. As was seen in the reference scenario, the imposition of CO2 costs resulted in higher electricity prices. Prices in the carbon price sensitivity are 2% higher in 2025, 10% higher in 2030 and 19% higher in 2037.

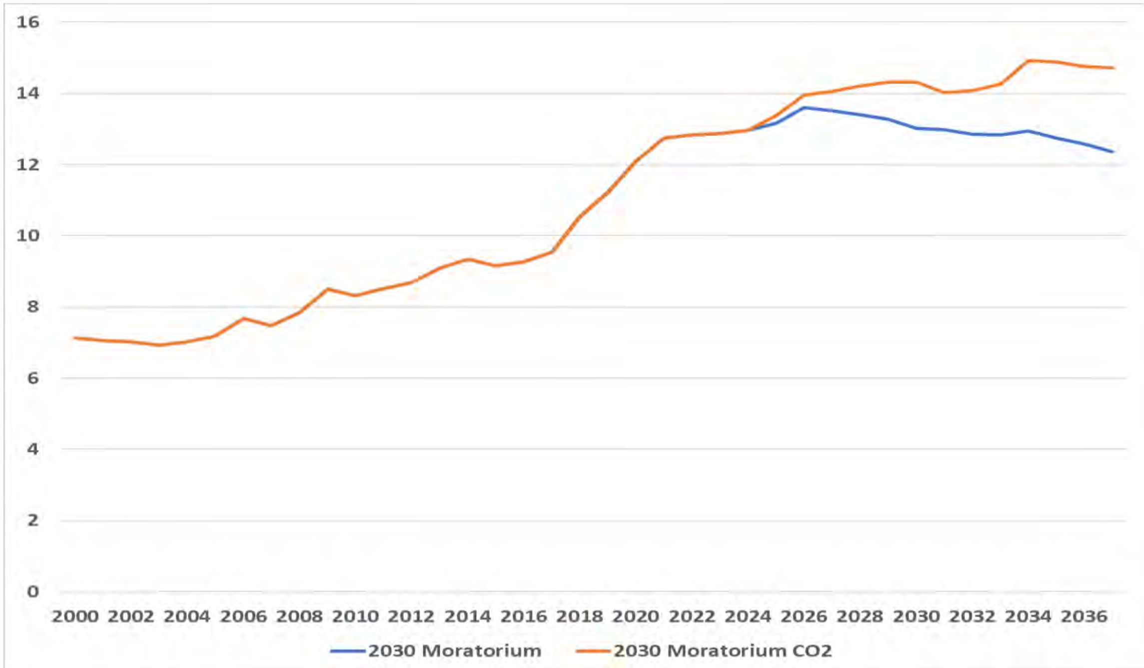

Figure 31. Indiana Electricity Price Projection for 2030 Moratorium Scenario with and without Carbon Price (2017 cents/kWh)

Carbon Price Sensitivity for Low Renewables Cost Scenario

Table 10 shows the selected resources for the carbon price sensitivity to the 2030 moratorium scenario and Figure 32 compares the total resources added with and without the carbon price. The inclusion of a carbon price results in an extremely large amount of wind capacity being selected (34.4 GW). A lower amount of combustion turbine capacity is selected (3.5 GW vs. 5.1 GW) and combined cycle capacity is largely unchanged. Interestingly, solar capacity is lower in the carbon price sensitivity (3.7 GW vs. 8.3 GW) as the model needs dispatchable resources to handle the intermittency of very large amounts of wind. As was the case in the high natural gas price scenario, which also saw the selection of very large amounts of wind capacity, the availability of energy storage in the model could have resulted in a different mix.

