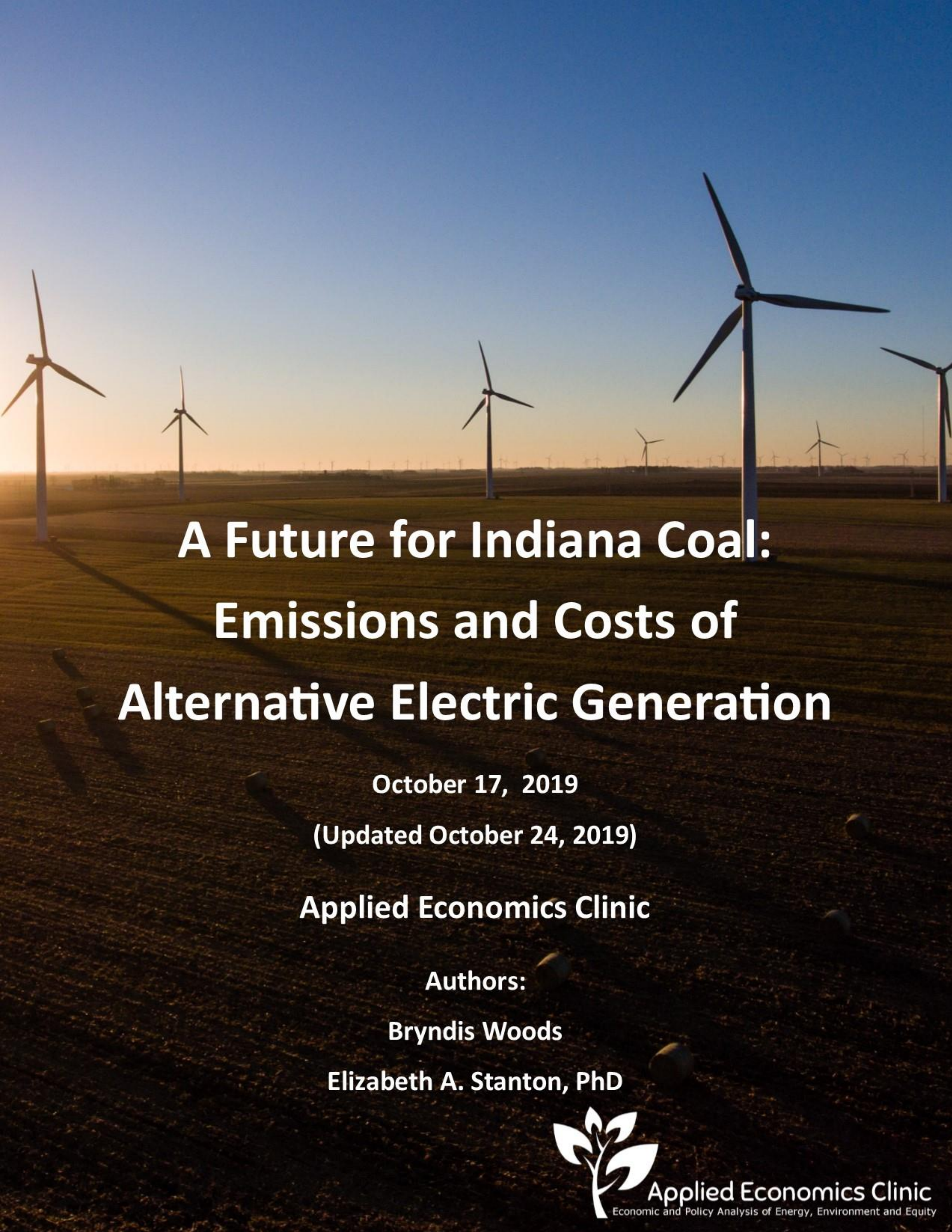

A Future for Indiana Coal: Emissions and Costs of Alternative Electric Generation

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Economic and Policy Analysis of Energy, Environment and Equity

Executive Summary

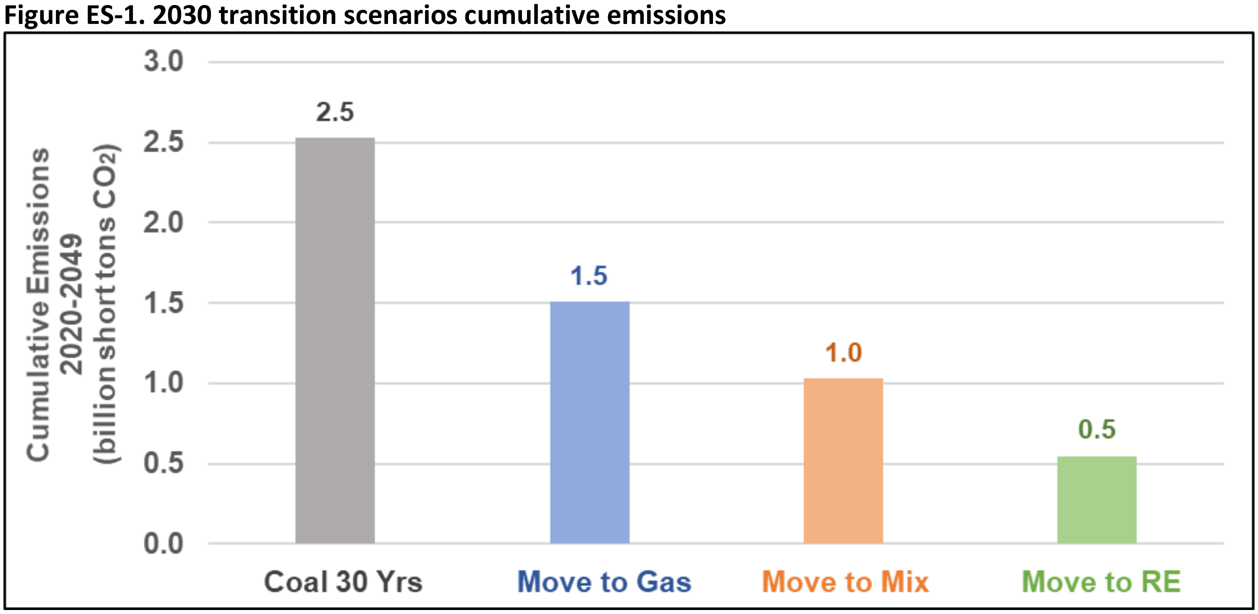
In 2018, Indiana produced more coal-fired electric generation than all but one state: 77,000 gigawatt-hours (GWh) compared to Texas' 112,000 GWh. Indiana's coal-fired power plants produce 70 percent of Indiana's total electricity, placing the state fifth out of all 50 states in the share of total of electric generation produced from coal (after West Virginia, Wyoming, Kentucky and Missouri).

