Economic Effects of the Changing Energy Mix in Indiana

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Executive Summary

- Indiana is in the midst of an historical shift in fuel use, which is occurring across two axes. Coal is being replaced by natural gas, while fossil fuels are being supplanted by the use of renewable energy sources, primarily wind, solar, and bio-mass.
- These fuel adjustments are primarily attributable to cost changes. Electricity production through the use of renewable energy sources (wind and solar) are now lower than the cost of natural gas or coal.
- Energy consumers in Indiana are now more efficient than ever, the BTUs per dollar of GDP have declined steadily since the late 1990s and overall energy consumption in Indiana peaked in 2014. In 2018, Hoosiers produced a dollar of GDP using 11.9 percent less electricity than it took to produce a dollar of GDP in 2010 (using constant dollar GDP).
- This change in fuel use has not resulted in dramatic changes in energy costs to Hoosier consumers. After adjusting for inflation, the price per kilowatt hour for energy is roughly identical to the price in 1990 for all users; commercial, industrial and residential.
- Employment related to coal-fired power plants peaked in 2012, and remains in decline. Employment related to natural gas use continues to climb, while employment related to wind, solar, and biomass continues to grow. We project this trend to continue for the full range of our forecast horizon (ten years).
- The employment and fiscal effects of electric power generation in Indiana remain very significant. We project continued shift towards renewable energy through our forecast horizon of 2030.

Our conclusion stated at the end of this analysis is that the shift to renewable energy will reduce average and incremental costs of power subsequent to the initial investments. Renewables will stabilize energy prices, offer more permanent supply, reduce the local labor demand shocks associated with shifting fuel extraction and move energy production into more Indiana communities than is the current experience. Renewable energy growth will make Indiana more attractive to firms and households who favor lower prices and fewer emissions, it will lead to less environmental restrictions on firm location and will generate employment growth above what we can experience with continued reliance on fossil fuels. The shift to renewable energy will not be complete, and will not, in the coming decades fully remove fossil fuels from our mix of electric power production. However, as renewables are less expensive and generate more employment across a broader geography they should remain a welcome feature of the changing energy landscape of Indiana.

Background

The United States in in the midst of an historic shift of energy production along two axes. The use of coal for the generation of electricity is being rapidly displaced by natural gas. At the same time, the use of all fossil fuels are being substituted for a small, but exponentially growing amount of renewable energy.

These changes are motivated primarily by cost considerations. On the first axis, the discovery of large natural gas reserves in the United States quickly made continued reliance on coal-generated electric power less attractive to utilities and consumers. The use of coal is now 16 percent more expensive than natural gas for base load power production, and the use of coal for electric power generation declined from roughly half of all energy produced in 2007 to only 27.5 percent in 2018.[1]

On the second axis, the **use of renewable energy has also grown, driven by large reduction in the cost of production**. Together, biomass, wind, hydro-electric, and solar power produced 9.9 percent of the nation's energy in 2007. By 2018 that grew to 16.9 percent.[2] The shift of natural gas from coal, along with the replacement of fossil fuel electricity production with renewable energy, has several important features that are important for both policymakers and consumers to understand.

The historic role of cost in shifting production cannot be overemphasized. Despite evidence of increasing consumer willingness to pay for renewable energy, these preferences are a relatively new phenomenon, affecting primarily industrial and commercial firms.[3] **While federal and state subsidies played a starting role in the development of renewable energy sources, the years after the Federal Stimulus Bill saw significant reductions in spending.** Most subsidies to

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[1] See Stacy, Thomas F. and George S. Taylor, The Levelized Cost of Electricity from Existing Generation Sources, Institute for Energy Research, and Energy Information Administration, Electric Power Annual, 2018.

[2] See Gelman, Rachel and Steve Hockett (2009) 2008 Renewable Energy Data Book, Energy Information Administration and EIA, Electric Power Annual, 2018.

[3] See Farhar, Barbara C. and Ashley H. Houston (1996) "Willingness to Pay for Electricity from Renewable Energy" National Renewable Energy Laboratory, 1996.

renewable energy were in the form of R&D expenditures, which approached $900 million in 2013. By FY 2016, this spending was under $450 million. Direct federal spending on renewable energy was over $8 billion in FY2013, dropping below $1 billion in FY2016.[4] Cost changes drove the adjustment in fuel mixes across both axes.

A changing fuels mix stabilizes energy prices, especially as the mix becomes more heavily dominated by renewables. Renewable prices are influenced more heavily by fixed costs (infrastructure), not variable input costs, thus are less volatile. Renewable fuels enjoy an effectively permanent supply, and are unlikely to experience geographic changes in production as have fossil fuels. Similarly, production of renewable energy can occur in a much broader geography, reducing the concentration of energy production that accompanies the extraction of fossil fuels. Changing fuel mixes also require larger initial infrastructure expenditures on transmission and distribution networks.

The changing geography of production imposes different labor demand shocks, both positive and negative, reducing the volatility of energy production related employment. The shift from coal to natural gas and the adjustment from fossil fuel to renewable fuels also alters the environmental footprint of energy production.

Taken together, these changes are broad and on net unambiguously beneficial. This report cannot examine all these issues, and so focuses on just two important facets of changing sources of electric power production in Indiana. **We examine the cost of different sources, evaluating the likely path of expenditures in the state across different sources of energy production. We then evaluate the local impact of these choices, focusing on impacts of renewable energy sources on the state.**

To accomplish these goals, we review the changing fuel mix in Indiana, with a focus on evaluating the cost and consumer price impacts of those changes. We do not address the environmental issues in this section. We then turn our attention to state and local employment effects of these changing fuel mixes, and provide forecasts of change through 2030.

This section includes models of specific employment effects across different types of electric power generation. To further explore this, we model the effects locally of representative facilities, to include fiscal effects associated with new investment.

Throughout this study we will address issues surrounding the replacement of coal with natural gas in Indiana. However, despite much interest in Indiana's coal industry we will explore this issue lightly, for two reasons. First, Indiana is a modest producer of natural gas. The shifting mix of fossil fuels is dictated almost exclusively by cost considerations to electric utilities and consumers. **The continued decline in the roughly 2,600 coal mining jobs in Indiana will continue based on simple electricity production economics and will be limited to a few counties in the state.**

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[4] See Energy Information Administration (2018) Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2016 (April, 2018).

Secondly, the major employment shock associated with electricity power generation in Indiana involves the shift to renewable energy. **As this study details, this shift will result in a net increase in employment and a broadening of the economic distribution of these jobs.** This phenomenon, and the associated fiscal effects, will thus dominate our discussion. We begin with a history of energy power production and use in Indiana.

The Changing Fuels Mix and Energy Prices

The Indiana economy is growing less energy-intensive over time, a phenomenon resulting from several trends. Energy efficiency within energy intensive sectors of the economy reduces the overall intensity of energy use, while household consumption is increasingly turning towards less energy intensive sectors. Between the 1960s and today, the share of household spending on manufactured goods declined from 50 percent to roughly 30 percent, reducing the share of energy intensive production within the economy.