Table 10. Indiana Resource Plan for Low Renewables Cost Scenario with Carbon Price (MW)

Year	Peak Demand	Existing/ Approved Resources	Incremental Change in Resources	Required Additional Resources	Additional Selected Resources				
					CT	CC	Wind	Solar	Total
2018	19,444	25,271		0	0	0	0	0	0
2019	19,316	25,175	-96	0	0	0	0	0	0
2020	19,329	25,429	254	0	0	0	0	0	0
2021	19,193	25,288	-141	0	0	0	0	0	0
2022	19,151	25,433	145	0	0	0	0	0	0
2023	19,119	23,688	-1,744	0	0	23	0	0	23
2024	19,261	21,347	-2,341	1,594	79	1,840	23	348	2,290
2025	19,318	21,348	1	1,662	269	1,904	2,947	526	5,646
2026	19,251	20,522	-826	2,408	269	2,090	6,539	1,091	9,988
2027	19,256	20,523	0	2,413	269	2,234	7,887	1,631	12,021
2028	19,244	19,398	-1,124	3,524	269	2,314	7,999	1,717	12,299
2029	19,260	17,775	-1,623	5,166	613	3,141	7,999	3,479	15,232
2030	19,390	17,370	-405	5,726	613	3,141	13,373	3,511	20,638
2031	19,471	17,258	-112	5,934	613	3,141	14,314	3,511	21,579
2032	19,547	16,846	-412	6,437	613	3,141	16,939	3,511	24,204
2033	19,536	15,136	-1,710	8,133	1,205	3,434	25,854	3,511	34,004
2034	19,518	13,496	-1,640	9,752	2,893	3,502	29,196	3,511	39,102
2035	19,629	13,286	-210	10,095	3,517	3,502	30,872	3,683	41,573
2036	19,682	13,236	-50	10,207	3,539	3,502	32,371	3,683	43,095
2037	19,812	13,211	-25	10,387	3,539	3,502	34,421	3,690	45,153

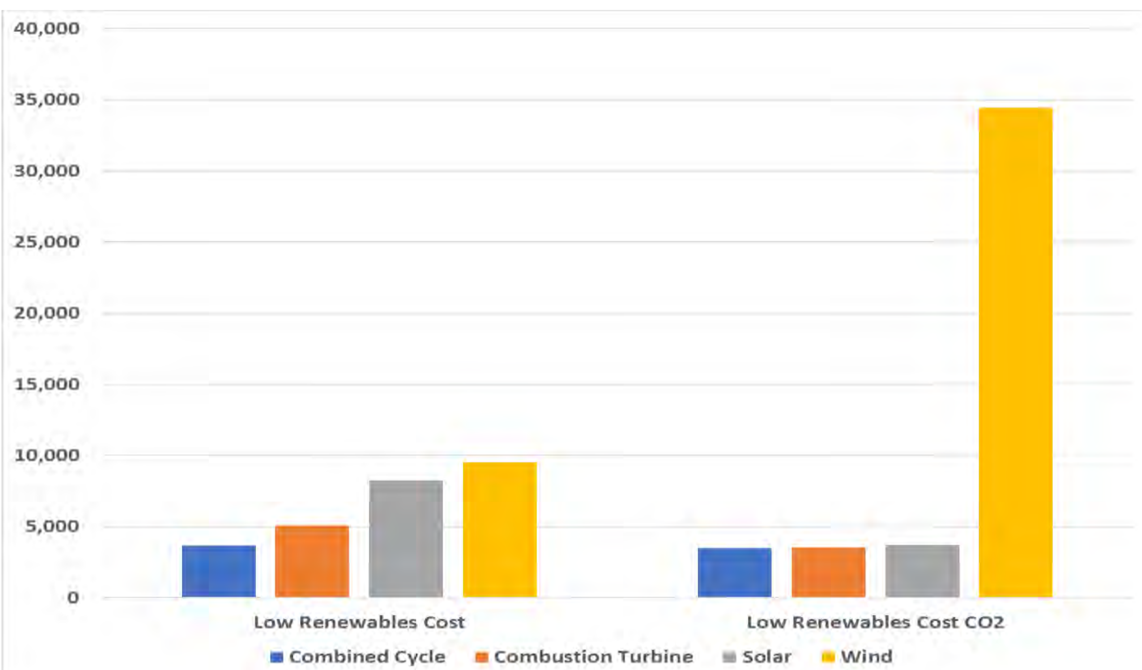

Figure 32. Resource Additions by Type through 2037 for Low Renewables Cost Scenario with and without Carbon Price (MW)