This Applied Economics Clinic (AEC) report on behalf of Indiana's Citizens Action Coalition examines the cost and emission impacts of various options available to the State of Indiana as it replaces its aging coal generation fleet with other electric-generating resources.

1. Replacing aging coal with renewables reduces emissions

Replacing coal-fired power plants will lower Indiana's greenhouse gas emissions. Replacing coal with gas by 2030 will reduce the state's carbon dioxide (CO_2) emissions by 1 billion short tons (in cumulative terms) over 30 years (see Figure ES-1). Replacing coal, instead, with a combination of solar and wind (called renewables or "RE" in the figures below) reduces the state's CO_2 emissions by double that amount: 2 billion short tons over 30 years.

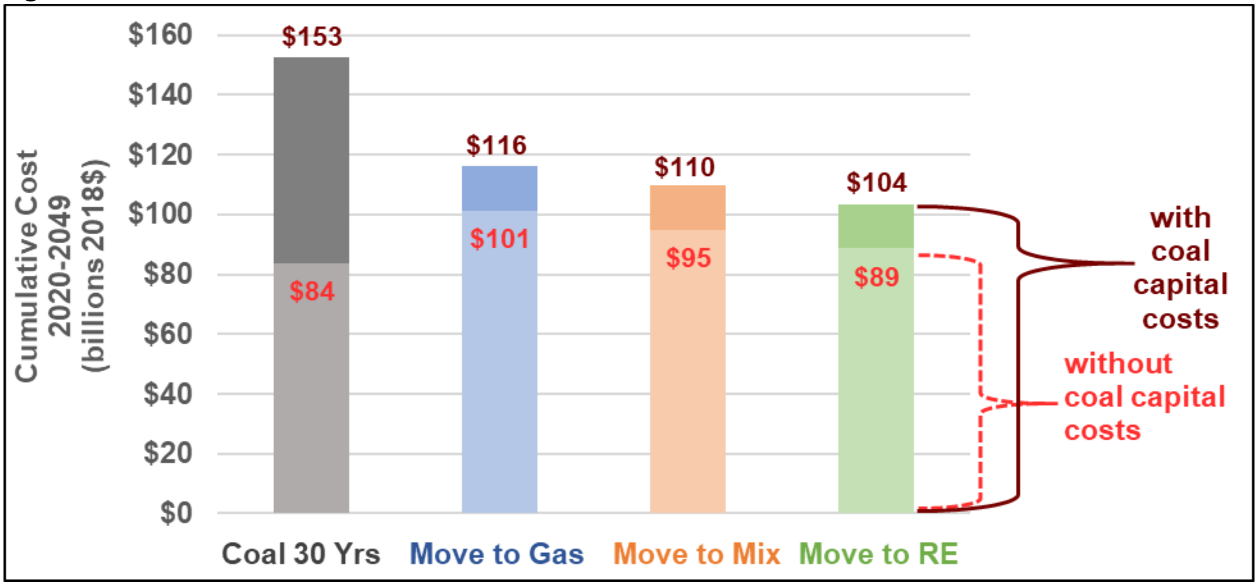
Figure ES-1. 2030 transition scenarios cumulative emissions



2. Replacing aging coal with renewables saves money

Maintaining Indiana's coal fleet for the next 30 years is the most expensive option for the state, while replacing all coal with 100 percent renewable resources by 2030 is the least-cost option (see Figure ES-2). The cost to repair or replace the existing coal fleet (called "coal capital costs" in Figure ES-2) is a key determinant in comparing costs across alternatives; when coal capital costs are included, maintaining coal is the most expensive option, but when they are not included, maintaining coal becomes the least expensive option. It is important to note that—while we do not know the exact costs needed to keep existing coal plants in running order—we do know that this amount is greater than zero. The scenario presented in this report without coal capital costs is presented for illustrative purposes only.

Figure ES-2. 2030 transition scenarios costs



3. A quicker transition away from coal is cheaper than a slower transition

Across all replacement scenarios, retiring all coal resources by 2030 is cheaper than waiting until 2040 (see Table ES-2). The greatest savings are realized in the scenario in which coal resources are replaced with 100 percent renewables by 2030—a $49 billion savings over continuing to run coal for another 30 years.