Over the past two decades real Gross Domestic Product in Indiana has risen, while the energy use within those sectors dropped from 11.5 BTUs per dollar of GDP to 8.44 BTUs per dollar of GDP. This is over a 30 percent reduction.

Not only has the energy intensity of GDP production declined substantially, total energy use in Indiana peaked before the Great Recession. The state is becoming far more energy efficient than in previous decades. This trend is consistent with trends observed across the United States.[5]

Figure 1 illustrates the stark decline in energy intensity contrasted with the increase in Gross Domestic Product in Indiana. This is an almost 40 percent reduction in energy use per dollar of GDP produced. The overall energy efficiency is important to consider when evaluating the mix of fuels. For example, electric vehicles may be more efficient than those powered directly by fossil fuels, so shifting from gasoline to electric vehicles can improve overall energy efficiency. However, the use of electricity in Indiana has also enjoyed deep efficiencies. From 2010 to 2018, there was an 11.9 percent decline in the amount of energy used to produce a dollar of real Gross Domestic Product. So, Indiana is experiencing deep productivity gains across all energy sources and across the use of electricity. One consequence of this is that energy use in Indiana peaked in 2007. *See Figure 2.*

[5] See Cooper, Adam and Lorraine Watkins (2019) Energy Efficiency Trends in the Electric Power Industry, The Edison Foundation, March 2019.

Figure 1. Energy Intensity and GDP in Indiana

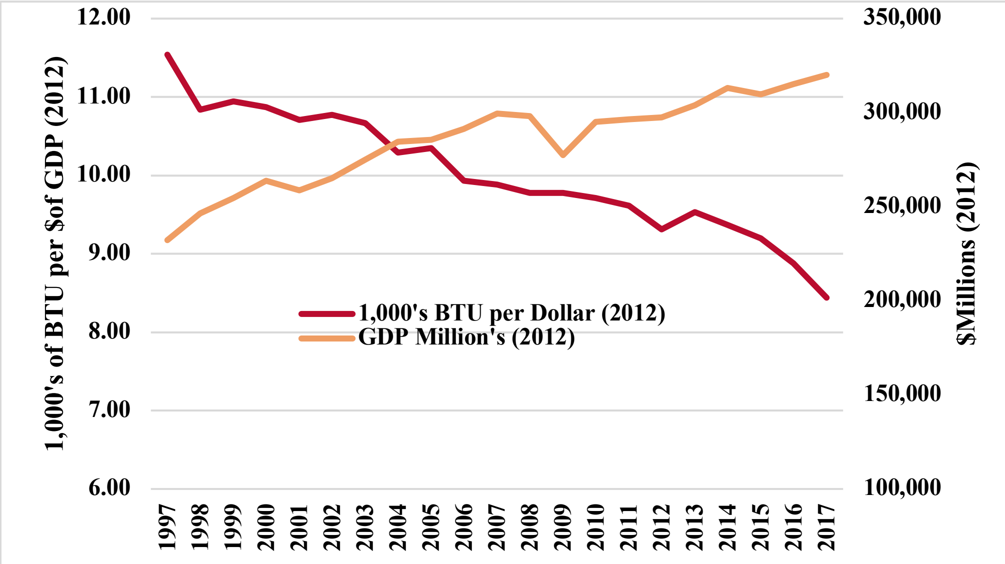
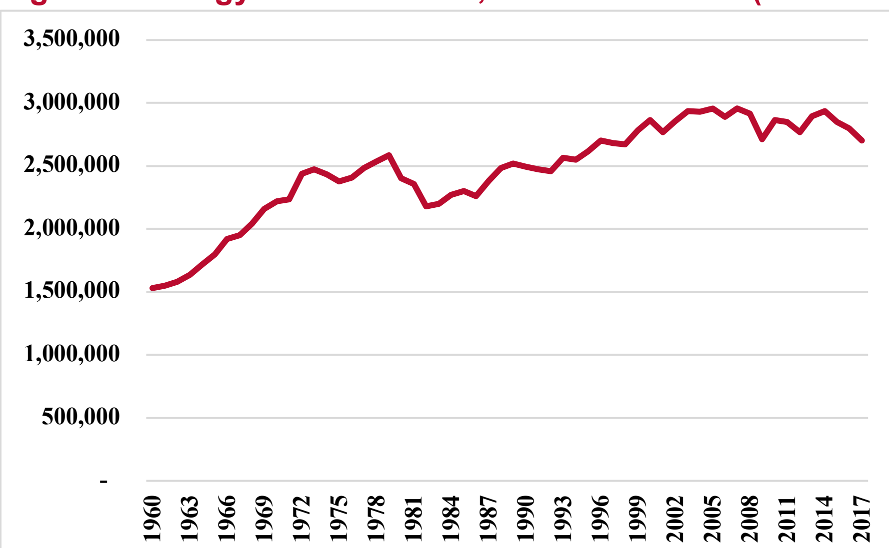
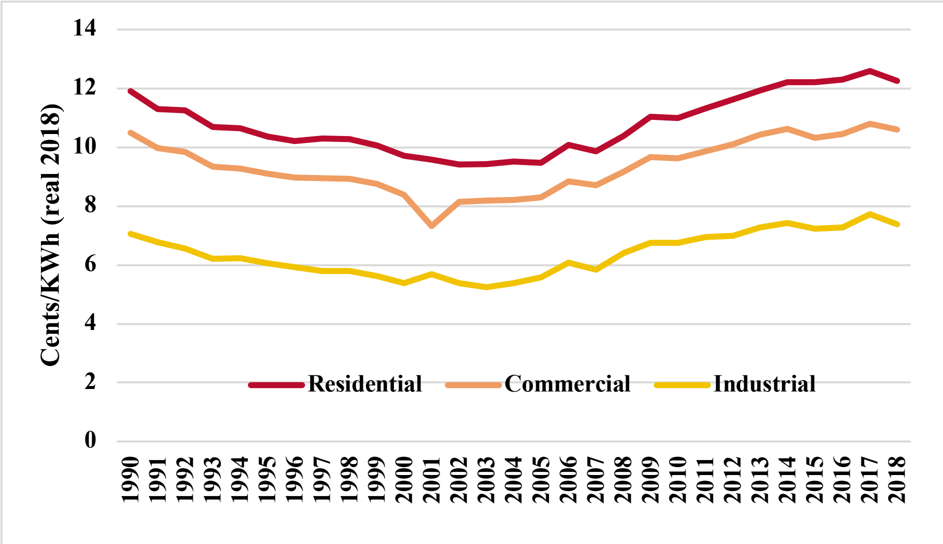


Figure 2. Energy Use in Indiana, Billions of BTUs (1960-2017)



Coincident with these changes, the retail price of electricity has remained remarkably stable, with prices today similar to prices in 1990 across all consumer types. These prices are subject to Rate of Return Regulation as well as firm specific contract negation. As such, they include capital costs. *See Figure 3.*

Figure 3. Real Electricity Prices in Indiana (1990-2018), ($2018)



The shifting energy mix in Indiana mimics the nation as a whole, which is substituting natural gas and renewables for coal-fired electricity production. As noted above, nationally, the use of coal for electricity production declined from 48 percent in 2008 to under 28 percent in 2018.[6] This changing mix of fuels was dictated by energy production economics, which changed following the widespread use of fracking, combined with horizontal drilling and other improvements in technology to reach large natural gas reserves in the United States that were previously thought to be commercially unfeasible to access.

