

# Understanding and Assessing Climate Change: Preparing for Nebraska's Future

## 2024 Climate Change Impact Assessment Report Chapter 6 - Energy





# Chapter 6

## Energy

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### Key messages

1. Energy-related emissions (burning fossil fuel for electricity, transportation, heat, steam, and fertilizer production) are Nebraska's leading cause of greenhouse gas emissions.
2. Nebraskans consume energy directly (fuel and energy purchases) and indirectly (in products and services).
3. Reducing emissions can have a positive financial impact (reduced energy and fertilizer costs).
4. Nebraskans will need to consider where the most significant impacts from energy efficiency and fuel switching can be made at all levels. This includes residential (heating and cooling), commercial (heating and cooling), transportation (vehicles), business-level policy, local policy, state-level policy, and national policy.
5. Emissions reduction goals should be compatible with reliability goals.



# Introduction

Energy is a power or force derived from physical or chemical resources used to perform work, such as operating machines and providing light and heat. Energy is necessary for individuals and societies to survive and thrive. Humans use energy every day in various forms to refrigerate and freeze our food, cook our food, heat and cool our homes, manufacture products, and travel from place to place. Modern society is built on reliable energy sources and thrives on low-cost and reliable sources. Energy use results in emissions driving global climate change and reduced environmental quality. Emissions from energy use depend on the type of energy and how much is used. Greenhouse gas (GHG) emissions from energy generation are mainly carbon dioxide, yet other GHGs, such as methane, also contribute to total GHG emissions. Emissions are usually represented in carbon dioxide equivalents. Energy generation emissions can also include air pollution, such as particulates, volatile organic compounds, and nitrogen oxides. Air pollution and GHGs are both emitted when burning fossil fuels. Sixty-nine percent of Nebraska's total energy use comes from fossil fuels.

Total energy use in Nebraska (Figure 6.1) is led by petroleum used for transportation, followed by coal (electricity), renewables (electricity and transportation), natural gas (electricity and heating), and nuclear (electricity) (NDEE, 2023b). Nebraska's renewable energy consumption in 2023 comprised 11.5% biofuels, 8.9% wind, 1.35% hydroelectric, and less than 1% of others (wood and waste, geothermal, and solar). The national trend of total energy consumption has plateaued somewhat since 2000, yet total consumption is expected to grow from 0% to 15% between 2022 and 2050 (EIA, 2023a). The 2023 Annual Energy Outlook (AEO) contains estimates of future consumption and production based on various price and demand scenarios (EIA, 2023a). The AEO concludes a likely increase in electrification due to cheaper electricity driven by improved end-use technologies, efficiency, and declining costs of generation technologies. The greatest increase in electricity demand is predicted to come from increases in cooling demand and electric vehicles. Total energy consumption will depend on the growth of the economy. Nebraska will likely follow these

## Nebraska's Total Energy Consumption by Fuel Source in 2021

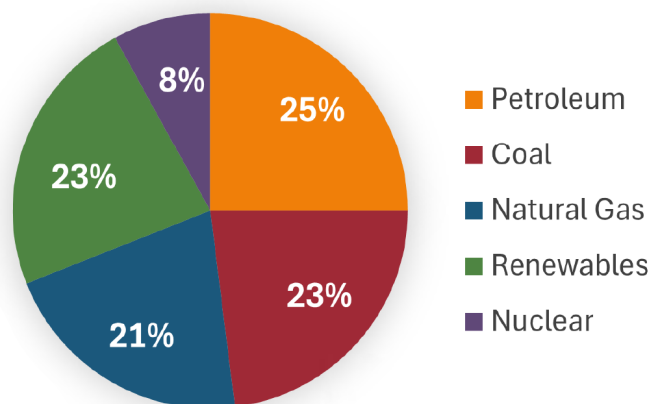


Figure 6.1. Nebraska's total energy consumption by fuel source, 2020. (Source: NDEE, 2023b)

trends of increased energy use as the economy grows.