Table ES-2. Cumulative costs with coal capital costs included

2020-2049	All Coal Retired By Year	Scenario			
		Coal 30 Yrs	Move to Gas	Move to Mix	Move to RE
Cumulative costs WITH coal capital costs (billions $2018)	2030	$153	$116	$110	$104
	2040	$153	$125	$119	$114

4. Gas-fired resources do not provide clear benefits as a bridge to renewables

The choice to use gas as a temporary bridge to an eventual renewable future does not have clear cost or emission benefits for Indiana. In the "fast transition" scenarios (where all coal is retired by 2030), replacing coal with gas is $12 billion more expensive (in cumulative terms) than replacing coal with wind and solar over the 30-year analysis period, and results in 1 billion tons more cumulative emissions over that same timeframe (see Table ES-3). Moving directly from coal to wind and solar saves ratepayer dollars and reduces Indiana's emissions.

Table ES-3. Cumulative emissions summary

2020-2049	All Coal Retired By Year	Scenario			
		Coal 30 Yrs	Move to Gas	Move to Mix	Move to RE
Cumulative emissions (billion short tons CO_2)	2030	2.5	1.5	1.0	0.5
	2040	2.5	1.7	1.3	1.0

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1. Introduction

In its 2019 legislative session, the Indiana General Assembly created "The 21st Century Energy Policy Development Task Force,"[1] a 15-person group tasked with evaluating and examining state's policies concerning electric generation portfolios. Specifically, the Task Force is charged with considering how a shift away from coal may impact the reliability, system resilience, and affordability of electric utility service in Indiana.[2]

The Task Force will hold a series of meetings over two years and is required to produce a final report containing policy recommendations regarding any challenges related to the transition from coal, and whether state regulators have the necessary tools to consider those challenges. In addition, the Task Force recommendations are to include how to maintain reliable, resilient, and affordable electric service for all consumers, while encouraging the adoption and deployment of advanced energy technologies. The Task Force's recommendations are to be delivered to the Indiana General Assembly, the Indiana Utility Regulatory Commission, the Indiana Office of the Utility Consumer Counselor, and Governor Eric Holcomb by December 2020.[3]

This Applied Economics Clinic (AEC) report—produced on behalf of Citizens Action Coalition of Indiana—presents a preliminary examination of the cost and emission impacts of various infrastructure investment options available to Indiana as it replaces its aging coal fleet. This report presents: an overview of Indiana's electric system today in Section 2; the scope and results of our analysis in Section 3; and the data, assumptions and methods underlying the analysis in Section 4.

2. Background: Indiana's Electric System Today

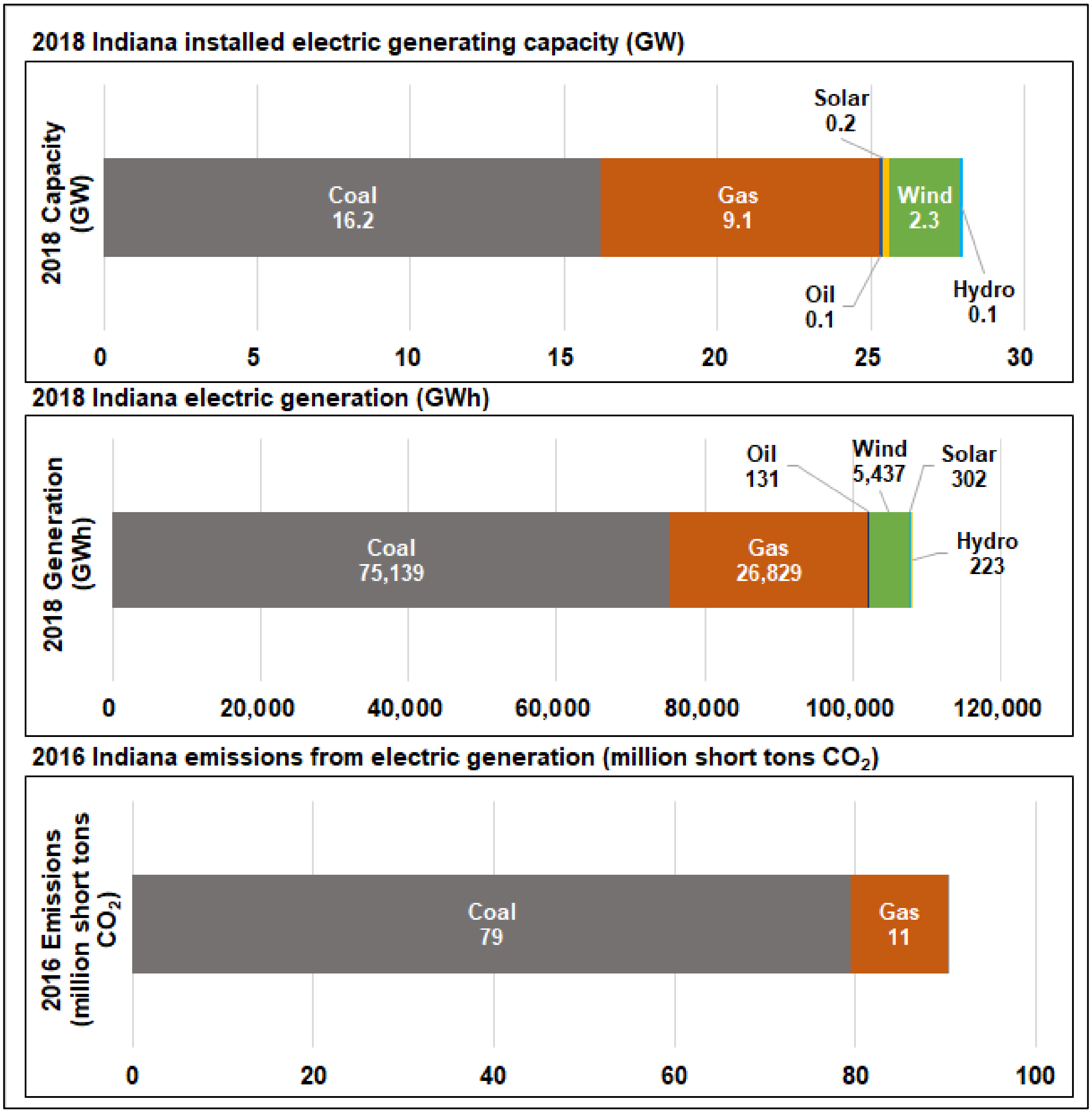
In 2018, Indiana's 16.2 gigawatts (GW) of coal-fired power plants represented 58 percent of the state's electric generating capacity (see Figure 1 below).

