Idaho Climate-Economy Impacts Assessment
Energy Report

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Key Messages

- Changes in temperature, precipitation, and snowpack impact Idaho's energy resources.
- Increasing temperature and a growing population will likely increase summer energy demand. Demand increases may vary in different regions of the state.
- Decreasing summer streamflow can impact hydropower generation, the main source of Idaho's electricity.
- The extension and modernization of electrification is one of the most anticipated, but also challenging, changes to the current energy system. Electrification can allow for cleaner (and even zero-carbon) transportation and heating; it has the potential to lower long-term costs compared to technologies using other types of fuels.
- Opportunities exist for increasing generation through renewable, flow-based resources like solar and wind, and will not only reduce carbon emissions and reduce feedback from energy to the climate, but also stand to create jobs and economic growth.
- Investing in alternatives, such as microgrids, can enhance local resilience to increasing extreme weather events and protect critical community electricity infrastructure.

1. Introduction

This report focuses on the impacts of climate on energy and the dynamic effects of climate and energy on Idaho's economy. The changing climate carries implications for planning, policy, and social impacts at the international, national, regional, state, and local levels. Concerns surrounding energy and climate center around the availability of primary energy resources necessary for an increasing population and increasing electricity consumption in commercial and household heating and cooling. The relationships among climate, energy production, and the economy are complex. There is a reinforcing loop between energy and the economy; as the economy grows, more energy is required for both production and consumption. Increased energy demand can exceed available output, creating a secondary balancing loop between the economy and energy; as prices increase, costs of economic output also increase and overall output is decreased.

There are strong correlations among climate, energy, and the economy; as climate becomes more variable, certain sources of primary energy (solar, natural gas, etc.), in turn, become more variable. For example, as streamflow diminishes due to decreased snowpack, hydropower output also decreases, leaving a deficit in the energy mix. Higher cost, and higher emission, sources of primary energy may be used, which, in turn, increase costs of economic output due to increases in the factors of production. As production and consumption increase, so do carbon emissions, ranging from energy generation to transportation of goods and people, which could further contribute to climate change. Production and consumption generate carbon during the beginning and middle stages of the life cycle, while disposal of goods may add to climate change through increases in other greenhouse gases, such as methane. Changes in temperature, precipitation, and snowpack impact Idaho's energy resources.

2. Idaho's Energy Landscape[1]

Idaho's energy supply is comprised of firm energy sources and intermittent (variable) energy sources. Idaho's baseload firm resources, including hydropower, natural gas, coal, geothermal, biomass, and petroleum provide a constant source of reliable energy (Office of Energy and Mineral Resources (OEMR), 2021a). Idaho's electric portfolio also is comprised of intermittent sources, such as wind and solar (OEMR, 2021a). Intermittent energy sources are those that are dependent on external factors that are not always constant. In order to maintain a baseload energy supply, and be equipped for fluctuations in demand, it is necessary to have firm sources that can mitigate any losses of supply associated with intermittent generation, such as wind and solar. For heating, the state relies on natural gas, geothermal, and biomass. Idaho's transportation sector is dependent on petroleum, discussed further in Section 4. Figures 1, 2, and 3 illustrate natural gas, electricity, and petroleum systems, respectively, in Idaho.

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[1] Most of this section was provided by Dr. Veronika Vazhnik, Sustainability Consultant.

Figure 1: Idaho natural gas system. (This figure will be released in the next Idaho Energy Assurance Plan.)

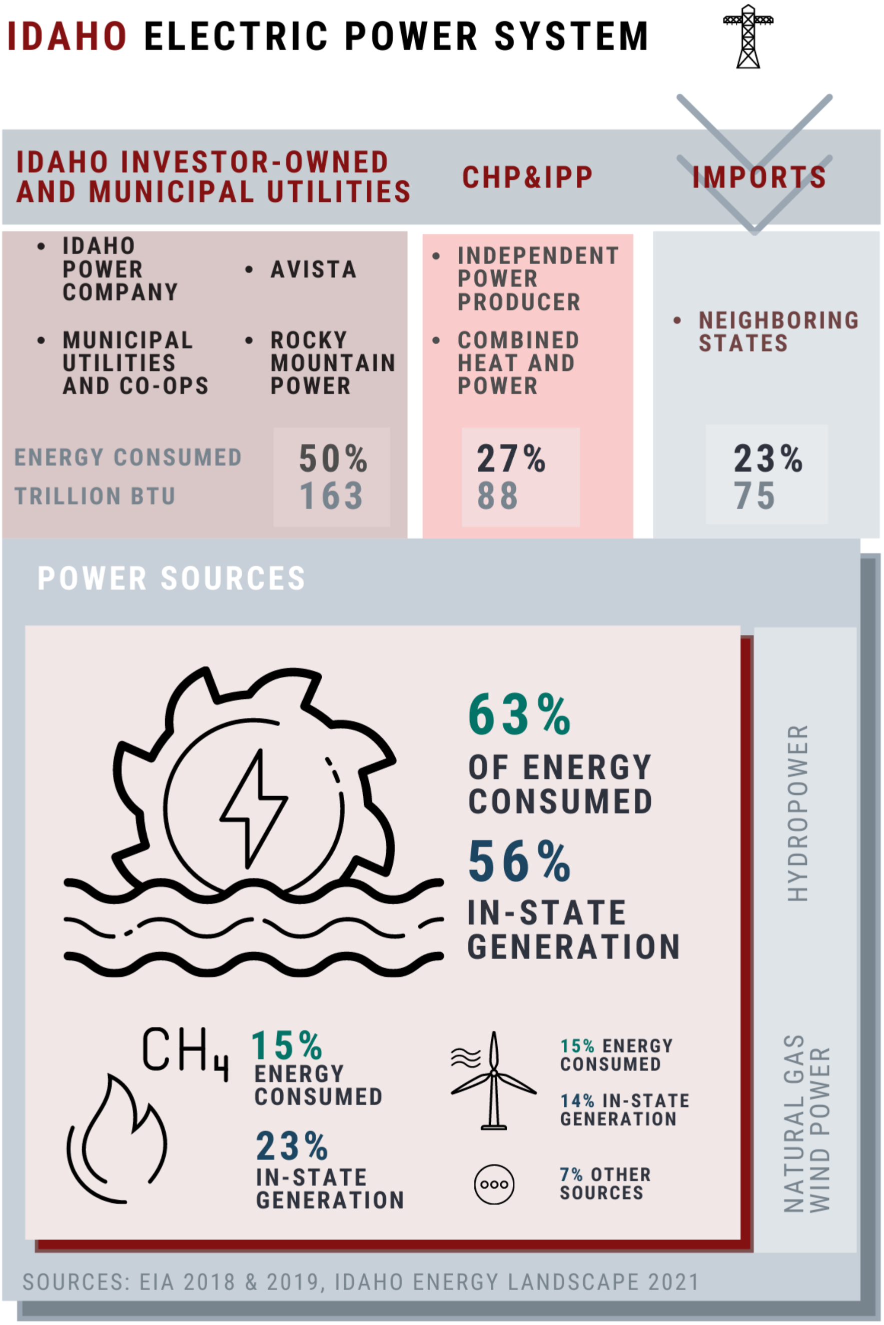

Figure 2: Idaho electric power system. (This figure will be released in the next Idaho Energy Assurance Plan.)