Petroleum use in Nebraska is about half gasoline and half diesel fuel, with a smaller amount of aviation fuel. Coal burned in Nebraska is used exclusively for electrical generation. Nebraska's renewable sources are about half biofuels (mostly ethanol), about 40% wind power, 6% hydroelectric, and 0.3% solar. Natural gas consumption in Nebraska is 54% industrial use for manufacturing, 22% residential heating and water heating, 18% commercial heating and water heating, and 6% electricity production. Nuclear energy consumption is exclusively for electricity production. Individual Nebraskans are part of the energy system as they purchase fuel for their cars, trucks, and tractors and pay electricity and natural gas bills in their homes.

Nebraska's energy consumption by sector yields more details on how Nebraskans use energy (Figure 6.2). The industrial sector is Nebraska's largest energy user and accounts for energy used in manufacturing, mining, construction, and agriculture. Transportation mainly uses gasoline and diesel fuel, with a smaller amount of aviation fuels and natural gas. Electricity is a growing transportation fuel, and electric vehicle purchases are growing. Commercial energy use is mainly from buildings, with major energy use from warehouses, storage, offices, services, mercantile, public assemblies, religious worship, education, and food services. Residential energy use is dominated by space heating,

water heating, and air conditioning. Nebraskans may not directly purchase energy used in commercial and industrial sectors, yet they indirectly purchase that energy through their use of services and purchase of products. From a cost standpoint, transportation dominates the total energy expenditure in Nebraska. Although only 23.6% of total energy consumption is transportation fuels, they are more expensive than fuels used in industrial applications, leading to higher total expenditures. Nebraska's electricity consumption in the commercial sector is seeing substantial increases due to economic growth, including growth in the data center and data mining fields. This increased need for electrical cooling at data centers will continue nationally, with greater use of data on computers and mobile devices and artificial intelligence. Consumers use data in mobile devices and computing, driving demand for more data centers, which is an example of indirect emissions. The direct and indirect use of energy in Nebraska leads to emissions. These emissions drive both climate change and increase air pollution.

Energy is the primary source of emissions in the United States. Figure 6.3 shows the total U.S. greenhouse gas emissions by economic sector. For the U.S. the primary source of emissions is burning fossil fuels, except for agriculture, whose primary emission sources are methane from enteric fermentation and nitrous oxides from soils. Nebraska's breakdown of emissions (Figure 6.4) is led by agriculture (41.7%), electricity production (24.2%), transportation (15.2%) and industry (11.4%).

Fossil fuel emissions from greenhouse gases and air pollutants such as nitrogen oxides and particulates can be broken into direct emissions, such as the emissions from burned fuels, and indirect emissions from upstream processes to extract and transport fuel, manufacturing construction, and conversion equipment. Indirect emissions are also important to consider for all energy sources, including fossil fuels and renewables. Some energy systems, like wind and solar, do not produce fuel emissions. As a result, most of their emissions come from indirect emissions. Advertising commonly declares renewables like wind, solar, or electric cars as having zero emissions. These claims may be valid if the emissions are only looked at

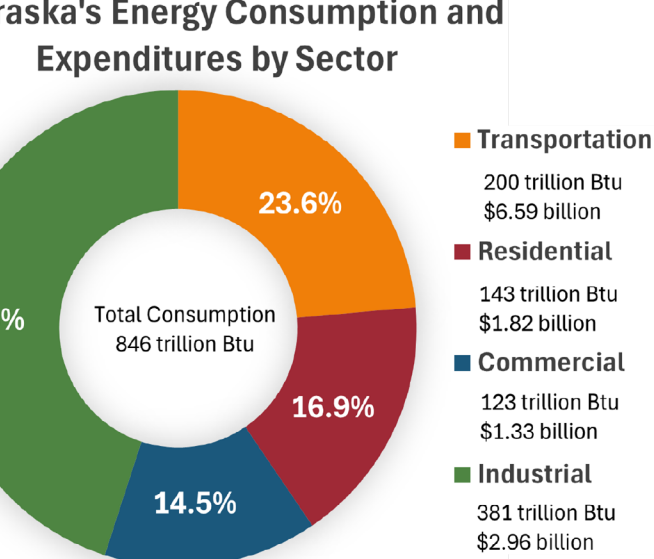


Figure 6.2. Nebraska's energy consumption and expenditures by sector. (Source: EIA, 2024)