[1] Indiana House of Representatives. June 10, 2019. Bosma statement on state's new energy task force. Available at: https://www.indianahouserepublicans.com/news/press-releases/bosma-statement-on-state-s-new-energy-task-force/.

[2] Colias-Pete, M. August 27, 2019. Task force to mull Indiana's future energy sources. *Chicago Tribune*. Available at: https://www.chicagotribune.com/suburbs/post-tribune/ct-ptb-energy-task-force-st-0828-20190827-6uejml3cj5aaxaeb7tvzrfxzhe-story.html.

[3] Berman, E. June 12, 2019. Legislative Task Force to Craft Energy Policy. *93.1 FM WIBC*. Available at: https://www.wibc.com/news/local-news/legislative-task-force-craft-energy-policy.

Figure 1. Indiana 2018 electric generating capacity, 2018 generation and 2016 emissions



Sources: (1) U.S. Energy Information Administration (EIA). 2018. Form EIA-860 Data - Schedule 3 Generator Data. Available at: https://www.eia.gov/electricity/data/eia860/; (2) U.S. EIA. 2018. EIA-923 Monthly Generation and Fuel Consumption Time Series File. Available at: https://www.eia.gov/electricity/data/eia923/; (3) U.S. Environmental Protection Agency (EPA). 2016. Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

These coal plants ran 53 percent of the time, producing 75,139 gigawatt-hours (GWh) of electric generation. Coal-fired power plants produced 70 percent of Indiana's total electricity in 2018 (see Figure 1 above). Because electricity generated from coal emits more carbon dioxide (CO2) per unit of generation than electricity generated in other ways (like gas-fired generation, for example), a full 82 percent (or 79 million short tons) of Indiana's electric-sector CO2 emissions came from coal in 2018.

This Applied Economics Clinic analysis asks: How could the approximately 75,000 gigawatt-hours (GWh) of energy currently produced from coal in Indiana be generated in the future? All analysis in this report is based on annual generation equal to 75,000 GWh in order to represent potential future resource mixes that produce the same amount of generation as Indiana's current coal fleet.

3. Analysis

This study examines the CO_2 emissions and costs of a total of seven scenarios that represent options for Indiana's current coal-fired generation over the next 30 years (2020-2049): one scenario in which existing coal-fired plants are repaired or replaced with new coal generating capacity and coal generation continues for the full 30 year-period; three "fast transition" scenarios in which all coal is retired by 2030 and is replaced by gas, renewables, or a mix of the two; and three "slow transition" scenarios in which all coal is retired by 2040 and replaced.

