# COMPARISON OF COAL-, NATURAL GAS-, AND WIND-POWERED ENERGY SOURCES

This memorandum provides information regarding a comparison of coal-, natural gas-, and wind-powered energy sources.

## GRID STRUCTURE AND CONVENTIONAL AND RENEWABLE ENERGY SOURCES

The electric generation, transmission, and distribution system is owned by a variety of entities including investor-owned utilities (IOUs), publicly owned utilities, cooperatives, and independent power producers. Investor-owned utilities are for-profit companies owned by their shareholders. The state regulates an IOU's distribution system and retail sales and the Federal Energy Regulatory Commission regulates an IOU's interstate generation, transmission, and wholesale power sales. Publicly owned utilities are not-for-profit utilities generally regulated by their own local government, and include city-owned municipal utilities. Cooperatives are member-owned not-for-profit entities that historically have served rural areas. A cooperative's members receive any revenues generated in excess of costs. Independent power producers are privately owned businesses that operate their own generation assets. Independent power producers sell power to end users and other utilities.

To maintain reliable service, utility systems often enter reserve-sharing agreements, which has led to the formation of power pools. The transmission and dispatch of electricity supplied by power pools generally is managed on a regional basis by a regional transmission organization (RTO) or an independent system operator. The two RTOs serving North Dakota are the Midcontinent Independent System Operator and the Southwest Power Pool. The regional transmission organization has operational control over the transmission system and ensures a sufficient supply of electricity is available to meet forecasted demands. Lower-cost electricity generally is dispatched before higher-cost electricity, which may result in certain power sources decreasing capacity or powering down to accommodate the influx of power from lower-cost sources.

The power that supplies the electric grid is generated by both conventional and renewable energy sources. Conventional energy sources include coal- and natural gas-fired power plants, and renewable energy sources include wind-powered electric generators. Unlike wind-powered electric generators, coal- and natural gas-fired power plants require a fuel source to operate, which must be extracted, processed, and delivered to the generation facility. Each energy source has its costs and benefits and contributes to powering the electric grid to meet fluctuating user demands for electricity. Coal-fired plants are effective at satisfying base-load electricity demands and natural gas-fired plants, which have faster startup times, are effective at satisfying electricity demands during periods of peak energy use. Electricity generated by wind-powered sources is added to the grid on an intermittent basis when the wind is blowing.

## SHARE OF TOTAL GENERATION SUPPLIED BY VARIOUS ENERGY SOURCES

The United States Energy Information Administration's (EIA) January 2018, *Short-Term Energy Outlook* provides historical data pertaining to coal, natural gas, and wind resources for calendar year 2017. The publication also provides comparable data estimates for calendar years 2018 and 2019. Historical data pertaining to the total amount of utility-scale electricity generated in the United States in 2017 shows 31.7 percent of the total amount of electricity generated was generated by natural gas, 30.1 percent was generated by coal, and 6.3 percent was generated by wind. In 2018, EIA anticipates 33.1 percent of the total amount of electricity generated will be generated by natural gas, 29.6 percent will be generated by coal, and 6.4 percent will be generated by wind. In 2019, EIA expects 34.3 percent of the total amount of electricity generated will be generated by natural gas, 28.1 percent will be generated by coal, and 6.9 percent will be generated by wind.

The Energy Information Administration attributes the declining share of electricity generated by coal-fired power plants in 2018 and 2019 to low natural gas prices and the anticipated retirement of 13 gigawatts (GW) of coal-fired capacity. The increasing share of electricity generated by natural gas-fired power plants is attributed to low natural gas prices, a reduction in the share of electricity generated by hydroelectric power, and the projected addition of 20 GW of new natural gas-fired capacity. Slow but steady growth in the share of electricity generated by wind-powered sources reflects an increase in large-scale wind capacity from 88 GW at the end of 2017, to an estimated 96 GW by the end of 2018, and an estimated 104 GW by the end of 2019.

## COMPARABLE COSTS OF ENERGY SOURCES

The Energy Information Administration also provides projections regarding the comparable costs of various electricity sources in its April 2017, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017*. The levelized cost of electricity (LCOE) represents the per-megawatt hour (MWh) cost of building and operating a generating plant over the plant's assumed financial life. Factors taken into account

when calculating LCOE include fuel costs, financing costs, capital costs, fixed and variable operating and maintenance (O&M) costs, and the utilization rate for each type of plant, which can be impacted by an area's existing resource mix. The levelized avoided cost of electricity (LACE) measures the cost of generation and capacity resources displaced by a marginal unit of new generation capacity to provide an estimate of the value of building the new generation source. Comparing both the levelized and avoided costs of various energy sources provides a better assessment of the economic competitiveness of energy sources.

The following table provides a summary of the publication's findings regarding the difference between the levelized and avoided costs of electricity for plants entering service in 2022. Costs are compared using 2016 dollars per MWh of electricity generated and take into account Clean Power Plan impacts and state-level renewable electricity requirements as of November 2016.

**United States Average LCOE and LACE (in 2016 Dollars per MWh) for Plants Entering Service in 2022**

| Plant Type | Capacity Factor | Levelized Capital Cost | Fixed O&M Costs | Variable O&M Costs | Transmission Investment | Total LCOE[1] | Total LACE | Net Difference[2] |
|---|---|---|---|---|---|---|---|---|
| Coal with 30% carbon sequestration[3] | 85 | 94.9 | 9.3 | 34.6 | 1.2 | 140.0 | 58.7 | -81.3 |
| Coal with 90% carbon sequestration[3] | 85 | 78.0 | 10.8 | 33.1 | 1.2 | 123.2 | 58.7 | -64.5 |
| Natural gas-fired conventional combined cycle | 87 | 13.9 | 1.4 | 40.8 | 1.2 | 57.3 | 58.1 | 0.9 |
| Natural gas-fired advanced combined cycle | 87 | 15.8 | 1.3 | 38.1 | 1.2 | 56.5 | 58.1 | 1.7 |
| Natural gas-fired advanced combined cycle with carbon capture and sequestration | 87 | 29.5 | 4.4 | 47.4 | 1.2 | 82.4 | 58.1 | -24.2 |
| Onshore wind | 39 | 47.2 | 13.7 | 0.0 | 2.8 | 63.7[4] | 53.2 | -10.5 |

[1]State and federal tax credits have not been included in calculating the total LCOE.

[2]A negative net difference indicates the cost of a marginal new unit of capacity exceeds its value to the system. A positive net difference indicates the value of the marginal new unit exceeds its cost by displacing more expensive generation and capacity options.

[3]Coal plants placed in service in 2022 will be required to comply with carbon dioxide emission standards pursuant to Section 111(b) of the federal Clean Air Act. Capital costs will increase relative to the percentage of carbon dioxide emissions that are captured.

[4]Onshore wind plants generally are built in regions with the lowest costs and the highest values. The LCOE for wind capacity coming online in 2022 is $43.40 per MWh in the region with the best available resources.

The nationwide average estimates provided in the table vary at the regional level and are subject to change based on a variety of factors including the development of new technologies, fluctuating fuel prices, and future policy changes relating to environmental regulations or taxation.