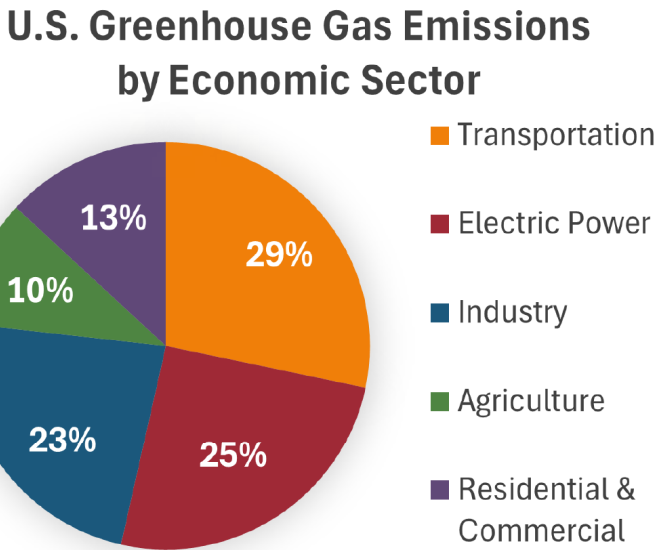


Figure 6.3. U.S. greenhouse and gas emissions by economic sector (EPA, 2024e). (Bottom, left) Nebraska greenhouse and gas emissions by economic sector in 2021 (NDEE, 2024). (Bottom, right) Nebraska greenhouse and gas emissions by economic sector in 2021 (Source: NDEE, 2024b)

narrowly after wind and solar installation or only during the electric car's operation. However, when total life-cycle emissions are included, renewables and electric cars have emissions that should be considered.



# Nebraska Greenhouse Gas Emissions by Economic Sector

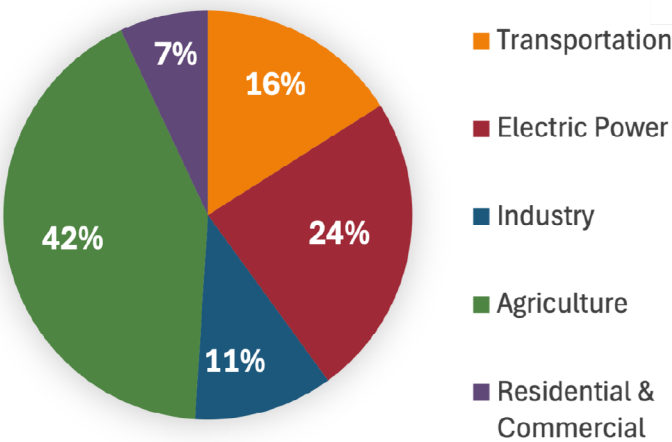


Figure 6.4. Nebraska greenhouse gas emissions by economic sector in 2021 (Source: NDEE, 2024b).

Table 6.1 contains a list of life-cycle emissions for different fuel types. These emissions are reported per unit of energy. To calculate these, the direct and indirect emissions are totaled for the planned lifetime of the project or product and divided by the estimated total energy produced or consumed during its lifetime. Units for Table 6.1 are carbon dioxide equivalent (CO<sub>2</sub>e) emissions per unit of energy generated or used in kilowatt hours (kWh). Carbon dioxide equivalents are used to standardize emissions values regardless of emissions type. For example, when methane is emitted, it would equal 28 CO<sub>2</sub>e. Comparisons of these values should only be made between similar fuels; for example, comparing diesel with biodiesel or renewable diesel compares fuels that work in equipment with similar efficiencies and shows bio and renewable diesel to

have considerably fewer emissions than petroleum diesel fuel. Care should be taken when comparing fuels that cannot directly replace the other. For example, comparing electricity used for transportation with gasoline leads to comparison problems because of the difference in efficiency between these two systems. To make this comparison more informative, the values could be converted to CO<sub>2</sub>e per mile driven. For example, a gasoline car has emissions of 412 grams of CO<sub>2</sub>e per mile driven, while a similarly sized electric car (charging from the Nebraska Grid Mix in 2021) has 283 grams of CO<sub>2</sub>e per mile driven. Electricity has larger emissions per unit of energy than gasoline, yet the per mile emissions are lower because of electric motors’ higher efficiency than gasoline engines (Argonne National Laboratory, 2022). Similarly, a comparison of emissions from electricity generation should be made with consideration to the type of generation. Dispatchable generation sources such as natural gas, coal, and nuclear can be turned on or off, or their output can be increased or decreased, to match electricity demand as needed, although each has limits on how quickly or flexibly it can be adjusted. By contrast, renewable energy sources such as solar and wind are non-dispatchable or intermittent, producing power only when their natural resources (wind and sunlight) are available. However, innovative solutions such as energy storage and smart grids address concerns related to intermittency. Ensuring a continuous electricity supply requires a balanced mix of resources, including renewables, dispatchable generation, and storage. Future planning for electricity generation and emissions reductions will need to consider the availability and characteristics of different sources to provide both reliability and lower emissions.