Figures 33 and 34 show the energy mix by fuel source for the carbon price sensitivity to the low renewables cost scenario. This sensitivity acquires the least amount of energy from coal (6% in 2035) and the most from wind (59% in 2035) of any of the scenarios and sensitivities. Only the high natural gas price scenario uses less natural gas-fired generation. Comparing the results with (Figure 34) and without (Figure 5) shows that the carbon price causes energy from coal to drop (17% vs. 35% in 2030 and 6% vs. 27% in 2035), natural gas to drop late in the analysis period (18% vs. 33% in 2035) and wind to increase (33% vs. 16% in 2030 and 59% vs. 19% in 2035).

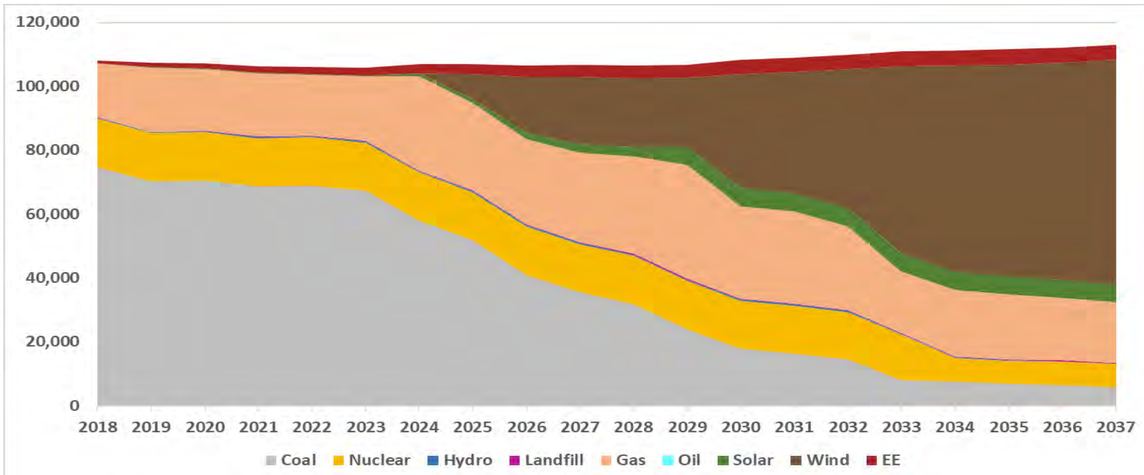

Figure 33. Electricity Supply by Resource for Low Renewables Cost Scenario with Carbon Price (GWh)