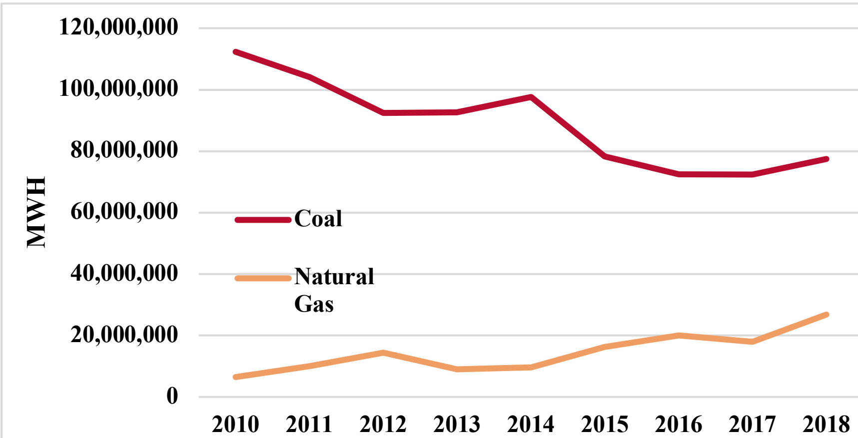
Historic and natural circumstances dictate state level fuel mixes. States that experienced significant infrastructure development during the New Deal currently experience high levels of hydro-electric power. Several states enjoy large-scale nuclear power energy production, and states adjacent to large bodies of water and windy environments use wind power. Places with considerable sun exposure also rely upon solar or photovoltaic cells. States that produce row crops of soybean and corn also produce electricity through the burning of biomass. Some states engaged in broad policies to promote distributed production by consumers, such as Hawaii, and states have different goals with respect to greenhouse gas emissions. These factors combine to cause differing fuel mixes across states.

Energy production in Indiana is dominated by coal and natural gas. Total fossil fuel production of electricity in Indiana was 96.7 percent of the state's entire energy consumption in 2010. **However, the use of natural gas for energy production is rapidly replacing that of coal.**

[6] Ibid. Energy Information Administration, Energy Production Annual various years.

Since 2010, natural gas has grown by 526 percent, while coal's share declined by 12.4. There is no nuclear power generation.[7] *See Figure 4.*

Figure 4. Changes in Coal and Natural Gas Use for Electric Power Production in Indiana



The cause of this shift in fuel sources is wholly due to the economics of electric power generation. Estimates of the **average cost of electricity production for coal range from $66 to $152, while combined cycle natural gas production costs range from $44 to $68 per Mega Watt hour (MWH).[8]** With fuel future markets demonstrating that long-term pricing trends will continue, it is nearly certain the displacement of coal with natural gas will continue for decades.

Renewable energy sources are a small, but growing part of Indiana's fuel mix. Renewable energy sources, including hydroelectric, wind, solar, or photovoltaic and biomass contributed 6.81 percent of Indiana's electric power generation across all types in 2018. This is a strong increase since 2010, when renewable use was 4.8 percent of energy use. **This shift is also being driven primarily by the lower cost of renewable energy. From 2010 to 2018, the average cost per MWH of wind dropped from $124 to $40, while solar average costs dropped from $248 to $40 per MWH**. But, to place this in context, the natural gas share of production rose from 19.8 percent in 2010 to 28.8 percent in 2018. Natural gas as a source of electric power generation grew by 4.7 times the rate of renewables.

Within Indiana, the mix of renewable energy for all electric power generation has risen rapidly, but remains modest in comparison to natural gas growth. Compared to the nation as a whole, Indiana remains a modest user of renewable energy.

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[7] There are no nuclear power generation facilities in Indiana; however, Indiana Michigan Power receives a significant amount of nuclear power from Michigan.

[8] See Lazard (2019) Levelized Cost of Energy Analysis, v. 13.0, Nov 7, 2019. These are utility scale range of unsubsidized average costs. High end for coal includes carbon capture.

Table 1. Fuel for Electric Power Generation in Indiana (2010 and 2018)			
	2010	2018	Change in MWh
Coal	89.7%	68.3%	-34,872,429
Natural Gas	5.2%	23.6%	20,342,009
Petroleum	0.1%	0.1%	-23,939
Other gases	1.7%	2.0%	181,673
Other Biomass	0.2%	0.4%	148,266
Hydro	0.4%	0.2%	-231,051
Solar	0.0%	0.3%	290,717
Wind	2.3%	4.8%	2,503,110
Other	0.3%	0.3%	-59,383
Total			-11,721,027

Figure 5. Mix of Renewable Energy Use in Indiana (all energy)

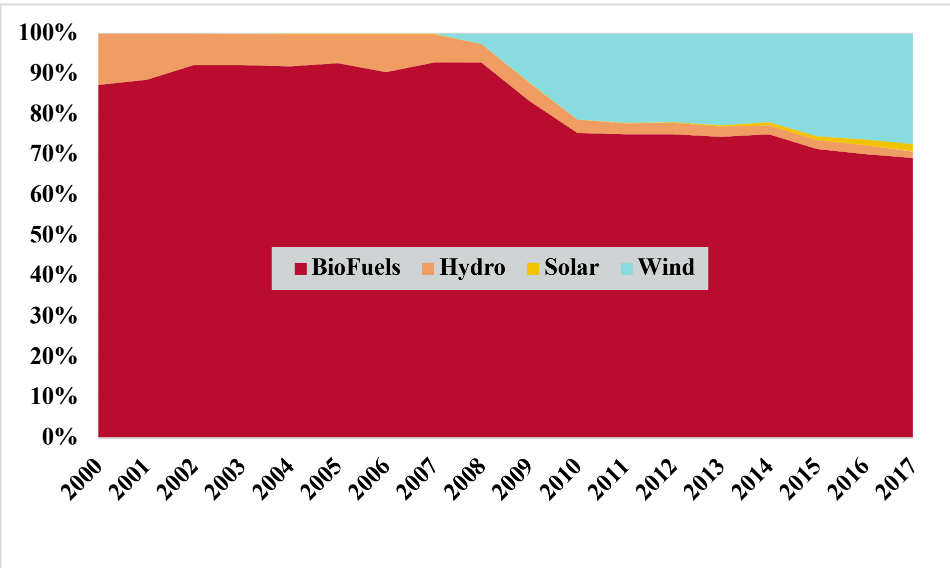
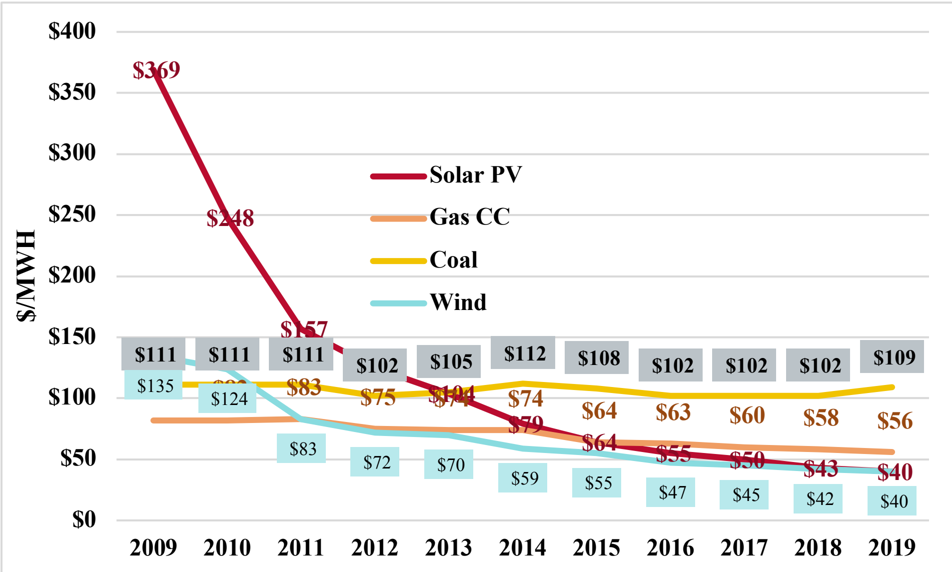