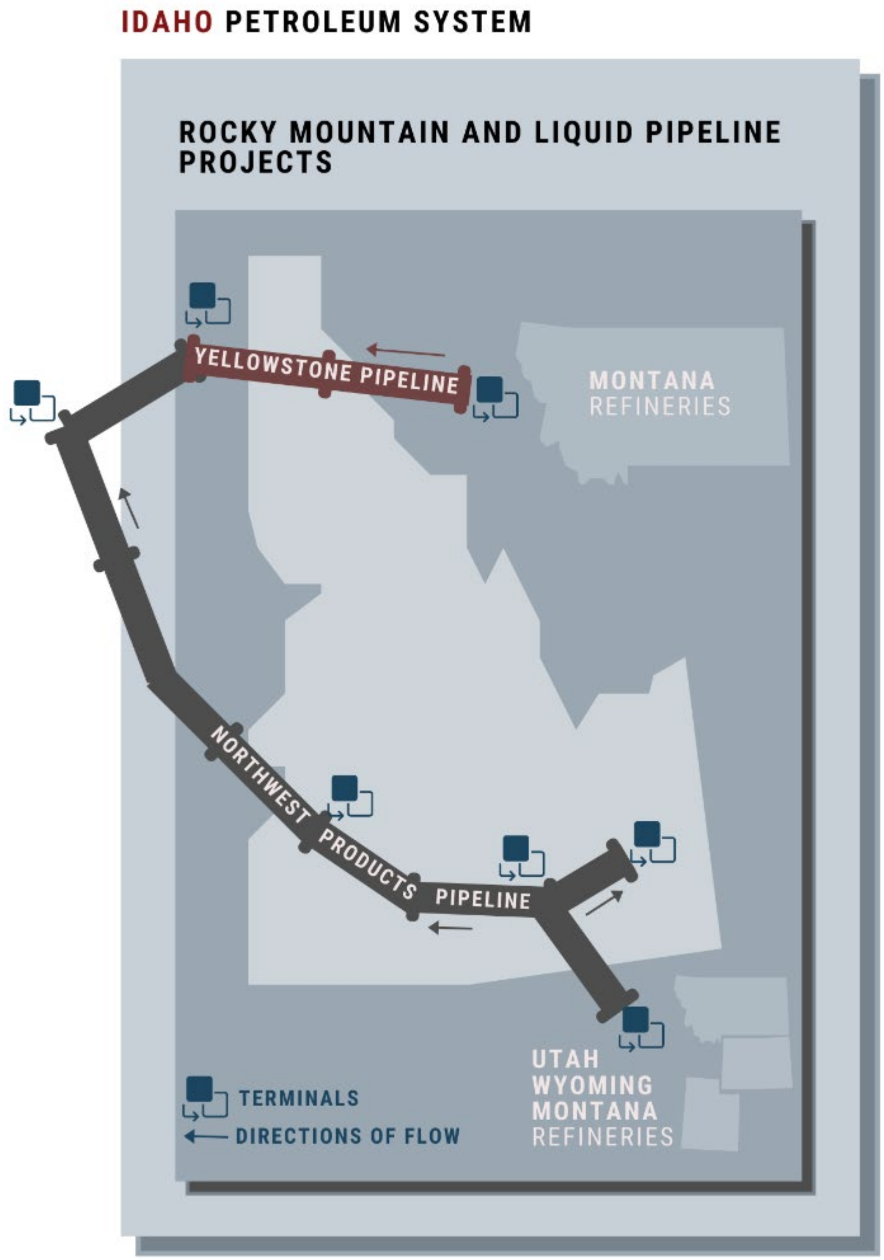

Figure 3: Idaho petroleum system. (This figure will be released in the next Idaho Energy Assurance Plan.)

Electric utilities in Idaho include investor-owned (IOUs), co-operative, and municipal utilities (Figure 4). The largest utilities in the state are the IOUs –Avista, Idaho Power, and Rocky Mountain Power. Avista also provides natural gas for heating, as do Dominion Energy and Intermountain Gas. Avista serves over 224,000 electric and natural gas customers in northern and central Idaho (OEMR, 2021a). Idaho Power serves more than 570,000 customers across a large service territory in southern Idaho (OEMR, 2021a). Rocky Mountain Power is concentrated in eastern Idaho and serves approximately 82,000 customers (OEMR, 2021a). Idaho has 23 municipalities and rural electric cooperatives that provide service to over 137,000 customers (OEMR, 2021a). Most of the electricity consumed in Idaho is produced within its borders; on average, 23% of Idaho's electricity is imported from neighboring states (Figure 2). Idaho imports most of its natural gas and petroleum and depends on reliable pipeline or truck transportation to maintain that supply (Figures 1 and 3).

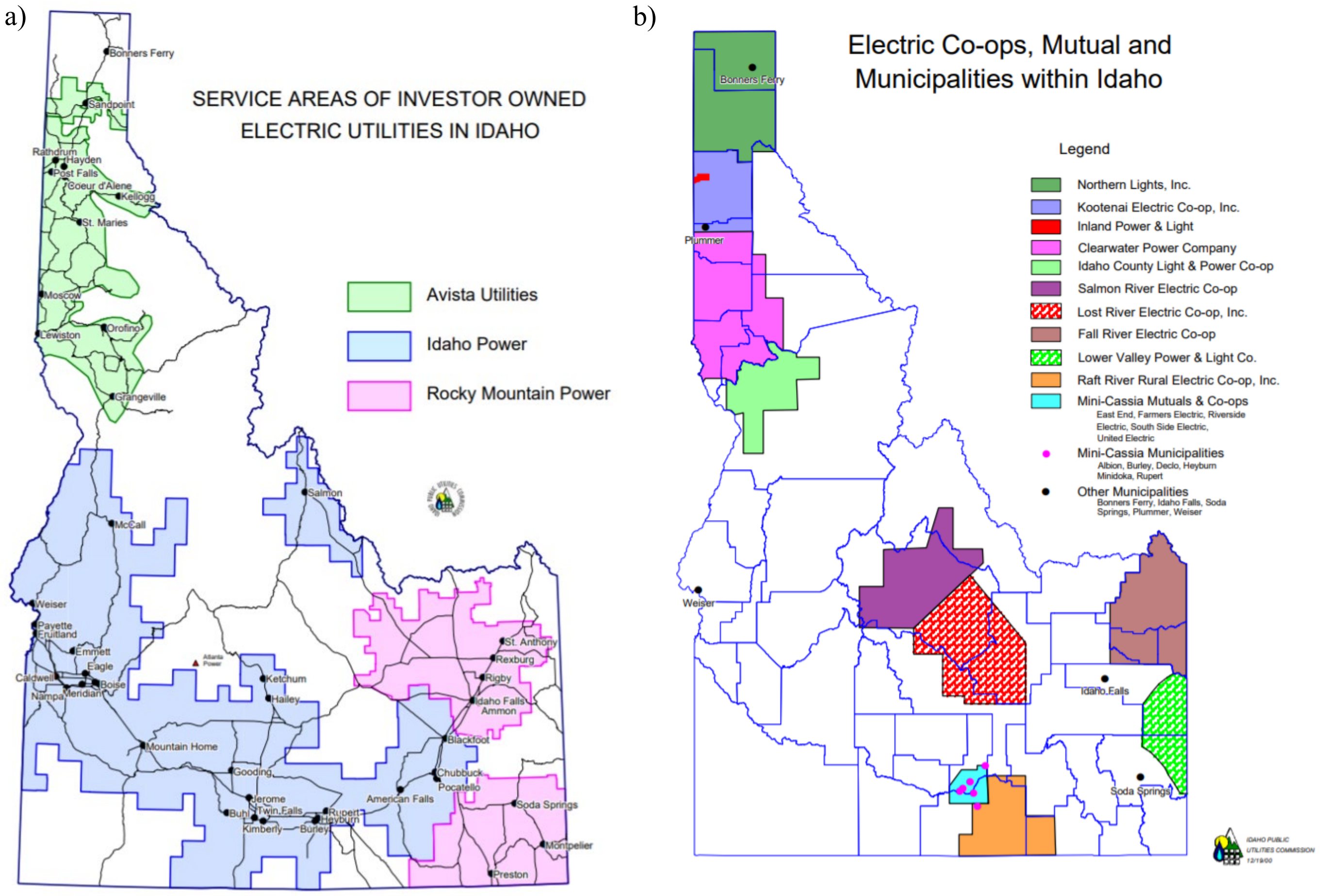

Figure 4. a) Idaho investor-owned electric utilities service territories and b) Idaho municipal and rural electric cooperative utilities service territories (OMER, 2021a).

The energy portfolios for Avista, Idaho Power, and Rocky Mountain Power are comprised of firm energy sources and intermittent (variable) energy sources. All three IOUs have announced clean energy goals (described in Section 7) and have announced decommissioning of or exit from coal-generated power,[2] a key component of firm energy generation. Reductions in coal generation will require replacement through other means of firm energy generation.

Incorporating additional intermittent generation sources into energy portfolios, decommissioning of and exit from firm generation and coal plants, and potential impacts to hydropower generation (discussed later

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[2] Avista owns coal-fired capacity in Eastern Montana, Idaho Power partially owns coal-fired capacity in Nevada and Wyoming, and Rocky Mountain Power owns coal-fired capacity in Arizona, Colorado, Montana, Utah, and Wyoming. Avista is planning to exit ownership by 2025. Idaho Power is exploring options to reduce emission from the Jim Bridger Plant, including early retirement for two of the Jim Bridger units. Idaho Power has an agreement to exit unit 2 by 2025. The Boardman plant ceased coal-fired operations in 2020. Rocky Mountain Power plans to retire 16 of the 24 coal-fired units by 2030. From: https://oemr.idaho.gov/sources/coal/

in this report) pose particular challenges.[3] As portfolios integrate additional variable energy sources, supplemental firm generation capacity and/or energy storage will be needed. Pump storage could play an important role in this transition. Rocky Mountain Power, for example, recently announced a major pump storage plan (Rocky Mountain Power, 2021a) Additional hydropower capacity also could be a resource. Increased spill could serve as a baseload or variable energy source. Other sources of baseload power from non-carbon sources likely will be needed to meet these clean energy goals. The shift in energy portfolio presents challenges, but also affords opportunities. (Opportunities are detailed in Section 9).