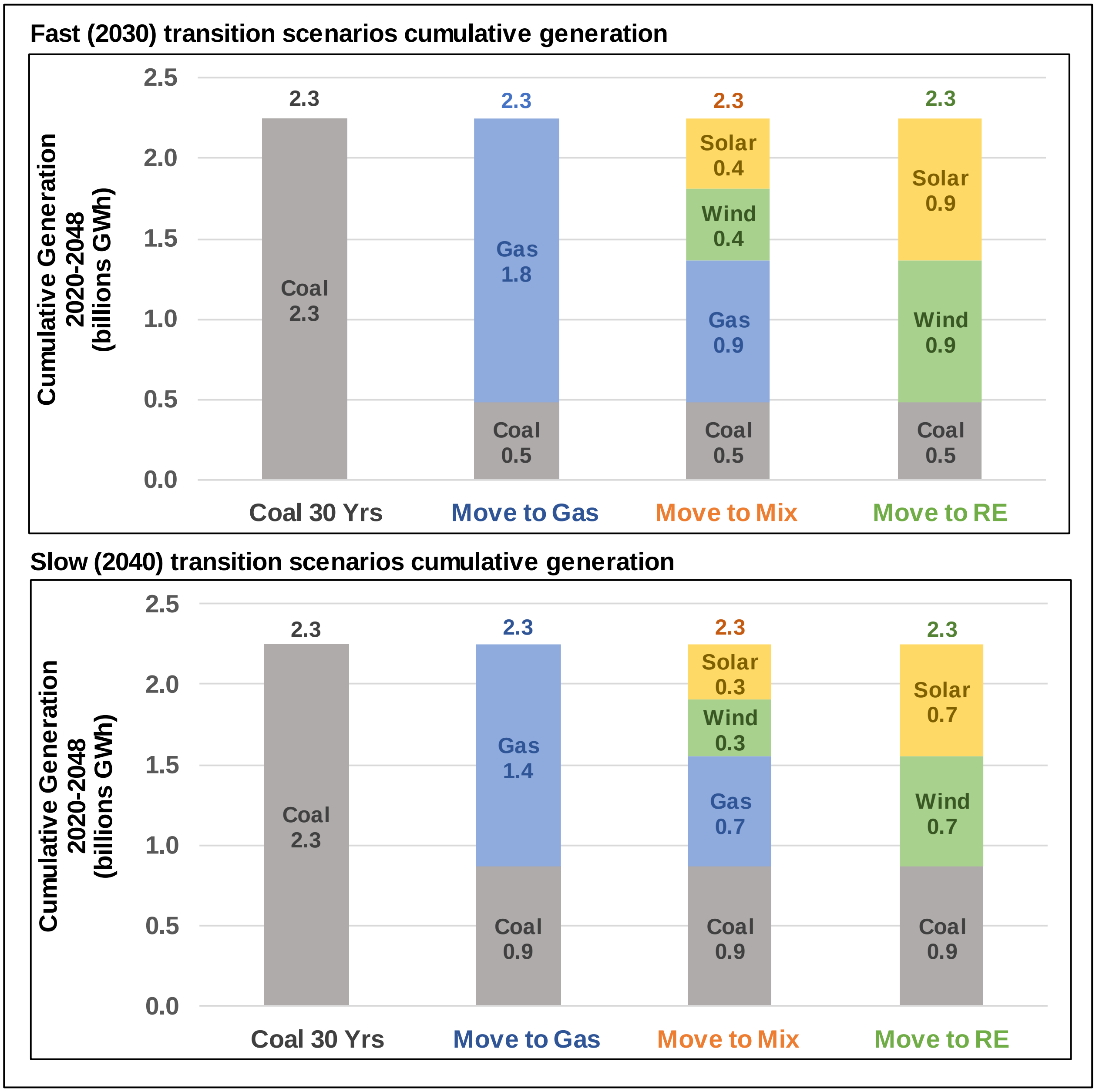
The scenarios under analysis are as follows:

Table 1. Scenario assumptions

Scenario	All Coal Until	No Coal In	Pace of Transition	New Generation
Coal 30 Yrs	2049	N/A	N/A	N/A
Move to Gas by 2030	2023	2030	Linear (constant rate)	All gas
Move to Mix by 2030	2023	2030	Linear (constant rate)	50% gas, 25% wind, 25% solar
Move to RE by 2030	2023	2030	Linear (constant rate)	50% wind, 50% solar
Move to Gas by 2040	2023	2040	Linear (constant rate)	All gas
Move to Mix by 2040	2023	2040	Linear (constant rate)	50% gas , 25% wind, 25% solar
Move to RE by 2040	2023	2040	Linear (constant rate)	50% wind, 50% solar

Each scenario produces the same amount of electricity (equal to Indiana's current 75,000 GWh of coal generation—or 2.3 billion GWh cumulative over the 30-year period analyzed) using a different mix of generating resources (see Figure 2).

Figure 2. Cumulative generation across scenarios



Note: Figures based on AEC scenario assumptions. See Table 1 above and Section 4: Methodology for more detail.

Our analysis finds that, when coal capital costs are accounted for, continuing to run Indiana's coal fleet and/or replacing existing coal with new coal over the next 30 years results in the highest emissions and highest costs. If Indiana's coal capacity were to be replaced with renewable wind and solar by 2030, the state would reduce its CO_2 emissions by 2 billion short tons (in cumulative terms) over the next 30 years (see Table 2 below).

Even when we adopt the unrealistic assumption that existing coal-fired power plants will not need any capital investments over the next 30 years, retiring all coal capacity and replacing it with wind and solar capacity by 2030 is just $5 billion more expensive (in cumulative terms) than continuing to run coal over the next 30 years. If this coal capacity were retired ten years later—by 2040—replacing it with wind and solar is only $4 billion more expensive than continuing to run coal. When we account for inevitable future costs of maintaining Indiana's aging coal plants, then continuing to run coal for the next 30 years becomes the most expensive option—$36 billion more than replacing coal capacity with gas capacity and $49 billion more expensive than replacing coal capacity with solar and wind over the next 30 years.