Figure 6. Levelized Cost of Energy, 2009-2018[9]



These data sets report inevitable, market-based changes in the sources of energy production to include electric power generation in Indiana. **This trend is similar, if lagging the nation as whole, which has a higher share of energy consumption in renewable energy and natural gas**.

These facts and the likelihood of the continued trend introduce two broad energy-related policy considerations for state and local policymakers, businesses, and citizens. The first question is whether energy production will remain available, in sufficient supply, and at a reasonable price to meet the demand of households, businesses, and governments? The second question is what benefits and costs to state and local economies do these shifts entail?

The answer to the first question is readily resolved. There are no examples in the modern record of gradual fuel source adjustments resulting in shortages or service interruptions. Indeed, in the most recent studies we could locate, service interruptions between 2008 and 2016 declined across all type of occurrences.[10] Indeed, there is no extant evidence of market-based supply issues contributing to energy supply unreliability in the United States in recent decades. For readers familiar with even the most modest understanding of portfolio analysis should find this unsurprising. However, there are also management and market innovations which contribute to energy reliability.

One example of important innovations in management of energy delivery is the Midcontinent Independent System Operator (MISO), which manages the delivery of power across 15 U.S.

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[9] Nominal dollars, from Lazard, 13.0 “Lazard’s Levelized Cost of Energy Analysis” November, 2019. These are utility scale mean unsubsidized costs.

[10] See LaCommare, Kristina H., Joseph J. Eto, Heidemarie C. Caswell, (2018) Distinguishing Among the Sources of Electric Service Interruptions, IEEE International Conference.

states and a Canadian province.[11] These organizations, referred to as Regional Transmission Organizations (RTOs) integrate energy purchases to ensure supply of energy meets demand for consumers across broad regions. Broad regional variability in demand at any particular time smooths demand fluctuations.[12]

One result of this is that energy reliability is now mostly a problem of unplanned interruptions resulting from major events, such as storms, which account for the vast majority of all service interruptions.[13] Indeed, we could find no evidence of supply-side service interruptions based on transition to renewable energy sources. This includes contemporaneous accounts, and through the integration of RTOs in the early part of the 21st Century. The most recent study on this compared U.S. and international experience, and was published in 1982.[14]

However, the economic impact of shifting fuel choices is a question that requires more analytical complexity than the potential for fuel based interruptions. It is to that issue we now turn our attention.

Economic Impact of Changing Energy Production in Indiana

Indiana is an energy importing state. This is particularly true with respect to our electricity consumption. We are 2.0 percent of the nation's population and consume 2.7 percent of the nation's energy.[15] Today, our largest single fuel source in use is coal. In 2018, Indiana produced 4.53 percent of the nation's coal. Our production of natural gas is very modest, despite the growth in use in Indiana. We import both coal and natural gas to produce electric power.

The extraction of fossil fuels generates economic activity in Indiana. As of the last available quarter of data (2018:Q3), Indiana employed 134 workers in the extraction of natural gas resources, and 2,662 coal miners. A further 438 workers were employed in support activities for mining (including non-coal resources), 1,879 workers were employed in the distribution of natural gas, for both home and commercial use, and 342 in natural gas pipeline transmission.

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[11] MISO employs over 900, and is headquartered in Carmel, Indiana

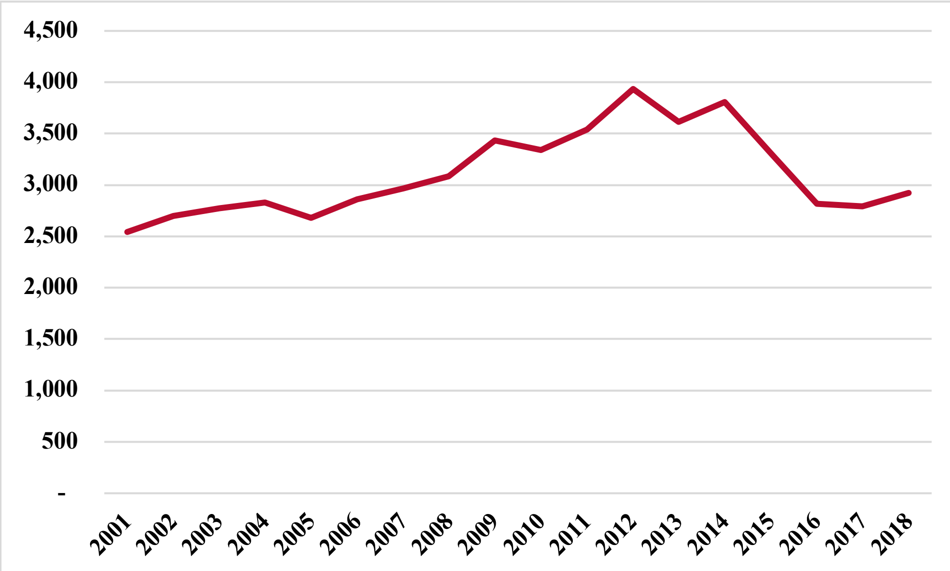
[12] For case studies of the development of MISO see Stafford, Benjamin A., and Elizabeth J. Wilson. "Winds of change in energy systems: Policy implementation, technology deployment, and regional transmission organizations." *Energy Research & Social Science* 21 (2016): 222-236; and Li, Mo, Timothy M. Smith, Yi Yang, and Elizabeth J. Wilson. "Marginal emission factors considering renewables: A case study of the US Midcontinent independent system operator (MISO) system." *Environmental science & technology* 51, no. 19 (2017): 11215-11223

[13] See LaCommare, Kristina H., Joseph J. Eto, Heidemarie C. Caswell, (2018) Distinguishing Among the Sources of Electric Service Interruptions, IEEE International Conference.