Table 6.1. Life-cycle greenhouse gas emissions by fuel type

| TRANSPORTATION |                                           |                                                       |                                                       |                                                        |
|----------------|-------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------|
| FUEL TYPE      | EMISSIONS<br>(GCO <sub>2</sub> E/<br>KWH) | EMISSIONS<br>(GCO <sub>2</sub> E PER<br>MILE DRIVEN ) | RANGE FROM<br>LITERATURE<br>(GCO <sub>2</sub> -E/KWH) | SOURCE                                                 |
| Gasoline       | 326                                       | 412                                                   | 320–393                                               | Argonne National Laboratory, 2022; Rahman et al., 2015 |
| Diesel         | 323                                       | 340–2800                                              | 321–397                                               | Argonne National Laboratory, 2022; Rahman et al., 2015 |



| TRANSPORTATION          |                                           |                                                       |                                                       |                                                            |
|-------------------------|-------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------------|
| FUEL TYPE               | EMISSIONS<br>(GCO <sub>2</sub> E/<br>KWH) | EMISSIONS<br>(GCO <sub>2</sub> E PER<br>MILE DRIVEN ) | RANGE FROM<br>LITERATURE<br>(GCO <sub>2</sub> -E/KWH) | SOURCE                                                     |
| Ethanol<br>(corn grain) | 200                                       | (E85) 288<br>(E10) 407                                | 135–234                                               | Argonne National Laboratory,<br>2022; Scully et al., 2021a |

| TRANSPORTATION                                          |                                           |                                                            |                                                       |                                                                                  |
|---------------------------------------------------------|-------------------------------------------|------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------|
| FUEL TYPE                                               | EMISSIONS<br>(GCO <sub>2</sub> E/<br>KWH) | EMISSIONS<br>(GCO <sub>2</sub> E PER<br>MILE DRIVEN )      | RANGE FROM<br>LITERATURE<br>(GCO <sub>2</sub> -E/KWH) | SOURCE                                                                           |
| Ethanol<br>(biomass,<br>switchgrass and<br>corn stover) | 90                                        | 92–139<br>(E85) 100<br>(E10) 278                           | -13– -108                                             | Argonne National Laboratory,<br>2022; Liu et al., 2020<br>Murphy & Kendall, 2015 |
| Biodiesel/<br>Renewable<br>Diesel                       | 113                                       | (biodiesel B20)<br>298<br>(renewable<br>diesel)<br>240–424 | 75–113                                                | Argonne National Laboratory,<br>2022; H. Xu et al., 2022                         |
| Electricity                                             | 466                                       | (U.S. mix) 165<br>(NE mix 2021)<br>283                     | 12–1,001                                              | Argonne National Laboratory,<br>2022                                             |

| ELECTRICITY GENERATION               |                                       |                                                   |                           |
|--------------------------------------|---------------------------------------|---------------------------------------------------|---------------------------|
| FUEL TYPE                            | EMISSIONS<br>(GCO <sub>2</sub> E/KWH) | RANGE FROM LITERATURE<br>(GCO <sub>2</sub> E/KWH) | SOURCE                    |
| Coal                                 | 1001                                  | 675–1,689                                         | Whitaker et al., 2012     |
| Natural Gas<br>Combined Cycle        | 460                                   | 420–480                                           | O'Donoughue et al., 2014  |
| Natural Gas<br>Combustion<br>Turbine | 640                                   | 486–750                                           | O'Donoughue et al., 2014  |
| Heavy Fuel Oil                       | 830                                   |                                                   | Tarannum & Mohammed, 2019 |
| Nuclear                              | 13                                    | 3.1–220                                           | Warner & Heath, 2012      |
| Wind (onshore)                       | 12                                    | 1.7–81                                            | Dolan & Heath, 2012       |