Idaho's energy system is connected to other states in the region. Being part of the larger grid and western energy market means the state's energy system is interlinked with regional energy issues. This also allows greater reliability in cases of high demand. For example, the June 2021 heatwave demanded a higher electric supply in the Idaho than usual; however, it did not result in significant outages because of the power available from other states in the western U.S. Similarly, Idaho's petroleum and natural gas systems are highly connected with other states, as neither resource is produced inside Idaho. Collaboration with other states in the region can support the resilience to changing energy demands.

Energy oversight is specific to the type of energy and condition. Delivery of electricity and natural gas from Idaho’s IOUs are regulated by Idaho Public Utilities Commission (PUC). The Commission oversees energy rates and has the authority to curtail or reduce energy use in case of an emergency (Idaho Administrative Procedure Act; IDAPA 31.11.01; Idaho Code 61-535). The Commission is also the primary agency that coordinates electric and natural gas emergency response. Idaho Governor's Office of Energy and Mineral Resources (OEMR) is the agency that supports energy policy and energy efficiency investments and coordinates action in case of petroleum emergencies.

Energy generation by IOUs is regulated by the state. Energy transportation across state borders is regulated by national entities, including the Federal Energy Regulatory Commission (FERC). While not often exercised, the legislature can prescribe energy standards according to national or international organizations and utilities report data about their performance to federal-level and international agencies like the EIA (U.S. Energy Information Agency) and NERC (North American Energy Reliability Corporation), respectively.

Nuclear energy does not currently contribute to Idaho’s commercial energy mix. However, it could serve as a replacement baseload firm energy source as coal plants are phased out. Idaho National Laboratory (INL), based in eastern Idaho, is a leader in nuclear energy research and development, including the work that focuses on small modular nuclear technology and microreactors. INL is a significant contributor to Idaho’s economy and one of Idaho’s largest employers. In 2020, INL accounted for $2.88 billion to Idaho’s economy and INL contractor Battelle Energy Alliance was Idaho’s 7th largest private employer (INL, 2020). As discussed later in this report, Idaho’s transition to clean energy and building a more resilient energy system could be assisted through increased use of nuclear energy.

At the regional level, Idaho is part of the Western Interconnection, which links Idaho, the western U.S., Alberta, and British Columbia on a local, sub-regional, and regional basis to ensure electricity integration and supply (OEMR, 2021a). The Western Electricity Coordinating Council (WECC) provides oversight and support (OEMR, 2021a). Bonneville Power Administration (BPA), under the U.S. Department of

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[3] Challenges of and opportunities for integrating variable energy sources described in detail here: https://www.nrel.gov/docs/fy13osti/60451.pdf

Energy (DOE), supplies power to many western states, including municipalities and rural electric cooperatives in Idaho (OEMR, 2021a). Also at the regional level, the Western Energy Imbalance Market (EIM) balances supply and demand across a large geographic footprint in real time using regional transmission systems (OEMR, 2021a). All three of Idaho's IOU providers are or will be part of the EIM (OEMR, 2021)[4] and BPA has a scheduled live date of March 2022 (BPA, 2021).

As the regional power supply shifts to carbon-free sources and hydropower generation may be impacted by a changing climate, additional carbon-free baseload power and/or storage capabilities will be needed to support energy demand. Proposals to develop several new nuclear technologies—at INL and in Washington and Wyoming—currently are under review by the U.S. Nuclear Regulatory Commission (Office of Nuclear Energy, 2020). These new technologies, including small-scale reactors, have a high ramp rate and provide dispatchable power. As such, they could serve to replace baseload sources that are coming offline and provide firm power backing for intermittent sources, such as solar and wind.

Climate Impacts on Energy Resources

Dr. Veronika Vazhnik, Sustainability Consultant

Increased frequency and intensity of drought is one of the greatest threats of climate change in Idaho. Drought means a decreased amount of available precipitation, especially in the middle and the end of summer. Besides the more straightforward effects on irrigation and access to water, drought can also impact energy systems. Drought can cause lower snowpack and lower levels of water in Idaho's rivers, lakes, and dams. Most of Idaho's electricity production comes from hydroelectric dams, which are dependent on flow from those bodies of water. A decrease in water volume and change in the timing of water availability likely will reduce the generation capacity of hydroelectric dams. The cascading effects of climate change may increase the demands on electricity while decreasing the capacity of existing electric producers. More information is available in the assessment's Water Report.

Another climate-induced risk that can influence the energy system is wildfire. Wildfires create a threat to electric power equipment; collaboration between land managers and power companies could be beneficial. Additionally, wildfires increase airplane fuel demands in remote locations. Both wildfires and drought pose challenges to the existing energy system, but afford opportunities to modernize the grid and create space for a resilient energy supply.

3. Idaho's Energy Use and Gross Domestic Product (GDP)

Figure 5 compares Idaho's population, gross domestic product (GDP), total carbon emissions, and primary energy consumption. Primary energy is the raw energy extracted from the environment and utilized, such as through fossil fuels, sunlight, wind, geothermal, biomass, and radioactive elements. Figures 5a, 5b, 5c, and 5e display an upward trend over time; with increasing population, increases in GDP, carbon emissions, and primary energy consumption may occur.

Decreases in real GDP during the recent recessions of 2000 and 2008 are distinguished in Figure 5b and identifiable in Figures 5c and 5e. This correlation suggests that the overall economy and energy are

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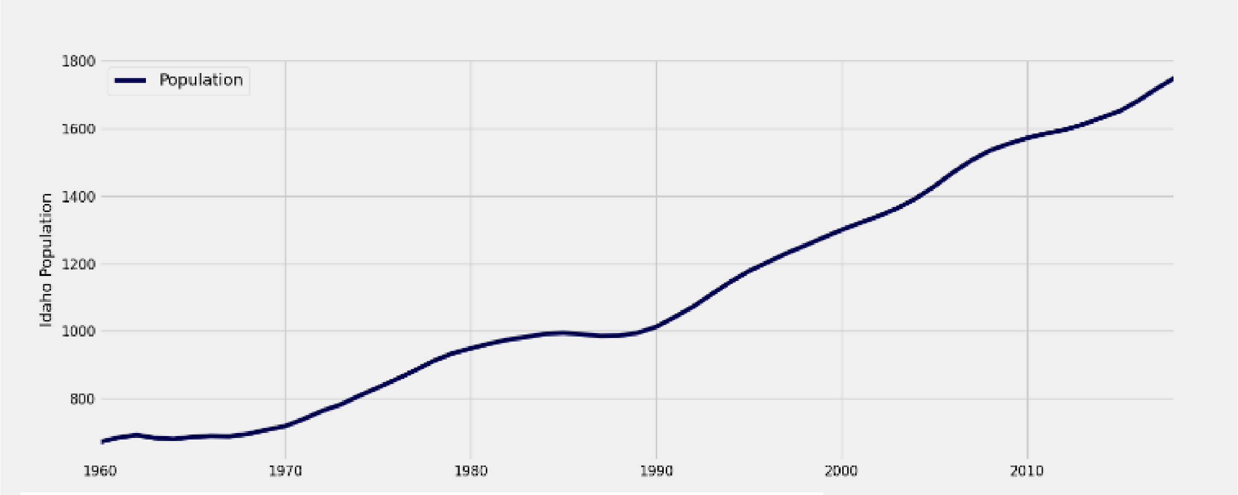
[4] The EIM launched in 2014, with PacifiCorp (Rocky Mountain Power) as a partner. Idaho Power joined in 2018 and Avista will begin participating in April 2022 (OEMR, 2021a).

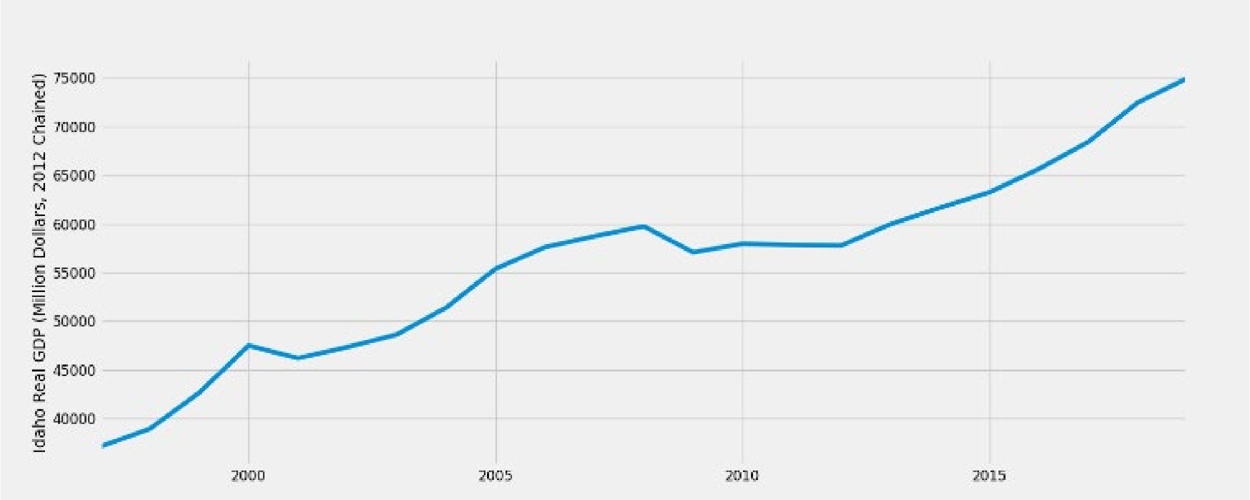
significantly intertwined (King, 2021).