[14] Sanghvi, Arun P. "Economic costs of electricity supply interruptions: US and foreign experience." *Energy Economics* 4, no. 3 (1982): 180-198.

[15] Ibid, Cooper and Watson, 2019, Table 3.

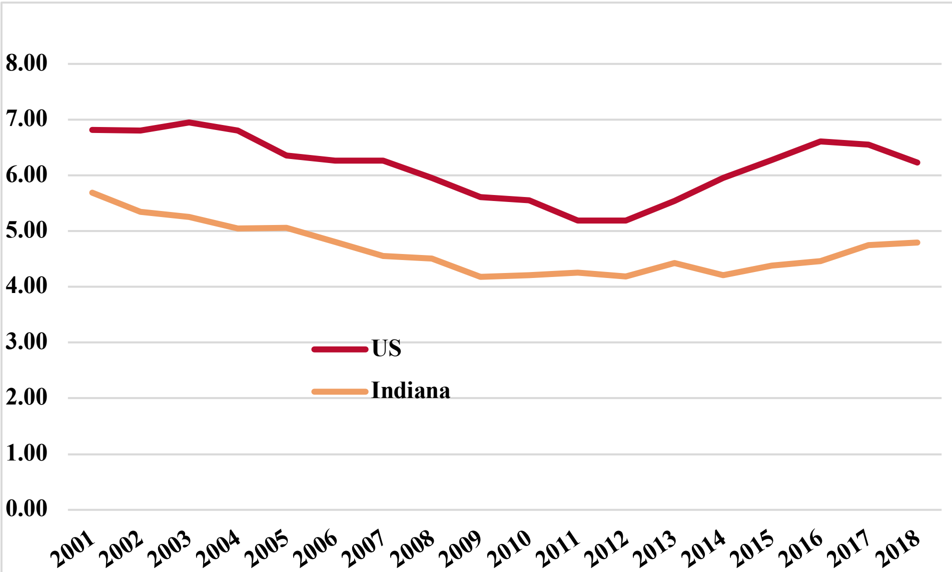
Figure 7. Coal Employment in Indiana



Significant attention has been paid to employment changes surrounding coal mining. The 21st Century coal mine employment peak in Indiana was in 2012. Nationally, employment peaked in 2011, and has since seen a 40 percent decline in employment. Indiana's experience has been somewhat better, with employment declining only 34 percent since peak 2011, and has since stabilized.

Indiana's less deep losses are not due solely to declining demand for coal, but by slower productivity growth in mining operations. This is almost certainly due to the shift towards more underground production, which is less productive than surface mining.

Figure 8. Productivity in Coal Mining (Short tons/labor hour)



Data on industry employment in renewables is not directly reported, since these jobs are similar to existing occupations. Instead, we must rely upon modeling of economic activity to evaluate the total economic effect of each type of electric power production. To do so, we include three steps. First, we collect annual state level electric power production by source from the Energy Information Administration. In this, we combine both the industrial and commercial power production. *See Table 2.*

Table 2. Indiana Electric Power Production, by Source, Millions of MWH, 2010 to 2018

Year	Coal	Natural Gas	Petroleum	Other Gases	Other Biomass	Hydro	Solar	Wind	Other	Total
2010	112.3	6.5	0.2	2.1	0.3	0.5	0.0	2.9	0.4	125.2
2011	104.2	10.1	1.3	2.2	0.3	0.4	0.0	3.3	0.4	122.1
2012	92.5	14.5	0.9	2.5	0.3	0.4	0.0	3.2	0.3	114.7
2013	92.7	9.0	1.6	2.4	0.4	0.4	0.0	3.5	0.4	110.4
2014	97.5	9.6	1.4	2.2	0.4	0.4	0.1	3.5	0.4	115.4
2015	78.2	16.3	1.3	2.3	0.4	0.4	0.2	4.5	0.4	104.0
2016	72.5	20.0	0.6	2.3	0.4	0.4	0.2	4.9	0.4	101.8
2017	72.4	18.0	0.1	2.0	0.5	0.3	0.3	5.1	0.3	98.9
2018	77.5	26.8	0.1	2.3	0.5	0.2	0.3	5.4	0.3	113.5

We then translate this production into revenues, using the real weighted average fuel price across all consumers as reported by the EIA. This yields revenue for each type of fuel or generating source. *See Table 3.*

Table 3. Revenue ($2018, Millions)										
Year	Coal	Natural Gas	Petroleum	Other Gases	Other Biomass	Hydro	Solar	Wind	Other	Total
2010	8,616	497	12	164	24	35	0	225	29	9,601
2011	8,343	806	107	175	27	33	0	263	30	9,783
2012	7,665	1,200	78	207	28	36	0	266	29	9,508
2013	8,090	789	137	210	33	34	3	304	39	9,638
2014	8,838	867	123	196	35	34	9	317	35	10,455
2015	7,033	1,462	120	204	40	34	14	406	38	9,351
2016	6,688	1,844	56	210	40	39	21	452	33	9,382
2017	7,072	1,756	12	195	46	30	27	497	30	9,665
2018	7,552	2,615	13	227	45	22	28	530	31	11,062

The total revenue estimates by industry provide a conceptual bridge to standard input-output modeling of impact per dollar of production. Using standard input-output modeling from a model maintained by Chmura Economics, LLC, we generate the employment, output and total compensation effects of different types of electric power production.

Input-output models are often used to generate static economic assessments of discrete changes to local economies. These models typically produce direct effects from a particular type of economic activity (here, the purchase of $100 million of electric power). The input-output framework then generates direct effects, which are the employment numbers associated with the facility itself.

The model also produces indirect effects, which are the impacts associated with supply chains, such as coal to a coal-fired power plant. The direct effects model the level of imports and in-state purchases to generate the effects of specific activities. Thus, these models are at the industry, not firm level and use average, not firm specific purchases of items within and outside the state. Finally, the model generates induced effects, which result from increased population due to the change in the local economy. These are summed to provide a total economic effect.

There are other local effects, such as emissions of pollutants and land use patterns. We will only briefly address these issues. The impact of changing fuel mixes also influences local fiscal conditions, which we address in detail in the final analytical section. *Table 4* details the effect of the purchase of $100 million of electricity from different types of facilities in Indiana. These impacts are only within the state, ignoring larger effects outside the region. These appear in *Table 4*.