| ELECTRICITY GENERATION     |                                       |                                                   |                        |
|----------------------------|---------------------------------------|---------------------------------------------------|------------------------|
| FUEL TYPE                  | EMISSIONS<br>(GCO <sub>2</sub> E/KWH) | RANGE FROM LITERATURE<br>(GCO <sub>2</sub> E/KWH) | SOURCE                 |
| Solar<br>(photovoltaic)    | 43                                    | 18–129                                            | Hsu et al., 2012       |
| Solar (Thermo<br>Electric) | 28                                    | 7–240                                             | Burkhardt et al., 2012 |
| Geothermal                 | 37                                    | 15–245                                            | Eberle et al., 2017    |

| ELECTRICITY GENERATION |                                       |                                                   |                                                                                                                         |
|------------------------|---------------------------------------|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| FUEL TYPE              | EMISSIONS<br>(GCO <sub>2</sub> E/KWH) | RANGE FROM LITERATURE<br>(GCO <sub>2</sub> E/KWH) | SOURCE                                                                                                                  |
| Hydroelectric          | 21                                    | 4–165                                             | Kumar et al., 2011                                                                                                      |
| Biomass                | 52                                    | 20–69                                             | <i>Literature Review and Sensitivity Analysis of Biopower Life Cycle Assessments and Greenhouse Gas Emission</i> , 2013 |

| STORAGE                          |                                       |                                                   |                                               |
|----------------------------------|---------------------------------------|---------------------------------------------------|-----------------------------------------------|
| FUEL TYPE                        | EMISSIONS<br>(GCO <sub>2</sub> E/KWH) | RANGE FROM LITERATURE<br>(GCO <sub>2</sub> E/KWH) | SOURCE                                        |
| Pumped Hydro<br>Storage (PHS)    | 86                                    | 58–530                                            | Kumar et al., 2011; Simon et al., 2023        |
| Lithium Ion<br>Battery           | 33                                    | 33–600                                            | Nicholson et al., 2021; Oliveira et al., 2015 |
| Hydrogen Fuel<br>Cell            | 38                                    | 30–315                                            | Frank et al., 2021; Khan et al., 2005         |
| Compressed Air<br>Energy Storage | 230                                   | 30–750                                            | Oliveira et al., 2015                         |

## Trends

## Electricity

The energy industry is changing due to new technology,



resource availability, and resource costs. The Energy Information Administration (EIA), in its Annual Energy Outlook (AEO), uses possible scenarios to estimate the generation mix in future years. Scenarios allow for estimates based on possible future costs, such as high oil and gas prices, low oil and gas prices, and high or low renewable energy prices. In the 2023 AEO, the predicted trend for all economic scenarios is for the retirement of older coal and nuclear power plants and the addition of natural gas, wind, solar, and energy storage. Coal and nuclear retirements are fewer for scenarios with low oil and gas supplies and high costs for renewables. Scenarios with high oil and gas supplies and low renewables costs saw higher coal and nuclear retirements and higher wind and solar additions. In all cases, the trend shows the retirement of coal and nuclear and the addition of natural gas, wind, and solar (EIA, 2023a). These are just predictions, and the reality will depend not only on supplies and costs but also on changes in public policy, consumer demand, and geopolitics.

## Oil

Through 2024, the U.S. has been the world's leading oil producer. Production is predicted to be high through 2050, with variability based on changes in supply.

Exports of refined products drive oil production, and predictions vary widely due to possible changes in price and international policy. U.S. oil consumption is predicted to remain steady, with little to no increase through 2050. Although the total number of cars may increase, oil demand is predicted to remain steady due to the continued increase in fuel efficiency of gasoline and diesel vehicles, as well as an increase in non-fossil fuel vehicles such as electric vehicles (EIA, 2023a).

## Natural gas

The Annual Energy Outlook (EIA, 2023a) predictions for natural gas suggest little to no increase in demand. A more detailed look shows industrial uses are predicted to increase through 2050 while electrical generation uses decline. The decline in electrical use prediction has substantial variability and will depend on economic growth, the price of electricity storage (batteries), and the cost of low-carbon generation technologies.