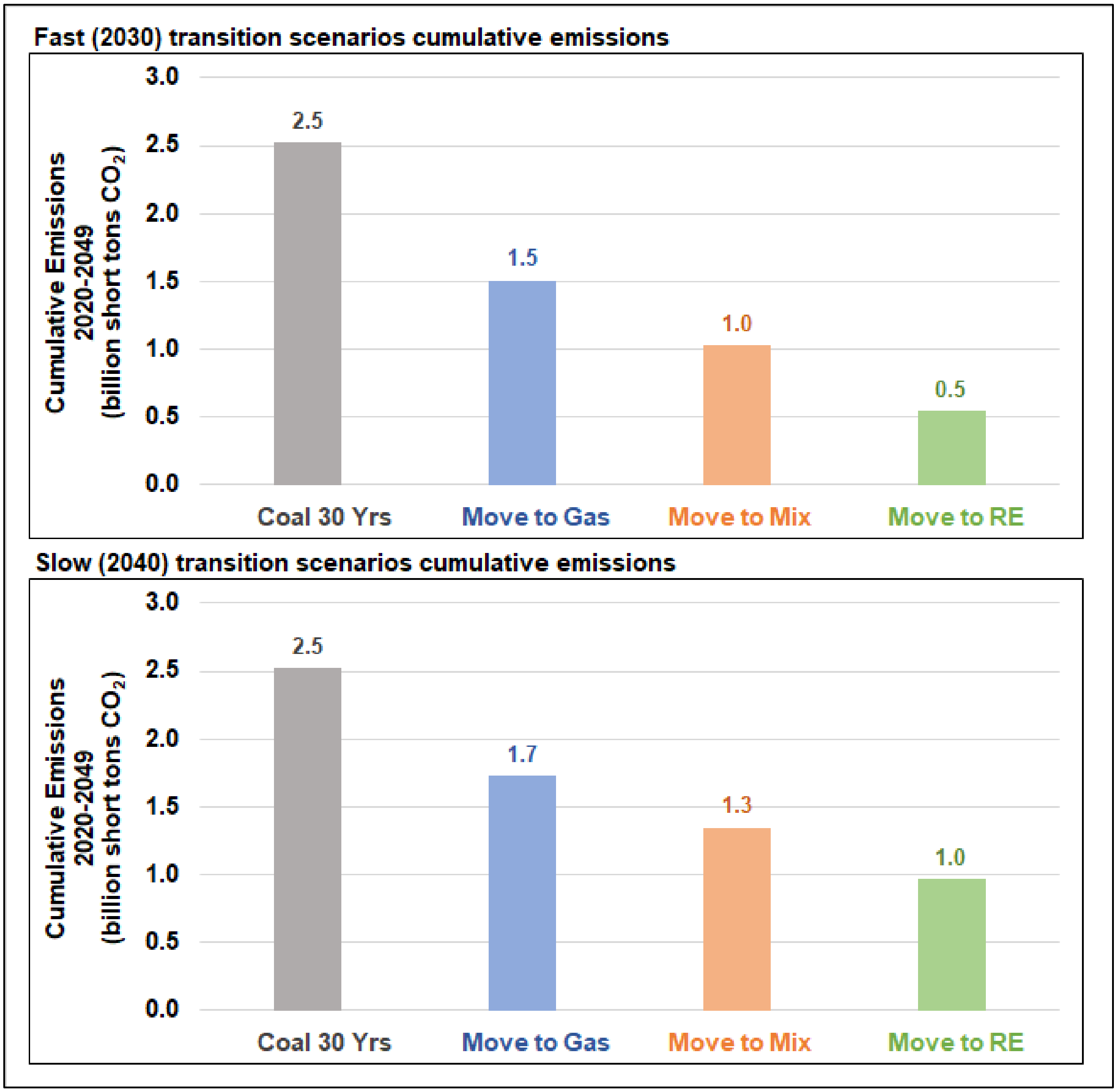
Table 2. Summary emissions and cost results

2020-2049	All Coal Retired By Year	Scenario			
		Coal 30 Yrs	Move to Gas	Move to Mix	Move to RE
Cumulative costs WITHOUT coal capital costs (billions $2018)	2030	$84	$101	$95	$89
	2040	$84	$98	$93	$88
Cumulative costs WITH coal capital costs (billions $2018)	2030	$153	$116	$110	$104
	2040	$153	$125	$119	$114
Cumulative emissions (billion short tons CO_2)	2030	2.5	1.5	1.0	0.5
	2040	2.5	1.7	1.3	1.0

Keeping coal plants running results in the highest emissions

Continuing to run coal for 30 years has the highest emissions of all scenarios followed (in both the faster and slower transitions) by moving to gas, moving to a mix, and moving to renewables (see Figure 3 below). Making any of these transitions more quickly lowers the associated cumulative emissions (relative to the cumulative emissions from continuing to run coal for 30 years): retiring all coal by 2030 (compared to 2040) reduces total emissions by 40 percent (versus 32 percent) in the Move to Gas scenario; 59 percent (versus 47 percent) in the Move to Mix scenario, and 78 percent (versus 62 percent) in the Move to Renewables scenario.

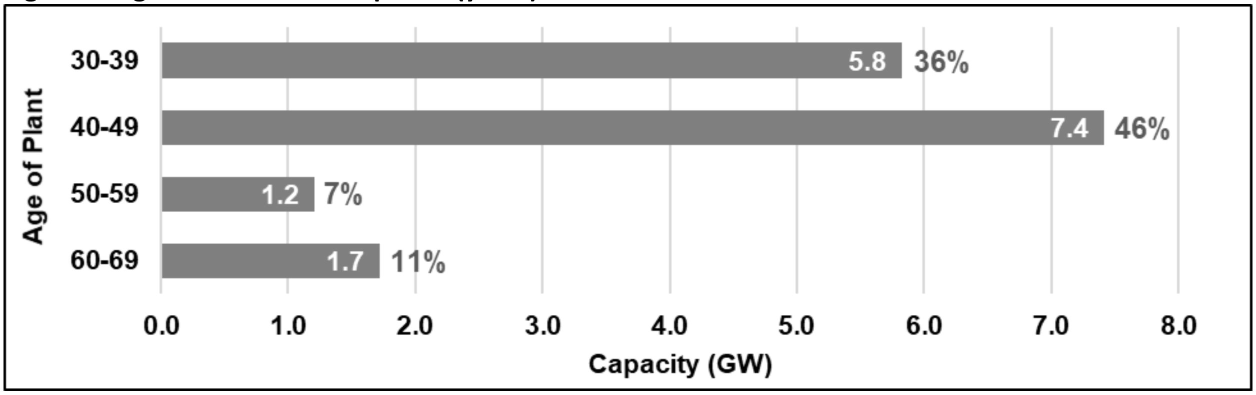
Figure 3. Cumulative emissions across scenarios