Table 4. Impact of $100 Million Electricity Production Revenue				
Indiana Annual Impact of Electric Power Generation (Event Size = $100 Million)				
	Direct	Indirect	Induced	Total
Employment	135	37	92	264
Sales/Output	$100,000,000	$8,980,318	$15,579,463	$124,559,780
Compensation	$20,391,353	$2,424,092	$4,945,431	$27,760,875

Indiana Annual Impact of Fossil Fuel Electric Power Generation (Event Size = $100 Million)				
	Direct	Indirect	Induced	Total
Employment	134	35	92	261
Sales/Output	$100,000,000	$8,611,085	$15,500,492	$124,111,578
Compensation	$20,383,050	$2,302,888	$4,920,352	$27,606,290
Indiana Annual Impact of Solar Electric Power Generation (Event Size = $100 Million)				
	Direct	Indirect	Induced	Total
Employment	292	101	108	501
Sales/Output	$100,000,000	$21,757,326	$18,256,147	$140,013,472
Compensation	$24,138,362	$6,643,029	$5,795,085	$36,576,475
Indiana Annual Impact of Wind Electric Power Generation (Event Size = $100 Million)				
	Direct	Indirect	Induced	Total
Employment	148	93	106	347
Sales/Output	$100,000,000	$20,037,066	$17,874,824	$137,911,890
Compensation	$20,673,245	$6,058,284	$5,674,041	$32,405,570
Indiana Annual Impact of Biomass Electric Power Generation (Event Size = $100 Million)				
	Direct	Indirect	Induced	Total
Employment	139	94	106	339
Sales/Output	$100,000,000	$20,153,043	$17,901,290	$138,054,333
Compensation	$19,971,177	$6,101,586	$5,682,442	$31,755,205
Indiana Annual Impact of Hydroelectric Power Generation (Event Size = $100 Million)				
	Direct	Indirect	Induced	Total
Employment	233	106	110	449
Sales/Output	$100,000,000	$23,415,580	$18,568,994	$141,984,574
Compensation	$5,242,501	$7,115,760	$5,894,392	$18,252,653

Combining the jobs per $100 million of revenue, by energy production source with the total energy sales by sector displayed in Table 3, permits us to estimate a total jobs impact of the changing mix of electricity production in Indiana from 2010 to 2018. This is a simple adjustment, and does not include estimates of changing productivity. As *Figure 7* illustrates, the productivity of coal mining changes slowly with time. While we have clear evidence of coal mining productivity, the data are silent on productivity changes to the variety of other fuel sources. Thus, we simply assume constant productivity across the time period analyzed. This is certainly an imperfect assumption, but the between firm variability in productivity is certainly larger than the between year average we would need to model. See *Table 5* for these effects.

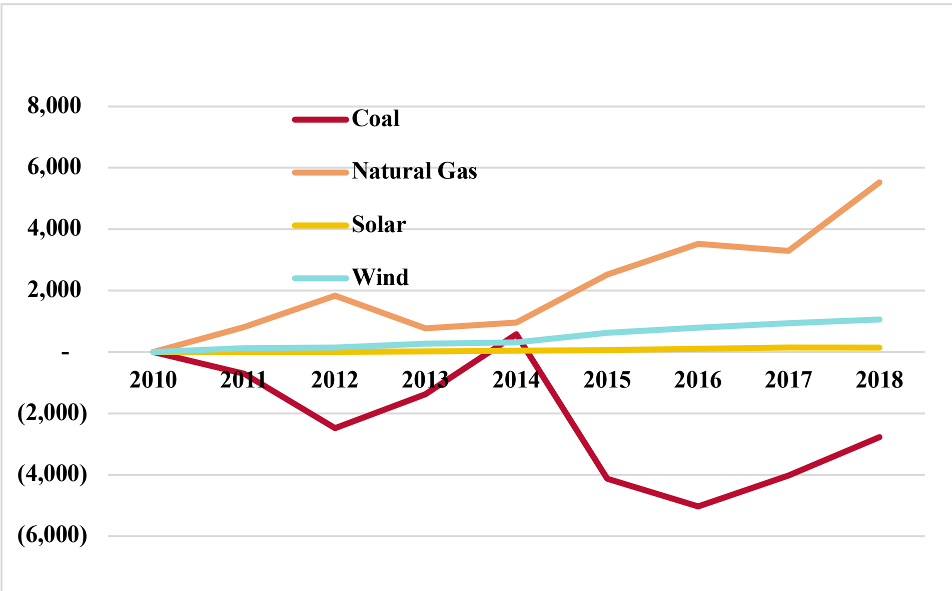
Table 5. Total Employment Effect of Electric Power Production in Indiana

Year	Coal	Natural Gas	Petroleum	Other Gases	Other Biomass	Hydro	Solar	Wind	Other	Total
2010	22,487	1,296	31	429	81	156	0	781	77	25,261
2011	21,774	2,104	279	456	91	147	0	913	78	25,765
2012	20,006	3,131	205	539	94	161	0	923	76	25,060
2013	21,116	2,058	358	549	111	152	13	1,055	102	25,412
2014	23,067	2,264	322	511	120	151	46	1,099	93	27,580
2015	18,356	3,816	314	532	136	154	70	1,409	100	24,787
2016	17,455	4,812	147	547	135	176	104	1,568	88	24,944
2017	18,458	4,584	32	508	157	134	136	1,725	79	25,734
2018	19,710	6,824	33	592	152	97	142	1,840	83	29,391

Net Change	-2,777	5,528	2	163	71	-59	142	1,059	6	4,135
% Change	-12.3%	426.5%	6.5%	38.0%	87.7%	-37.8%	N/A	135.6%	7.8%	16.3%

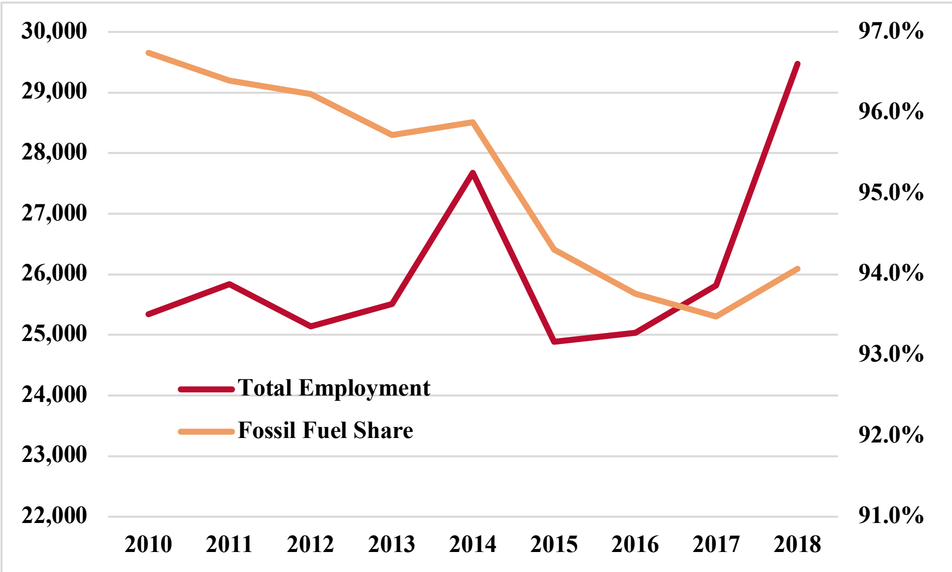
Note: figures may not sum due to rounding