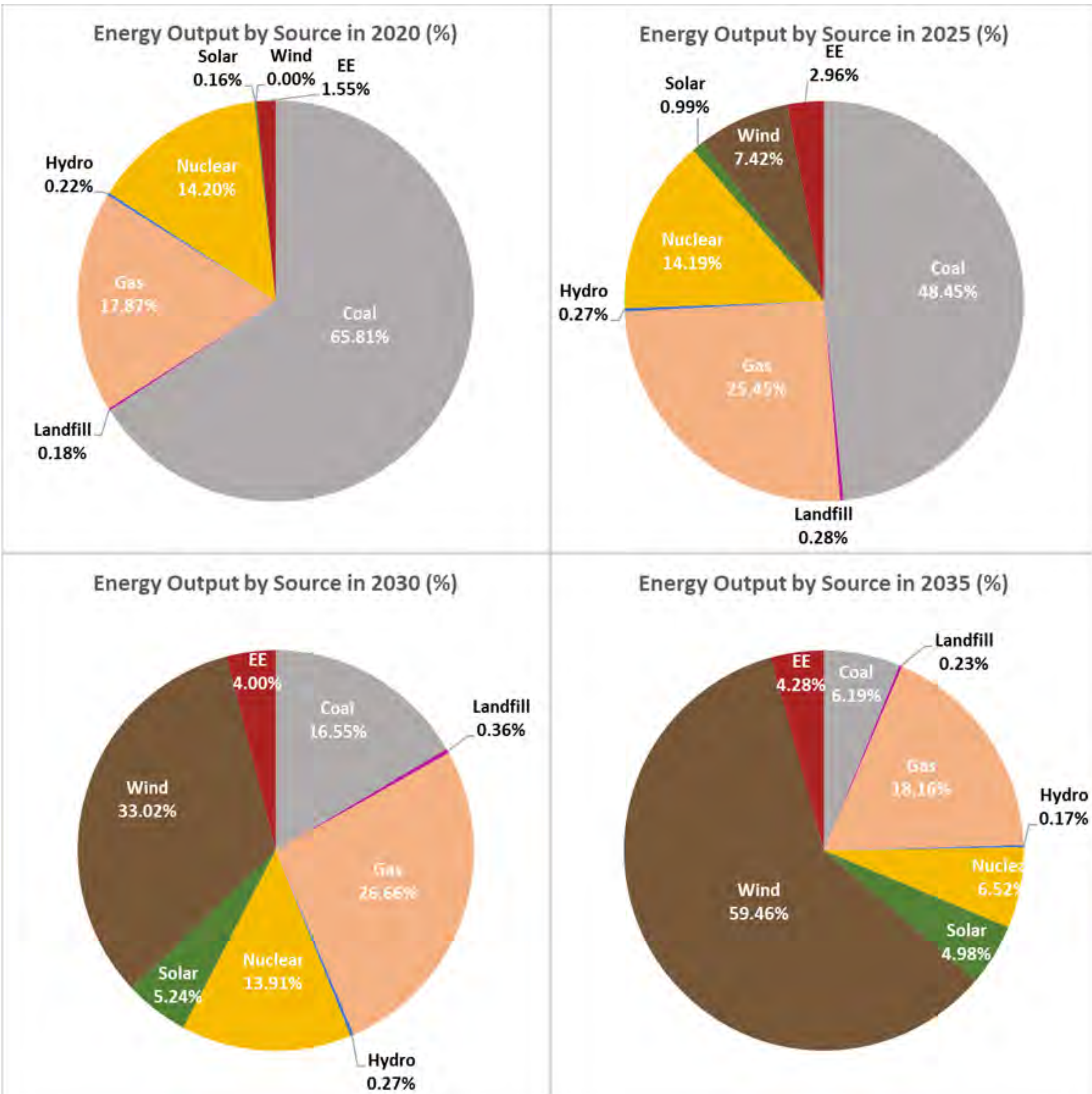

Figure 34. Energy Output by Source by Year for Low Renewables Cost Scenario with Carbon Price (%)

A comparison of the projected electricity prices with and without CO2 costs for the low renewables cost scenario is provided in Figure 35. As was seen in the previous sensitivities, the imposition of CO2 costs resulted in higher electricity prices. Prices in the carbon price sensitivity are 2% higher in 2025, 10% higher in 2030 and 27% higher in 2037.