Relative costs depend on how expensive it is to keep aging coal plants running

In 2018, Indiana's 15 coal plants totaled 16.2 GW of capacity. Assuming a 40-year lifetime for these coal plants,[4] 64 percent (10.3 GW) of Indiana's 2018 coal capacity is already past its economic lifetime (that is, 40 years old or older; see Figure 4). Only 36 percent (5.8 GW) of Indiana's coal plants are younger than 40 years, and these three most recently built plants will all be 40 years or older by 2026.

Figure 4. Age of Indiana's coal plants (years)



Source: U.S. EIA. 2018. Form EIA-860 Data - Schedule 3 Generator Data. Available at: https://www.eia.gov/electricity/data/eia860/.

For each scenario under analysis, we calculate cumulative emissions and cumulative costs with and without coal capital expenses over the next 30 years (2020 to 2049). The extent to which Indiana's aging coal fleet will require major repairs and replacements is unknown, however, zero coal capital expenses for updates and replacements over the next 30 years is extremely unlikely. Our cost estimates that include coal capital expenses apply the levelized cost of a new coal plant per MW—$5.7 million according to Lazard[5]—in each year for which coal is in operation. Using the levelized cost of a new coal plant may overestimate capital costs during the period before these plants are replaced, although some cost of repair—beyond the average operations and maintenance expected for every year of a plant's operation—can be expected. With no coal capital expenses for the next 30 years maintaining existing coal plants appears unrealistically economic; this scenario is included in this analysis only to illustrate a lower bound cost estimate. Given the age of these coal plants (see Figure 4), they can be reasonably expected to require some degree of repair, upgrades, or replacement.

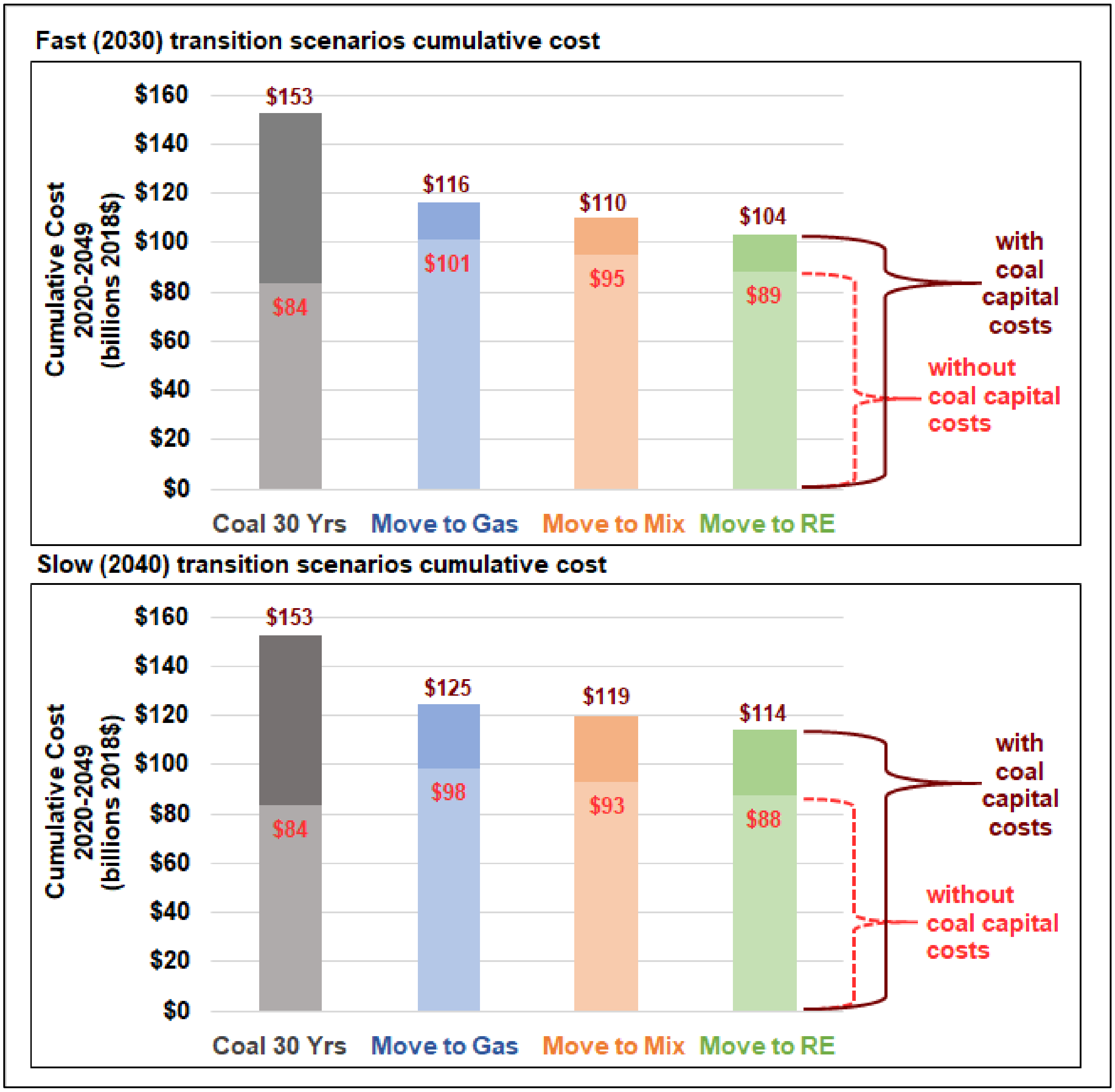
[4] Lazard. 2018. Lazard's Levelized Cost of Energy Analysis - Version 12.0. Available at: https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf..