Figures 5f and 5g show energy use per capita for both Idaho and neighboring states. As the Idaho population has increased, energy consumption per capita has been steadily and rapidly declining for two decades. A variety of energy efficiency tax credits and deductions have been offered at the federal and state levels, ranging from appliances to buildings and solar. As well, overall energy conservation has been required by the PUC. Comparatively, Idaho has the third highest energy consumption per capita in the western region, trailing only Wyoming and Montana, though the differentials between the lower consumption states is relatively small. Another trend is shown in Figure 5c; Idaho's carbon emissions have increased since the early part of the 21st century. Idaho's carbon emissions are low by United States standards, shown in Figure 5d.

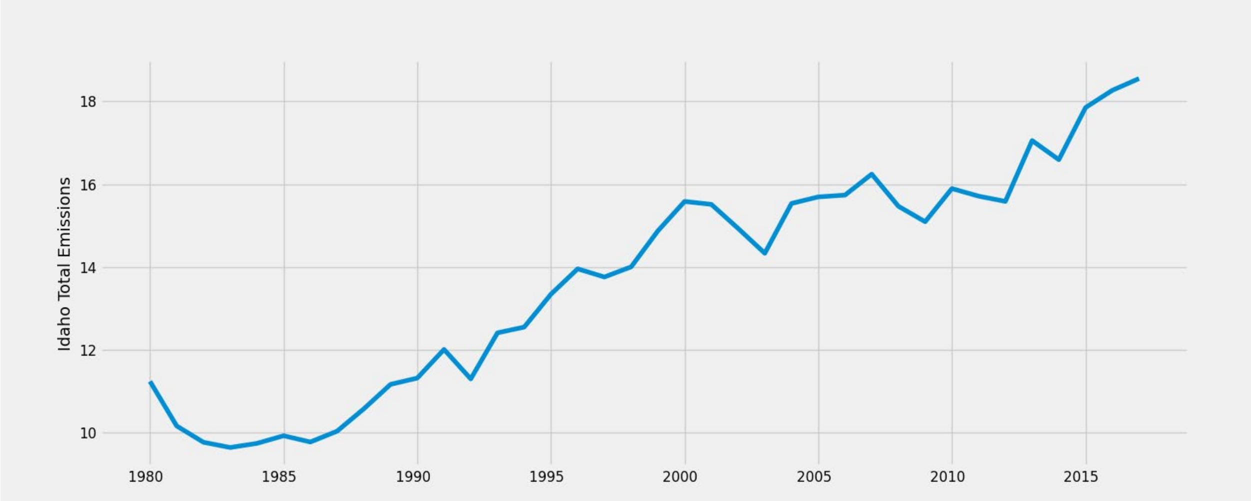
Figure 5: Summary of primary energy use, population growth, carbon emissions, and consumption per capita. Author's calculations using data from (EIA, 2021) and (BEA, 2021).



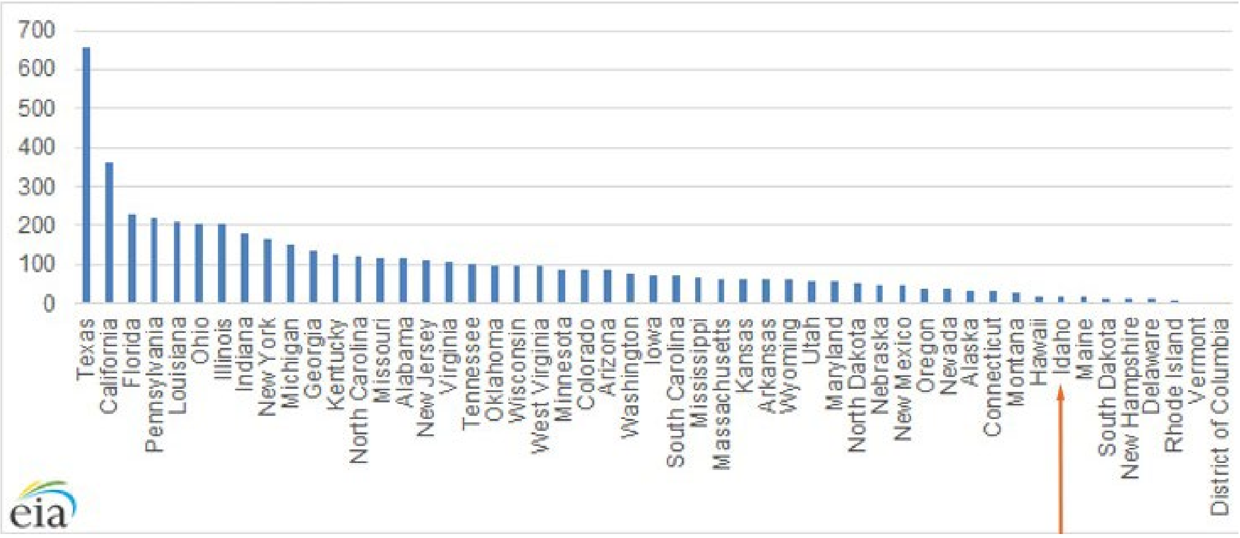
(a) Idaho population 1960-2018 (EIA, 2021). Units of population per 1,000.



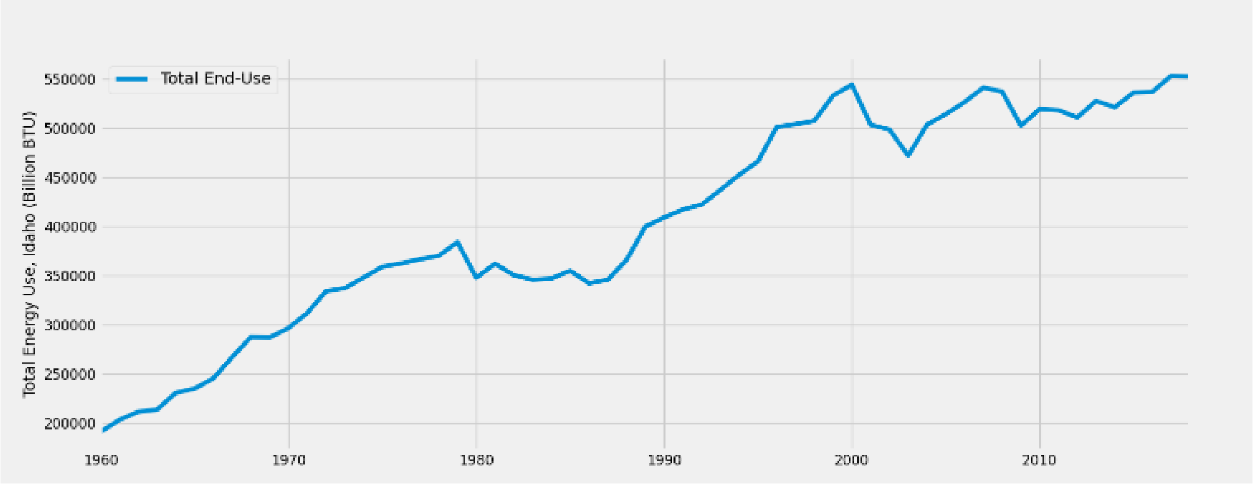
(b) Idaho real GDP (2012 dollars), all industries (1990-2018) (BEA, 2021).