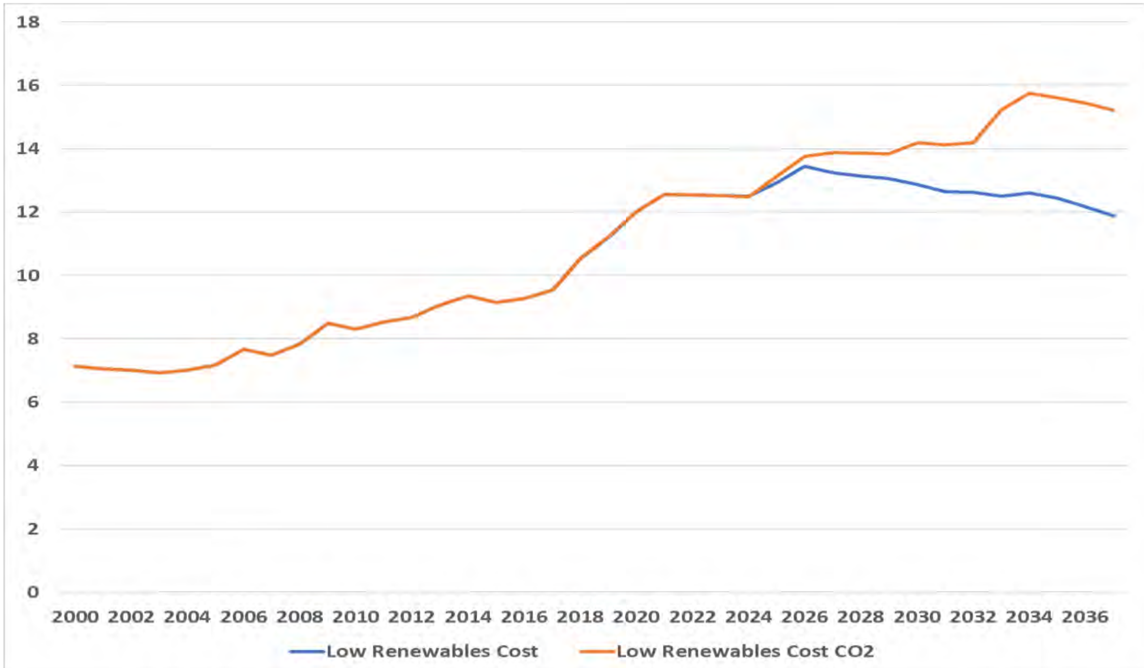

Figure 35. Indiana Electricity Price Projection for Low Renewables Cost Scenario with and without Carbon Price (2017 cents/kWh)

Observations

Resource Selection

Future resource selections in all scenarios and sensitivities are a combination of natural gas-fired generation (combustion turbines and combined cycle units), wind, and solar. Coal and nuclear options were never chosen, even in the high natural gas price scenario. The various factors defining the scenarios altered the mix and timing of the resource additions in largely predictable fashion. For instance, low renewables costs, high natural gas prices, and the imposition of carbon prices all resulted in more renewables being chosen and less natural gas.

Renewable Resources

Model results were highly sensitive to the price assumptions for renewable resources. While 13% of total energy in 2035 was provided by renewables in the reference scenario, that number increased to 29% in the low renewables cost scenario.

Energy from Coal

Energy derived from coal decreases over time in all scenarios, which is driven by a combination of retirements of existing generators and economic competition from natural gas and renewables. The imposition of retirement moratoria provides a boost to coal while they are in place, but energy from coal drops to roughly the same level in all non-carbon price scenarios (23-29% of total in 2035). The imposition of a carbon price results in large additional decreases in coal utilization. Energy from coal represents 6-9% of total in 2035 for the three carbon price sensitivities.

Effect of Carbon Prices

In general, the lower carbon prices imposed in the earlier years, tend to cause a shift from coal to natural gas-fired generation. In 2030 for the reference scenario, energy from coal drops from 35% to 22% with the imposition of the carbon price, while energy from natural gas increases from 33% to 46%. Similarly, for the 2030 retirement moratorium scenario, coal decreases from 61% to 47% and natural gas increases from 16% to 30%. In the low renewables cost scenario, however, the shift is from coal to wind rather than coal to natural gas. Energy from coal is cut in half (from 35% to 17%) while energy from wind doubles (from 16% to 33%).

The higher carbon prices in the later years show renewables displacing both coal and natural gas. In 2035 in the reference scenario, the carbon price causes coal-fired energy to drop from 28% to 9% and for natural gas-fired energy to fall from 47% to 40%. Meanwhile, energy from renewables triples from 13% to 39%. In the 2030 retirement moratorium scenario, coal (29% to 9%) and natural gas (55% to 41%) decreases while renewables (5% to 38%) increases. For the low renewables cost scenario, the effect is more pronounced, with coal falling from 27% to 6%, natural gas dropping from 33% to 18%, and renewables increasing from 29% to 64%. Interestingly, the increase is coming from wind, with energy from solar actually decreasing from the non-carbon price scenario.