[5] Ibid. Note that Lazard provides a range of coal capital costs per MW, from $3 to $8.4 million—we have used the average value.

Sticking with coal is the most costly option, switching to wind and solar is the cheapest

When future costs associated with continuing to run existing coal plants (such as coal plant repairs, upgrades or replacement) are included, scenarios' cumulative costs rank in the same order as cumulative emissions—continuing to run coal for 30 years has the highest cost (and highest emissions, followed by moving to gas, moving to a mix, and moving to renewables (see Figure 5).

Figure 5. Cumulative cost across scenarios



Retiring all coal by 2030 (compared to 2040) reduces the associated cumulative cost as compared to continuing to run coal for the next 30 years (see Figure 5 above): the total cost of the Move to Gas by 2030 scenario is 24 percent less expensive (versus 18 percent by 2040); the Move to Mix scenario is 28 percent less expensive (versus 22 percent); and the Move to Renewables is 32 percent less expensive (versus 25 percent). Only when we assume—unrealistically—that Indiana's existing coal plants will continue to run indefinitely without major upgrades or replacements is a scenario that continues to run coal over the next 30 years least expensive.

4. Methodology

This section presents the data, assumptions and methods used to model each of the scenarios analyzed in this report. **Error! Reference source not found.** summarizes the assumptions and parameter values utilized i n AEC's analysis.

Table 3. Parameter values

	Coal	Gas CC	Wind	Solar
Capacity Factor	53%	34%	27%	16%
Economic Life	40	20	20	30
Heat Rate (MMBtu/MWh)	10.0	6.5		
CO_2 emissions Rate (short tons/MWh)	1,123	545		
Variable O&M (per MWh)	$3.5	$2.8	$0.0	$0.0
Fixed O&M (kW-year)	$60	$6	$32	$11
Capital (kW)	$5,700	$960	$1,457	$1,151

Sources: See sources listed below in text.

Generation

- **Data:** (1) U.S. Energy Information Administration (EIA). 2018. "Form EIA-923 Monthly Generation and Fuel Consumption Time Series File". Available at: https://www.eia.gov/electricity/data/eia923/; (2) U.S. EIA. 2018. "Form EIA-860 Data - Schedule 3, 'Generator Data' (Operable Units Only)". Available at: https://www.eia.gov/electricity/data/eia860/.

- **Assumptions**: All scenarios assume that 75,000 GWh of annual coal-fired generation continues for at least the next 3 years (2020-2022). "Coal 30 Yrs" assumes that 75,000 GWh of annual coal-fired generation continues for the next 30 years (2020-2049). All coal generation is assumed to be replaced by alternatives by 2030 in the faster transition scenarios, and by 2040 in the slower transition scenarios. In the slow and fast transition scenarios, between 2023 and 2030 (or 2040), coal generation is assumed to decline at a constant, annual rate.
- **Methods**: Generation = 75,000 GWh * assumed share of generation for each resource according to the scenario assumptions * applicable resource capacity factor

Emissions

- **Data:** U.S. EPA. 2018. "Emissions & Generation Resource Integrated Database (eGRID)". eGRID2016 Data Files. Available at: https://www.epa.gov/sites/production/files/2018-02/egrid2016_data.xlsx.
- **Assumptions:** Each generation resource's CO_2 emissions rate is derived by taking its 2016 total CO_2 emissions divided by its 2018 total generation.
- **Methods**: Emissions = generation for each resource * applicable CO_2 emissions rate

Total costs

- **Data:** (1) Lazard. 2018. *Lazard's Levelized Cost of Energy Analysis - Version 12.0.* Available at: https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf; (2) Northern Indiana Public Service Company (NIPSCO) LLC*. 2016 Integrated Resource Plan.* Available at: https://www.in.gov/iurc/files/NIPSCO%202016%20IRP%20Without%20Appendices.pdf; (3) NIPSCO IRP Presentation. October 18, 2018. Available at: https://www.nipsco.com/docs/librariesprovider11/rates-and-tariffs/irp/2018-nipsco-irp-appendix-a.pdf?sfvrsn=2. (4) U.S. EIA. Energy prices by sector. Table 3.3 East North Central, Available at: https://www.eia.gov/outlooks/aeo/tables_ref.php; (5) U.S. EIA. Annual Energy Outlook Reference Case Projection Tables: Table 13: https://www.eia.gov/outlooks/aeo/tables_ref.php; (6) U.S. EIA. "No Date. Average Tested Heat Rates by Prime Mover and Energy Source, 2007 – 2017". Available at: https://www.eia.gov/electricity/annual/html/epa_08_02.html.
- **Assumptions:** All scenarios are run with and (for illustrative purpose) without coal capital costs. All scenarios include coal O&M costs.
- **Methods:** By resource type: Total costs = (Annual generation * Heat rate * Fuel price) + (Annual generation * O&M costs) + (Annual generation * Capital costs)