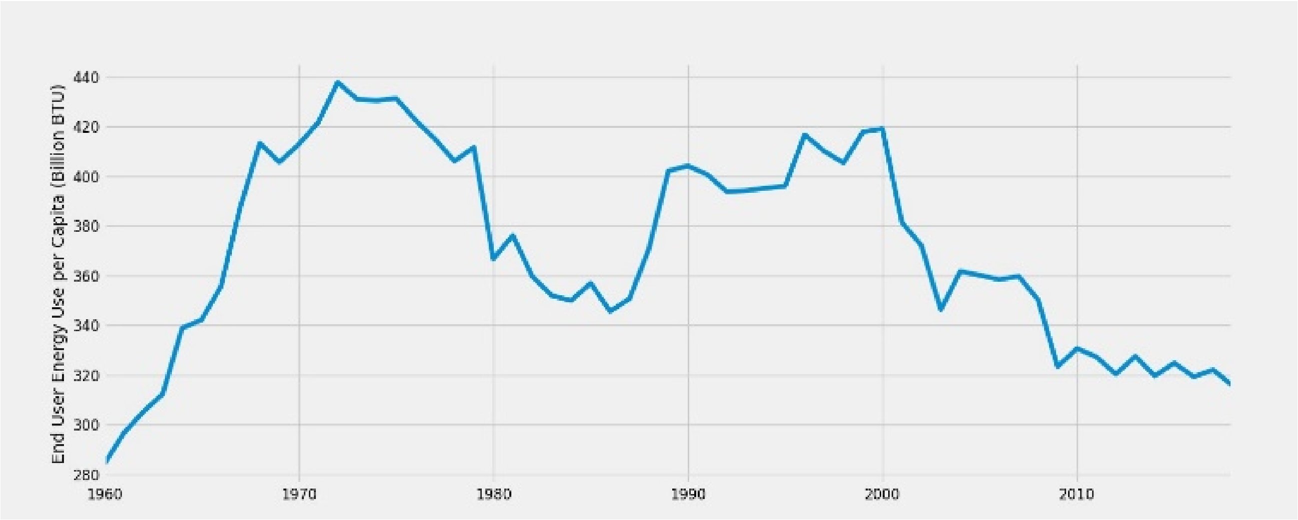
(c) Carbon emissions (million metric tons of CO_2), all sectors, Idaho total (1980- 2018) (EIA, 2021).



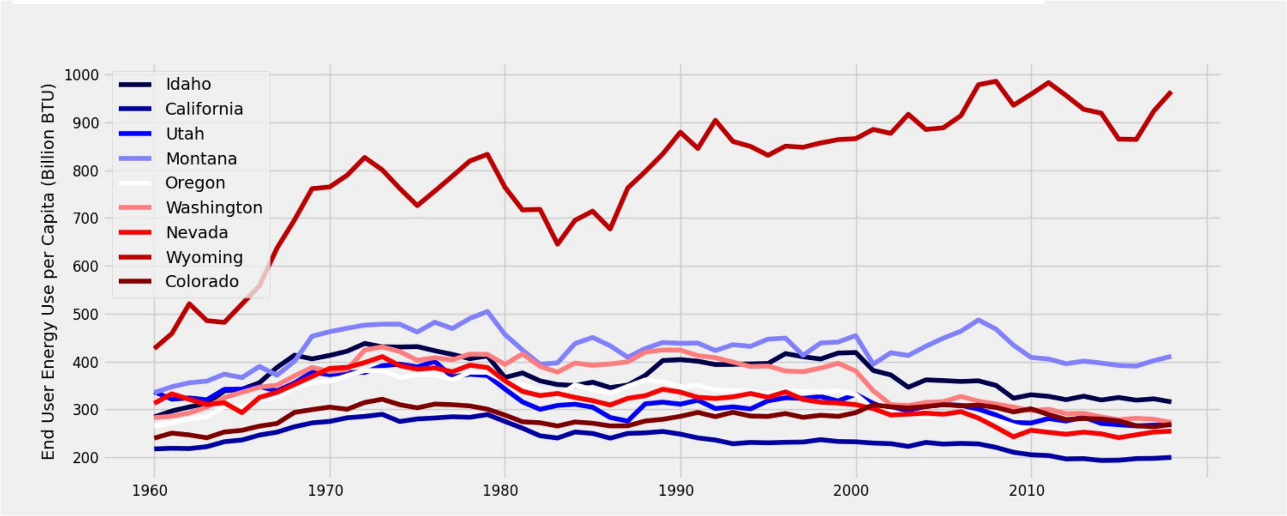
(d) 2018 carbon emissions (million metric tons of CO_2), all states (EIA, 2021).



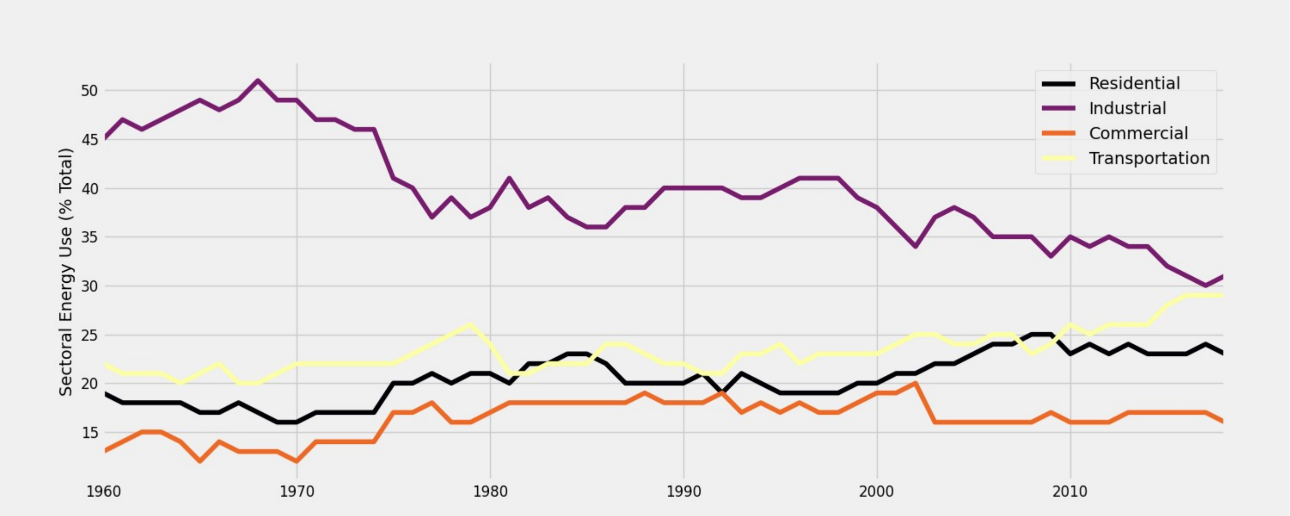
(e) Idaho primary energy consumption (1960-2018), total end users (EIA, 2021).



(f) Idaho total energy consumption per capita (1960-2018) (EIA, 2021).



(g) Regional energy consumption per capita (1960-2018), western United States (EIA, 2021).

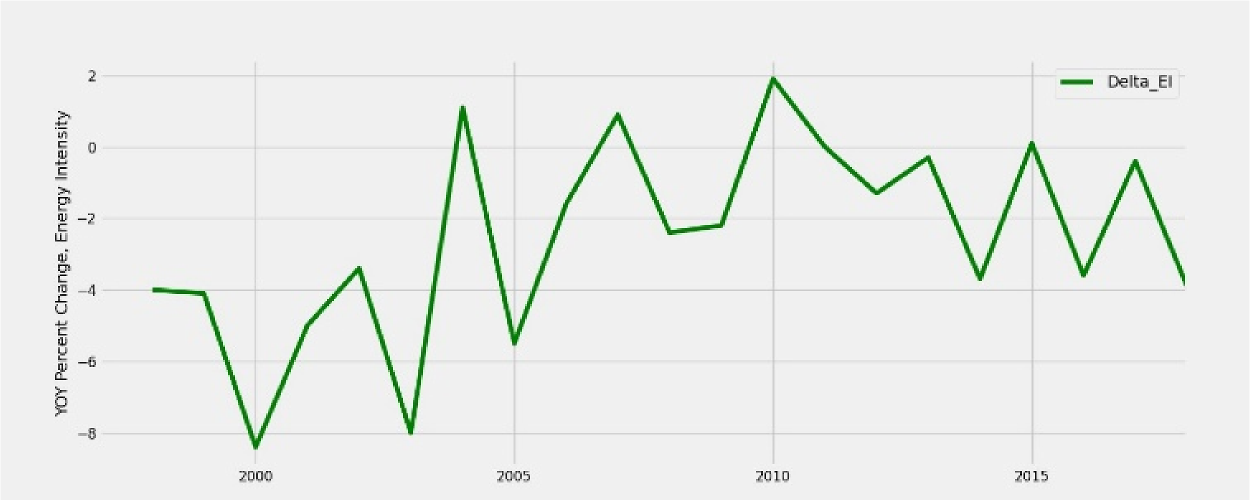


(h) Sectoral energy use in percentage terms, Idaho (EIA, 2021).