Figure 9. Cumulative Total Employment Change by Major Energy Source



As is clear from *Table 5*, **the shift from coal to natural gas and renewables is accompanied by employment growth in energy production-related sectors.**

Figure 10, Fossil Fuel Share and Total Employment

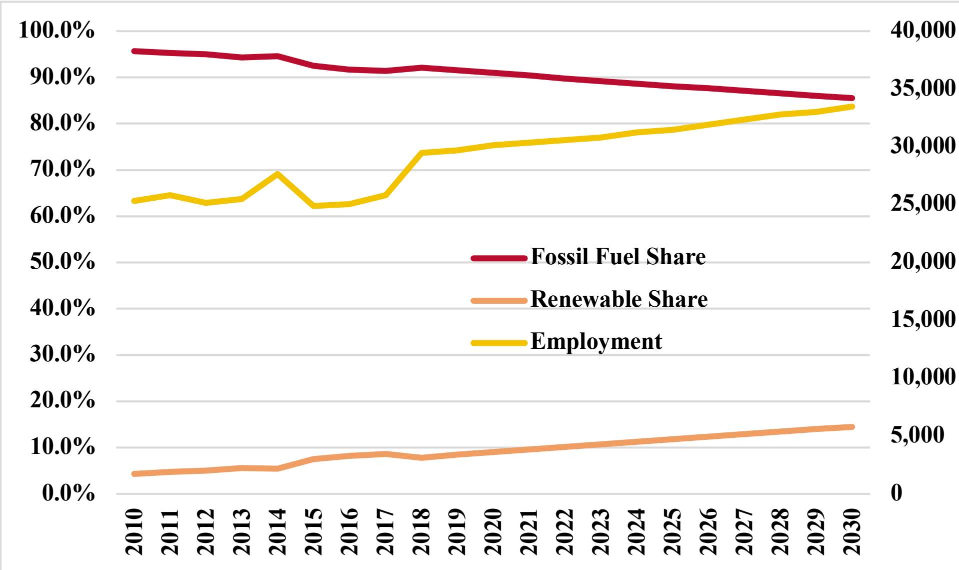


Projecting these trends into the new decade should offer some insight to the employment effects of shifting fuel sources for electric power generation. To do this we forecast energy production of fossil fuels and renewables, along with state-level GDP. For the GDP model, we use an ARMA (1,1) with trend. For fossil fuel production, renewable production and total energy sector employment, we deploy state level real GDP growth projections as an explanatory variable in projections of renewable and fossil fuel production through 2030. These models also include an ARMA (1,1) and trend.[16]

Using current trends, including an expected expansion of Indiana GDP at historical rates, we project growth of electric power generation of 9.7 percent. The total fossil fuel share would decline from 92.1 percent to 85.5 percent, with renewable fuels growing from 7.9 percent to 14.5 percent of the total energy production in Indiana. Accompanying this would be **job growth associated with electric power generation in Indiana from more than 29,000 to more than 33,000 workers.**

[16] An ARMA (1,1) is a first order autoregressive integrate moving average of the dependent variable. This with a trend is a common forecasting approach, particular with short annual time series which would lack seasonality.

Figure 11. Changing Mix of Generation and Total Electric Power Generation Employment



Importantly, the geographic mix of electric power generation will, through the increase of renewable energy, be more diffuse across Indiana. **Today, nearly all the direct fuel production is concentrated in three counties, with employment in coal mining concentrated almost wholly in a half a dozen counties.The inclusion of renewable energy resources, including solar, wind, and biomass will be distributed across a much broader geography of the state.**

Local and Fiscal Effects

The production of energy occurs locally, creating fiscal effects locally and across the state. The following section models the impacts of the construction and operation of a new 50 Megawatt production facility for coal, natural gas combined cycle, solar, wind, or biomass facility constructed in a representative Indiana county. We report the total effects on employment, sales (output or production) and compensation as per the tables reported above. We also include direct capital estimates from several sources, and the expected tax effects.

Property taxes in Indiana accrue to local governments. There is a 3.0 percent property tax cap on industrial property, but abatements are common, particularly for large investments. We assume an effective tax rate of 2.5 percent, which is close to the actual average rate across Indiana's 92 counties. These values are reported for the first year. We do not calculate abatements or depreciation. Depreciation faces a taxable floor at 30 percent, but with most capital investment, large depreciation levels also increase effective tax rate. Thus, rates may converge to 3.0 percent, on only 30 percent of the remaining capital. As an example, these two factors would typically result in property tax collections of $5 million initially, to drop to $1.8 million per year by the eighth year after the investment is made. My estimates of capital levels are conservative.[17]

Income taxes are paid to the state. We assume taxes at the statuary 3.1 percent against 80 percent of income. This likely a higher share of income against which we levy taxes, but in so doing, we have not included corporate or personal income taxes levied against the establishment itself. Thus, our estimated overall income tax collections are conservative.

Local Income Taxes (LIT) are paid to local governments. We assume a 0.8 percent rate, which is lower than in most counties, but we levy this against 80 percent of earnings. Thus, this is likely a conservative estimate. This does not include LIT assessed against an establishment, which is an LLC, which reinforces the conservative nature of the estimate.

Finally, we assess sales tax at the statutory rate of 7.0 percent assessed against 40 percent of earnings. We did not include business payment of sales tax, which likely accounts for 40 percent of state sales tax collections.[18] Thus, this is also conservative.

The first of our estimates, reported in *Table 6*, are the representative coal fired power plant. While Indiana is unlikely to again see a new coal plant at utility scale, new gas combined cycle plants are likely to be built in the coming years. (Note: These are not peak load plants, which are more expensive and capital intensive).

Again, some caution is in order. These estimates are conservative, but capital costs in particular are sensitive to new innovation. This has been true in both wind and solar power, but it is increasingly true in all scales of solar power generation. Also, local governments will almost always offer tax abatements, which diminish the impact of the investment on tax revenues. However, across each type we have not estimated any additional capital investment that might accompany indirect or induced economic growth in population or employment due to the addition of a new plant. Again, that preserves the goal of conservative estimates of use.

All the estimates are drawn from an Input-Output type model maintained at the 6-digit NAICS by Chmura Economics, LLC. However, the national input-output accounts typically use employment change as the variable from which to estimate economic impacts. Here, we seek generation capacity. Having already connected employment to capital usage, we connect capital to generation using the Overnight Capital Costs of each form of production. This approach has well-known strengths and weaknesses, but remains the standard for linking capital expenditures to energy production. *Table 6* summarizes the major effects here.

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[17] Faulk, Dagney, and Michael J. Hicks. "Residential Property Tax Deductions & Effective Property Tax Rates in Indiana."