## Innovation and uncertainty

Although trends show growth in natural gas, wind, and solar, other technologies, such as coal and natural gas with carbon capture and storage and advanced nuclear, may emerge. Numerous technologies are in various stages of development, which may impact future generations and emissions. Some examples, such as hydrogen, small modular nuclear, enhanced geothermal, and nuclear fusion, are regularly seen in the news. Unforeseen circumstances, such as changes in policy and geopolitical events, challenge predictions of energy production and consumption.

## Federal policy and subsidies

One definition of a subsidy is a sum of money a government gives to assist a business in keeping the price of a commodity low or competitive. However, some economists broaden the definition beyond just payments: "A subsidy is a benefit given to an individual, business, or institution, usually by the government" (Investopedia Team, 2023). This broadened definition can help when considering energy subsidies. The U.S. government has given energy subsidies ubiquitously for all types of energy generation. However, this report will focus only on more recent policy activity impacting generation and consumption now and in the near future.

## Subsidies for electricity

Renewable energy technologies have long benefited from federal and state subsidies to promote renewable energy generation. The most recent iteration is the Inflation Reduction Act (IRA) of 2022 (White House, 2023). Changes in presidential administrations have led to an on-again, off-again nature of subsidies, including portions of the IRA. The recently passed One Big Beautiful Bill Act, signed by President Trump in 2025, significantly modifies provisions of the IRA (H.R. 1 - 119th Congress, 2025). For example, portions of the IRA subsidizing wind and solar are set to expire early, while subsidies for nuclear, hydroelectric, and geothermal are retained. Additionally, subsidies for carbon capture and storage were expanded. A reduction in subsidies can influence the adoption rate of technologies, and the

expiration of wind and solar subsidies will likely slow growth. Other factors, such as price, the environmental goals of private industry and public entities, and market supply and demand, will likely lead to some level of continued development of new wind and solar capacity.

## Subsidies for biofuels

Nebraska is a leader in ethanol production and ranks second nationally, producing over 2.2 billion gallons annually. Nebraska also consumes ethanol in the form of gasoline blends. Ethanol and biofuel subsidies have a long history. However, more recent laws, such as the Energy Policy Act of 2005, called the Renewable Fuel Standard (RFS), and later, the Energy Policy Act of 2007 (RFS2), continue to impact the biofuel market (Congressional Research Service, 2023). Tax credit subsidies paid to blenders for blending biofuels were part of the RFS and RFS2. Those tax credits expired in 2011, and now only the other RFS2 provisions require blending to impact biofuel production and consumption. The RFS and RFS2 mandate that the fuel industry blends biofuels with petroleum fuels. This mandate is a form of subsidy because it benefits the biofuel industry by creating demand for their products. The blending requirement rules require increased biofuel blending volumes and specify the blending levels for different biofuels based on their emissions compared to gasoline. Nationally, corn ethanol production and consumption has grown to over 15 billion gallons per year before reaching somewhat of a plateau. The plateau is caused by starch-based ethanol reaching the required blending maximums in the RFS2 and the limitations of using ethanol blends beyond 10%. The future of biofuels will continue to be impacted by the current RFS2 and IRA policies. However, it is important to note that the quality of the fuel characteristics of the biofuel itself also drives the demand for biofuels. The fuel industry desires ethanol's high octane and oxygenate characteristics. Nebraska has proven to be an excellent location for corn-based ethanol, as our combination of corn production and cattle feeding has benefited ethanol producers in the state. With a flat growth in gasoline use predicted, the ethanol industry will need to look to higher blends and other uses to fuel growth (EIA, 2023a). The growth of blends beyond 10% and the growth of emerging markets like ethanol and sustainable aviation fuel (SAF) are ways corn-based

ethanol can maintain or grow beyond RFS2 limitations.