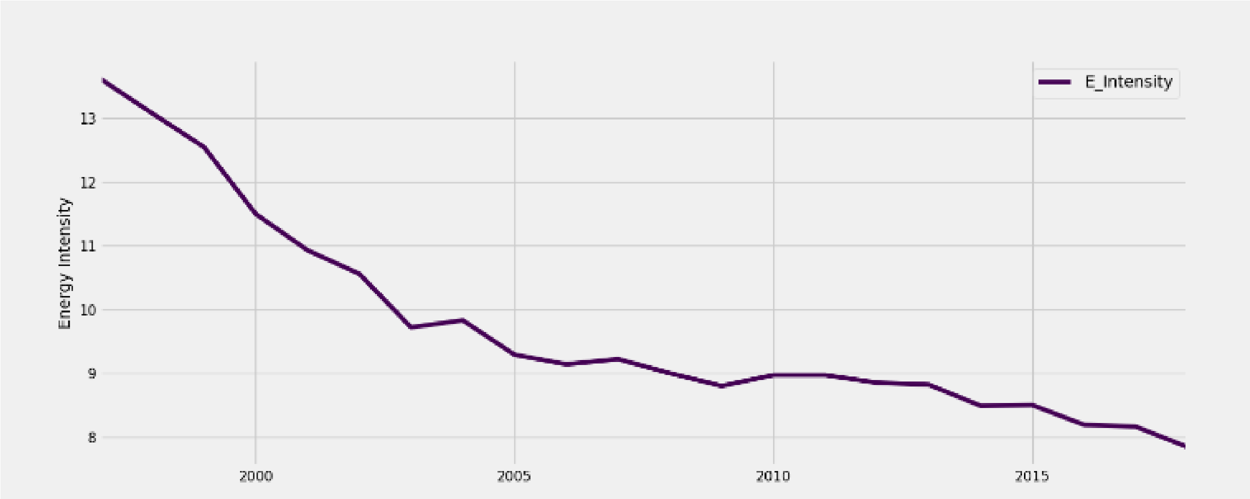
3.1. Energy Intensity

Energy intensity is a measure of productive output in the economy per unit of energy used. As shown in Figure 6a, this has fallen, while the year-over year changes indicated in Figure 6b are somewhat variable. Low energy intensity suggests that the economy is using resources efficiently. Factors which contribute to a decrease in energy intensity may include climate, technology, energy policy, and the amount of energy resources available (Aydin and Esen, 2018).

A shift from a manufacturing or agricultural economy to a service economy may also cause decreases in energy intensity (Sharma et al., 2019). From Figure 5h, one can see that Idaho energy consumption in the industrial sector, which includes agriculture in Idaho, has declined steadily over the past decade, while energy used in transport has increased. This implies that the energy mix itself could be gaining efficiency, in terms of energy intensity, as more energy intensive production activities are replaced by less intensive service activities. Regardless of the underlying cause, this increase in intensity is an opportunity; if Idaho plans to transition to a low carbon economy, efficient consumption would be a key factor in the transition in order to avoid unnecessary investments in additional generation and transmission infrastructure.



(a) Energy intensity (Consumption/rGDP) (EIA, 2021). rGDP is the real gross domestic product, an inflation-adjusted measure.



(b) Annual percentage change in energy (EIA, 2021).

Figure 6: Idaho energy intensity, 1997-2018. Author's calculations using data from (EIA, 2021).

4. Sectoral Analyses – Idaho

The EIA assigns primary energy use to four major sectors, which represent total end-use sectoral energy consumption: residential, commercial, industrial, and transportation[5] (EIA, 2021). Energy consumption in Idaho is also divided into these sectors. The electric power sector is also analyzed in this report, as secondary energy needs in the first three sectors are dependent on net electrical generation by electricity providers.[6] It is further suggested that increased electricity generation as secondary energy in the transportation sector will be part of a transition to carbon neutral transportation to reduce carbon emissions to sustainable levels (Hill et al., 2019; King, 2021).

As shown in Table 1, the majority of primary energy consumed by gross volume in Idaho (2018) was through industrial and transportation sectors, followed by residential and commercial sectors, respectively. This trend has existed since the beginning of record keeping in 1960, though as shown in Figure 5h, the percentage of total primary energy use consumed by the industrial sector has fallen, while the percentage of total primary energy use consumed by the transportation sector has increased 30% since 2008. During a period in which Idaho's population has grown considerably, residential and commercial primary energy use have both remained constant, even falling in 2018. This decrease likely is the result of the focus on energy conservation measures and the focus on increased energy efficiency overall.

	Residential	Industrial	Commercial	Transportation
2008	135,832	189,282	88,180	124,004
2009	127,606	167,397	84,725	122,803
2010	120,873	181,584	82,887	134,130
2011	125,277	178,557	85,263	129,300
2012	116,608	180,791	83,213	130,343
2013	127,028	177,849	88,008	134,786
2014	119,891	178,290	86,953	136,227
2015	122,911	174,169	88,995	150,232
2016	122,692	168,224	89,271	156,856
2017	134,257	168,088	92,421	158,590
2018	129,565	170,925	91,090	161,191

Table 1: Sectoral primary energy use by end users, Idaho (billion BTU) (EIA, 2021). Author's calculations using data from (EIA, 2021).

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[5] Sector definitions (EIA, 2021):

Residential: "Living quarters for households using energy for climate control, water heating, refrigeration, cooking, and various household appliances." **Commercial:** "Service providing facilities and equipment of business firms; federal, state and local governments; and other private and public organizations, such as religious, social, and fraternal groups. Energy uses are most commonly associated with climate control, water heating, lighting, refrigeration, cooking, and a wide variety of equipment. Commercial energy consumption includes electricity or thermal output production that supports the firm's mission, but is not typically sold to the general public." **Industrial:** "The industrial sector includes facilities and equipment used for producing, processing, or assembling goods. Includes North American Industry Classification System (NAICS) codes related to agriculture, forestry, fishing, hunting, mining, and construction. Energy use in this sector is mostly for climate control and powering machinery. Industrial energy consumption includes electricity or thermal output production that supports the firm's mission, but is not typically sold to the general public." **Transportation:** "A sector whose primary purpose is transporting goods and people from one location to another. Includes land and water-based vehicles, but not those whose primary purpose is not transporting people or goods, such as tractors, construction equipment, etc."

[6] **Electric power:** "Electric power sector includes energy consumption for electric utilities, independent power producers, and all NAICS category 22 firms whose primary business is to sell electricity or heat to the public." (NAICS Associations, 2018).

4.1 Residential Sector – Idaho

4.1.1 Consumption

Primary energy sources in the residential sector consist predominantly of electrical energy and natural gas, accounting for 76% of the primary energy used in this sector. Natural gas is the most common source of home heating and provides a percentage of cooking energy. In new residential construction, it is uncommon to find petroleum-based generators or fuel oil for heating.

Figure 7 shows the consumption of electricity and natural gas in Idaho per capita over the past 60 years. Over the past 25-40 years, consumption of natural gas per capita has increased. This could be attributed to the price elasticity of natural gas (as natural gas decreased in price, it became the more preferred source for heating) and increased energy conservation measures.