[18] See Thaiprasert, Nalitra, Dagney Faulk, and Michael J. Hicks. "A regional computable general equilibrium analysis of property tax rate caps and a sales tax rate increase in Indiana." *Public Finance Review* 41, no. 4 (2013): 446-472; and Faulk, Dagney, Nalitra Thaiprasert, Michael Hicks, and I. N. Muncie. The Economic Effects of Replacing the Property Tax with a Sales or Income Tax: A Computable General Equilibrium Approach. No. 201008. 2010.

Table 6, Selected Economic and Fiscal Effect of a New Facility Producing 50 MW of Power					
	Coal-Fired Electric Power	**Natural Gas CC plant**	**Solar Power Generation**	**Wind Electric Power**	**Biomass Electric Power**
Employment	418	112	477	250	821
Sales/Output	$197,708,048	$53,178,897	$122,670,189	$86,459,792	$163,468,135
Compensation (Wage)	$48,000	$46,560	$57,205	$47,630	$30,243
Capital	$181,800,000	$48,900,000	$133,850,000	$93,850,000	$249,250,000
Property Tax	$4,545,000	$1,222,500	$1,145,154	$1,580,640	$4,476,162
Income Tax	$497,312	$133,766	$676,387	$294,732	$615,451
LIT	$96,254	$25,890	$130,914	$57,045	$119,119
Sales Tax	$561,482	$151,026	$763,663	$332,762	$694,864

Some additional discussion is useful in interpreting these results. The Overnight Cost of Capital estimates are for maximum production levels, thus providing a comparison of capital costs across types of production. What is missing from this analysis are scale economy differences, which at the margin, influence both labor and capital used for the last MWH of production. We use the most common type of production technology across each type of energy production. There are others, and the presence of alternative technologies influences the capital and labor used.

This analysis includes all jobs created statewide as a consequence of a new facility. Most of these jobs are permanent, but a large share does not occur on site, or are not direct jobs. Employment used in the production of inputs, such as coal mining or farming, are included. So too are jobs created in maintaining equipment, providing spare parts, managing the network, and providing other business services. Also, these figures include jobs created through the spending of employees at the plant. Wages for these workers are reported, but proprietor incomes are typically excluded. This explains much of the large wage differences for the typical job created across types of production.

We note that these estimates are for Indiana only and not other states that may vary in their production of coal or natural gas, availability of biomass inputs, and the manufacturing and maintenance of photovoltaic cells or wind turbines as well as associated employment in transmission and other market management.

Finally, we have not attempted to model additional local affects that may be of importance to many policymakers. **The geographic distribution of biomass, wind, and solar production is much wider than that of coal or natural gas**. This is simply because the natural distribution of fossil fuels is more geographically concentrated than renewable sources. **One result of this distribution is that royalties and rents paid to property owners are likely more broadly distributed in renewable energy production than in fossil fuel production.** This also contributes to the differential impact of production in these sources on employment and tax revenues.

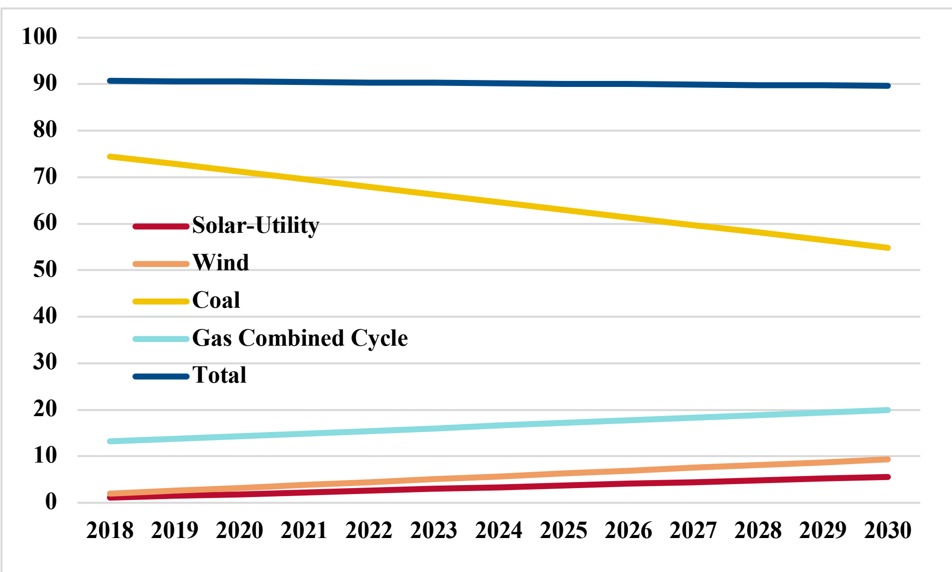
Summary

Indiana is in the midst of two trends. **The first is a shift from coal to natural gas electric power production, and the second is the shift from fossil fuels to renewable energy. Both of these trends are motivated by fundamental economics of energy production.** While natural gas is far less expensive as a fuel for power generation than coal, it is clear that renewables are increasingly cost effective, and **as of 2016 both wind and solar electric power generation were less expensive than either natural gas or coal**. This does not include production incentives.

We project this adjustment will continue for the foreseeable future, as renewable energy replaces fossil fuels, and gas replaces coal. In our final model, we evaluate the shifting share of solar, wind, coal, and natural gas production on total expenditures for energy in Indiana. This simulation illustrates a faster adjustment than forecasted, but is used to demonstrate how current technology and the mix of fuels at an accelerated shift of production would affect expenditures for energy (cost per MWH, times total usage).

Thus, *Figure 12* illustrates that total expenditures on electricity can remain constant, or decline modestly as cheaper fuels replace more expensive fuels at a rate not yet observed in Indiana.

Figure 12, Simulation of Expenditure Index on Different Energy Sources, 2018-2030



We do not offer this simulation as a policy prescription, merely as an illustration of the observed effects of transition have not significantly affected prices or expenditures. Also, we note that the shift from coal to natural gas is largely dictated by utility and consumer cost and pricing concerns, while adjustment to renewables has broader implications. These include, but are not restricted to environmental considerations not addressed by state regulations. For example, many firms have undertaken private efforts to reduce greenhouse gas emissions, and seek renewable sources as part of a corporate strategy distinct from state regulation. **Likewise, design and construction standards increasingly consider utility fuel sources.**[19] Both of these considerations may affect business location and the cost of new construction across both private and public activities. We have not modeled these factors, but note they matter now, and will matter more in coming years.

We conclude by observing that the shift to renewable energy will reduce average and incremental costs of power subsequent to the initial investments. Renewables will stabilize energy prices, offer more permanent supply, reduce the local labor demand shocks associated with shifting fuel extraction and move energy production into more Indiana communities than is the current experience. Renewable energy growth will make Indiana more attractive to firms and households who favor lower prices and fewer emissions, it will lead to less environmental restrictions on firm location, and will generate employment growth above that we can experience with continued reliance on fossil fuels. The shift to renewable energy will not be complete, and will not, in the coming decades fully remove fossil fuels from our mix of electric power production. However, as renewables are less expensive and generate more employment, across a broader geography they should remain a welcome feature of the changing energy landscape of Indiana.

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[19] See LEED v4.1 BD+C