Biodiesel can be made from a variety of vegetable oils and animal fats. Biodiesel is made by chemical reactions, converting triglycerides into methyl esters. Biodiesel can be used in diesel engines but is usually blended with petroleum diesel. Because of its different fuel characteristics, most engine manufacturers recommend blends of 20% or less. The biodiesel industry grew rapidly in the early 2000s, using soybean oil as a primary feedstock. Soybean oil remains the primary biodiesel feedstock, with 57% of biodiesel made from soy oil. Corn oil is second with 14%, followed by recycled waste oils (11%), canola (10%), and animal fats (8%). Nebraska currently has one biodiesel producer. Like biodiesel, renewable diesel is made from vegetable oils. Renewable diesel is made using a thermochemical refinery process and has fuel characteristics chemically equivalent to petroleum diesel. Soybean oil is the primary feedstock for renewable diesel, and 68% is made from soy oil. Corn oil is second with 20%, then canola oil at 7%, and recycled oils at 5% (EIA, 2022).

## Climate risks

Climate and weather extremes continuously challenge the energy sector. This section will review some of the risks faced by the energy sector in general terms and then note some examples of how Nebraska's energy sector has been impacted in the past. A look at the past will help in planning for future climate and weather conditions.

## Water

Water is used extensively in electricity generation. Large volumes of water are needed in thermal power plants, such as coal, nuclear, and combined cycle natural gas. Nebraska's 2023 electric energy was 53% coal, 19% nuclear, 22% wind, about 3% natural gas, and 3% hydroelectric, with small amounts of solar, biomass, and oil (NDEE, 2023b). With reliance on thermal electric systems, access to adequate water for cooling is critical for electric grid reliability. The USGS, in the report by Harris and Diehl (2019), indicates that as much as 32 gallons of water are pumped per kWh of electricity generated. Water quantity is critical to maintaining thermal electric production, yet reduced



quantity due to drought can lead to a secondary issue, which is increased water temperature. Power plants can be impacted when water levels are too low to operate, water inlet temperatures are too high, and water outlet temperatures are too high. These results could be lower thermal efficiency, plant curtailments, shutdowns, or working with permitting agencies to operate with variances. From 2000 to 2015, the National Renewable Energy Lab reported 43 instances where power plants were curtailed, shut down, or received variances due to water temperature, including one in Nebraska (McCall & Hillman, 2016). Excess water from flooding has also been a problem for electricity generation (see below, Climate Risk in Nebraska). The energy sector should continue to plan for weather and climate, preparing their systems to adjust to reduced water levels and increased water temperatures. Climate trends show reduced summer precipitation, reduced mountain snow water equivalent, and increasing

duration and frequency of droughts (Chapter 3).

## Climate risk in Nebraska

Climate risk is important for all forms of energy. Nebraska's energy system has experienced numerous problems due to extreme weather (Table 6.2). Some of these conditions will likely become more common as the climate changes. Flooding and drought have caused major issues for Nebraska's energy sector. However, more common weather events such as thunderstorms, wind, and falling trees caused the greatest number of utility outages from 2009 to 2019 (DOE, 2021). As severe weather events become more common, Nebraska can expect the risk of weather event–related utility outages to increase. See supplemental report 1, Table A.1. Summary of the potential climate impacts and adaptation considerations for more information (DOE, 2013).

*Table 6.2. Nebraska examples of extreme weather and climate impacts on energy systems. These examples are taken from the public record and represent only the largest events.*

| LOCATION                                                  | YEAR | IMPACT                                                                             |
|-----------------------------------------------------------|------|------------------------------------------------------------------------------------|
| North Platte River Hydropower                             | 2006 | A multiyear drought caused a reduction in power production                         |
| Fort Calhoun Nuclear                                      | 2011 | Floods caused shutdown                                                             |
| Spencer Dam Hydropower                                    | 2019 | Floods caused catastrophic dam failure                                             |
| Nebraska Electrical Grid                                  | 2021 | A polar vortex and energy demand spike led to rolling blackouts                    |
| Solar                                                     | 2023 | Large hail and high winds caused significant damage to a solar farm in Scottsbluff |
| North Omaha Coal<br>Nebraska City Coal                    | 2024 | The Missouri River froze at the water intake                                       |
| Lincoln-, Omaha-Area Transmission and Distribution System | 2024 | A windstorm caused widespread outages and the largest Omaha-area outage            |

# Nebraska's energy future

Nebraskans have many opportunities to react to the changing climate. Preparation for climate risks to minimize impact will be critically important for our energy sector. Additionally, Nebraskans can work to reduce emissions and subsequent impacts of greenhouse gas emissions. Actions to reduce emissions can be individual, local, or by governments and businesses. Some individual behaviors—such as improved fertilizer efficiency and reduced fossil fuel usage by increased efficiency—directly impact emissions. However, behaviors that impact local, state, national, and international policies and markets can have a more significant impact indirectly than individual direct impacts (Stern, 2000). This statement is not meant to discourage individual direct actions but to highlight the importance of actions such as voting and advocacy, which can impact future policies.