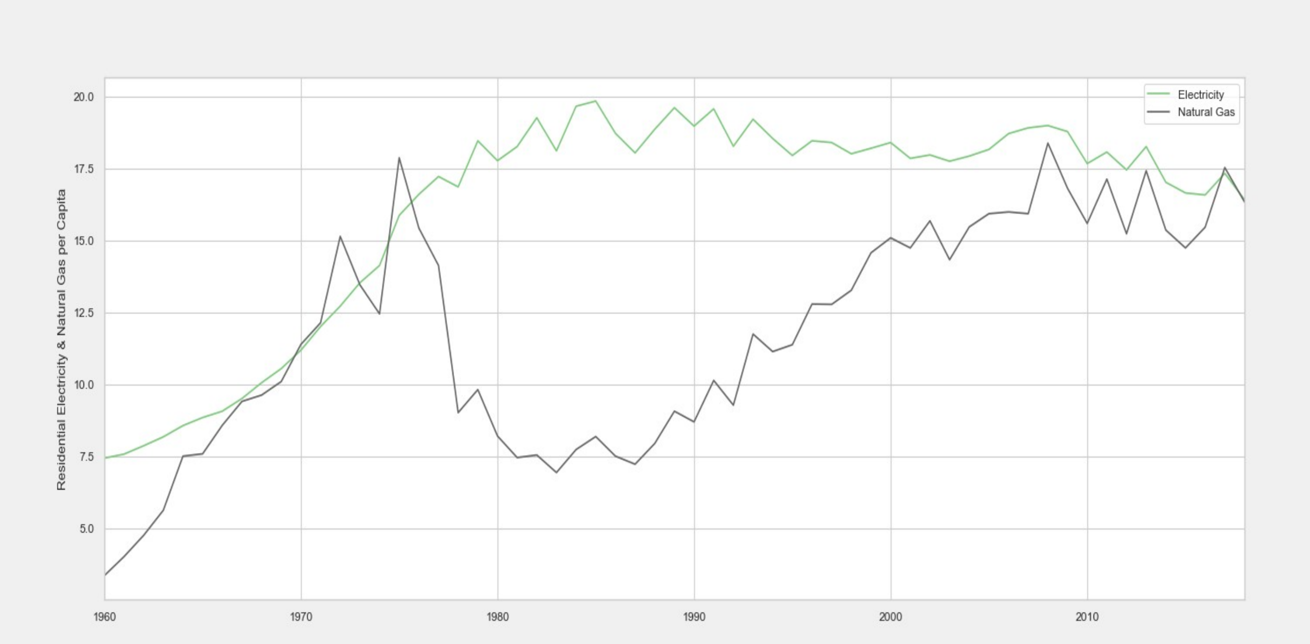


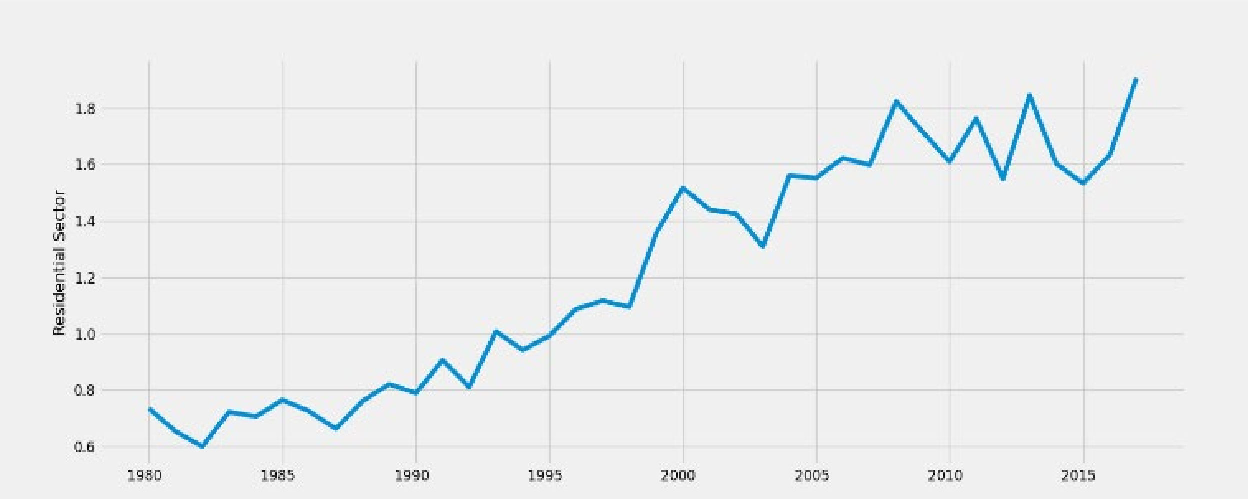
Figure 7: Natural gas and electricity consumption per capita, Idaho's residential sector (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.1.2 Carbon Emissions

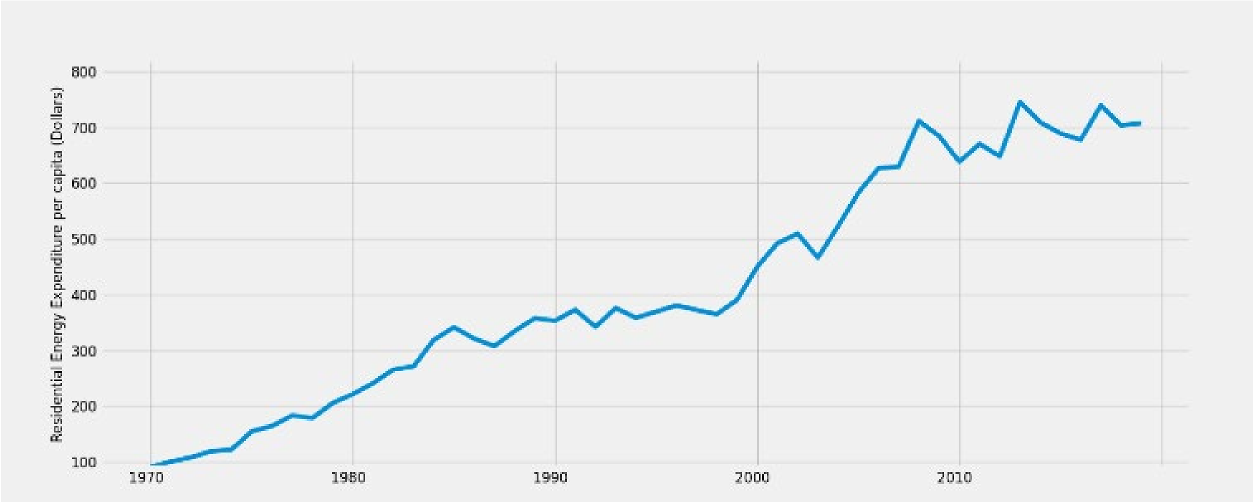
Figure 8a shows carbon emissions in the residential sector during the 2008-2017 period. Emissions decreased from 2008 through 2012, before spiking in 2013, above 2008 levels, and subsequently falling from 2014 through 2016. Idaho residences produced a record amount of carbon in 2017, at 1.9 million metric tons.

4.1.3 Expenditures

Figure 8b demonstrates that even while population in Idaho is growing at an increasing rate (see Figure 5a), energy expenditures have remained relatively stable for the past decade after increasing steadily for the 30 years' prior. Energy expenditure per capita stands at $707.49 for 2019 after varying around $700 per capita since 2008 (in 2012 chained USD).



(a) Residential carbon emissions (million metric tons of CO_2), Idaho (EIA, 2021).



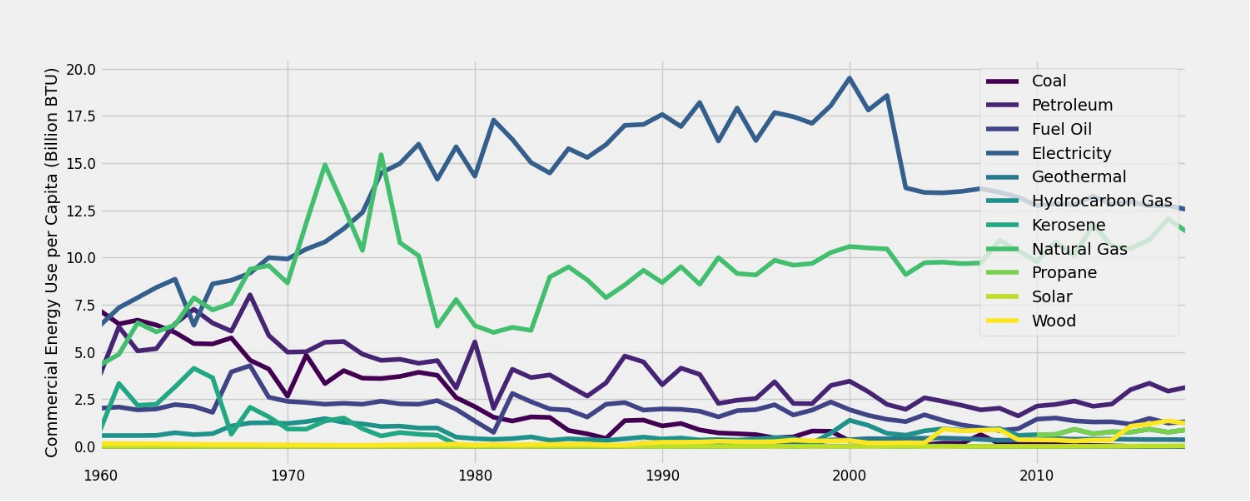
(b) Residential energy expenditures, Idaho (EIA, 2021), in 2012 USD.

Figure 8: Idaho residential carbon emissions and expenditures per capita. Author's calculations using data from (EIA, 2021).