## Agricultural emissions and strategies to reduce emissions

Nebraska's emissions from agriculture comprised 42% of the state's emissions in 2021. For the U.S., agricultural emissions comprise 10.6% of total greenhouse gas emissions. In the U.S., agricultural emissions are primarily comprised of three greenhouse gases: methane, nitrous oxides, and carbon dioxide (EPA, 2024e). Agricultural and energy emissions are connected through several pathways: the fuel used by farm equipment, the energy required to produce nitrogen fertilizers and other inputs, and the nitrous oxide released from nitrogen applications. Because of these connections, the energy chapter should briefly address agricultural emissions, beginning with methane. Most methane comes from enteric fermentation (a digestive process) in cattle and from manure. Reducing methane emissions is challenging, but new approaches,

such as using feed additives, show promise (Tseten et al., 2022). Better manure management, such as using anaerobic digesters, spreading manure daily, and composting, can also help reduce methane emissions.

Nitrous oxides are emitted from soils, and emissions are higher when nitrogen (fertilizers, manures) is applied to soils. Because nitrogen is essential for high-yielding agriculture, the best way to reduce nitrous oxides is to improve nitrogen use efficiency. Practices known as the “4 Rs”—using the right source, at the right rate, right time, and right place—save farmers money (less fertilizer costs), protect water quality and human health (less nitrate leaching or runoff), and lower greenhouse gas emissions. These climate-smart farming practices align with profitable farming practices, as they maintain yields, improve soil health, reduce energy and fertilizer waste, and make farms more resilient to climate extremes.

Methane and nitrous oxide are especially important to address because they trap far more heat than carbon dioxide. Focusing on these gases can create major climate and environmental benefits. Other emissions can also be reduced through practical steps, such as upgrading to more efficient equipment, improving driving practices, and reducing pesticide use.

Methane and nitrous oxide are especially important to address because they are the largest and most potent emissions, trapping significantly more heat than carbon dioxide. Prioritizing emissions reductions of these gases can lead to significant benefits for the climate and the environment. Other farming emissions can be reduced through practical steps, such as upgrading to higher-efficiency machinery, driving vehicles more efficiently (gear up, throttle down), and minimizing pesticide purchases.

# Conclusions

- » Nebraska depends heavily on fossil fuel sources, particularly oil, coal, and natural gas.
- » Nebraska must consider weather and climate extremes as it develops and implements new electricity generation and storage resources that trend toward lower emissions.
- » Planning for the increased incidence of extreme weather and climate events is crucial to ensuring a reliable energy supply during these events.
- » Adopting energy selection and efficiency strategies is important for meeting Nebraska's goals for the environment, the health of its citizens, and its economy.
- » By electing representatives at all levels of government who reflect their goals for Nebraska's environment, the health of its citizens, and its economy, Nebraskans can help ensure that their voices are heard.
- » By creating a trajectory toward increasingly efficient, cleaner, and more reliable energy systems, the state government can bring significant benefits to Nebraska, including improved energy security by diversifying sources, cost savings on energy bills, economic growth through job creation, and lower greenhouse gas emissions.
- » It has been said that every little bit helps, yet physicist David MacKay says, "If everyone does a little, we will achieve only a little." We need to achieve a lot to make a big impact (MacKay, 2009). Do not dismiss individual actions, but focus on improving at larger scales, such as government policy focused on our largest uses and emissions.

## Gaps and needs

- » Social science research focused on accepting nuclear energy in Nebraska communities.
- » Energy storage research on batteries and other utility-scale storage.
- » Public perceptions and opinions on distributed generation resources and policy in Nebraska.
- » Identification of markets for ethanol beyond gasoline fuel mix.
- » Continued research on greenhouse gas emissions from agriculture, including reducing methane emissions from cattle, products, or practices that reduce nitrous oxide emissions.