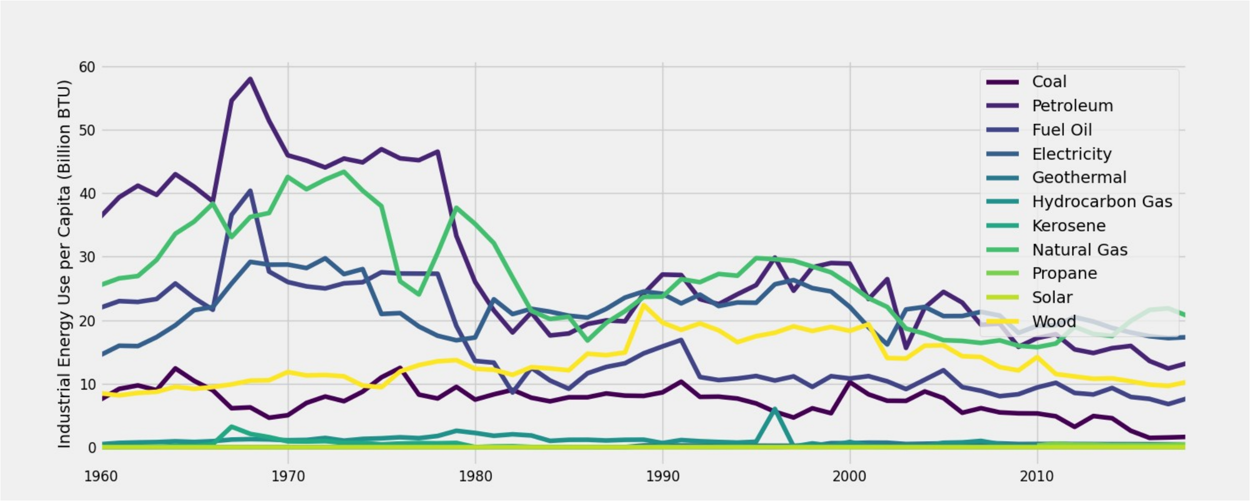
4.2 Commercial and Industrial Sectors – Idaho

4.2.1 Consumption

Electrical energy and natural gas account for an even greater share of the primary energy sources used in the commercial sector compared to the residential sector. Purchased electricity and natural gas provided the greatest segment of 2018 energy usage at 44% and 40%, respectively. Fuel oil, propane, and other hydrocarbon gases each made up less than 3% of the energy mix. Coal was at its highest point in 1960, at 33% of commercial energy consumption, falling to single digits by the 1980s, before disappearing from the commercial energy mix in 2015. See Figure 9a for more information. The industrial sector relies on electrical energy and natural gas, the two accounting for 58% of primary energy use in the sector. Petroleum and biomass contributed another 28% of the total and fuel oil accounts for 12% of the energy consumption mix. Like the residential and commercial sectors, the industrial sector is dependent, in part, on fossil fuels for primary energy. See Figure 9b for more information. Overall consumption from all sources in both sectors trends downward overall for the period 2008-2018.



(a) Idaho commercial energy consumption per capita (1960-2018).

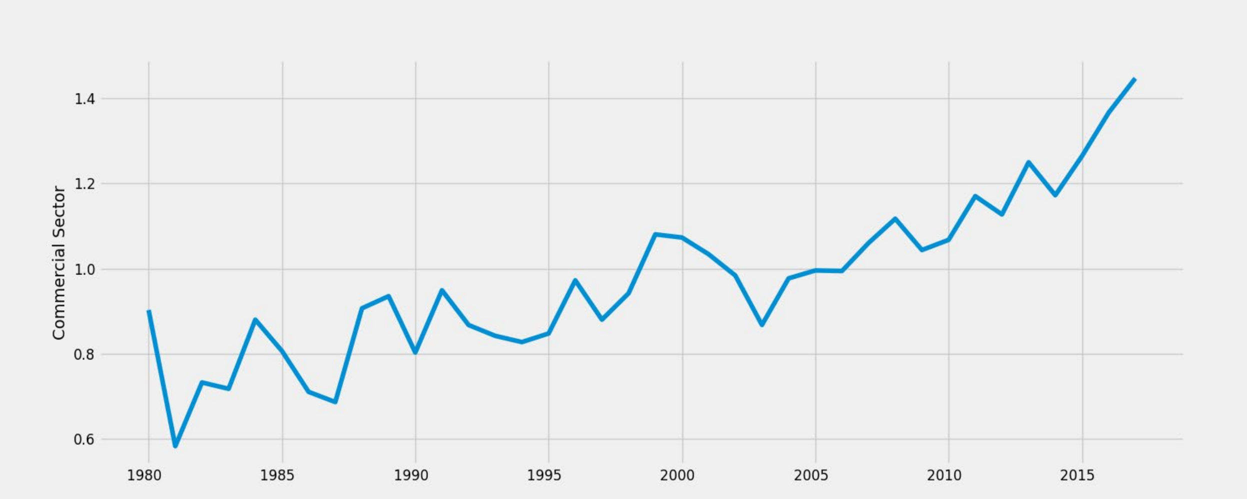


(b) Idaho industrial energy consumption per capita (1960-2018).

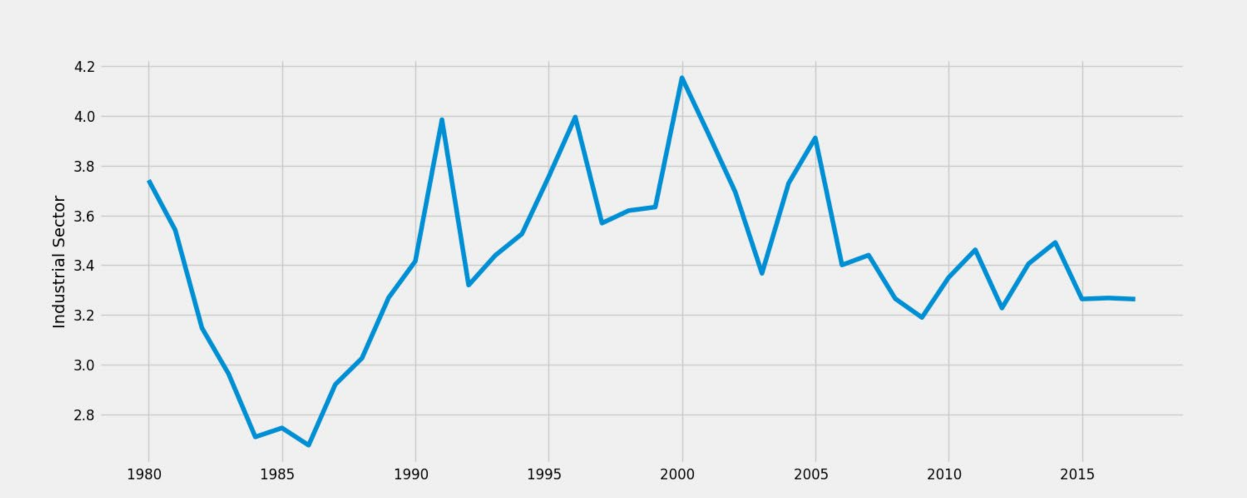
Figure 9: Idaho commercial and industrial energy consumption, controlling for population growth (1960-2018) (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.2.2 Carbon Emissions

Generally, carbon emissions in the commercial sector have increased, with a more rapid increase in 2014 (Figure 10a). As shown in Figure 10b, industrial sector emissions decreased and flattened during the same time period.



(a) Idaho commercial carbon emissions (million metric tons of CO_2).

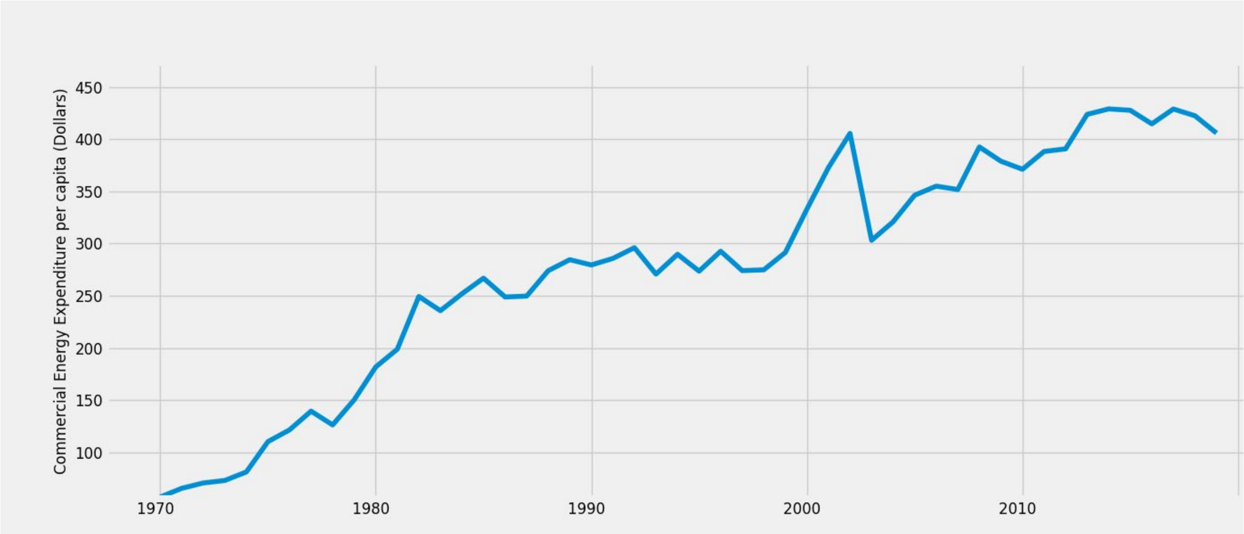


(b) Idaho industrial carbon emissions (million metric tons of CO_2).

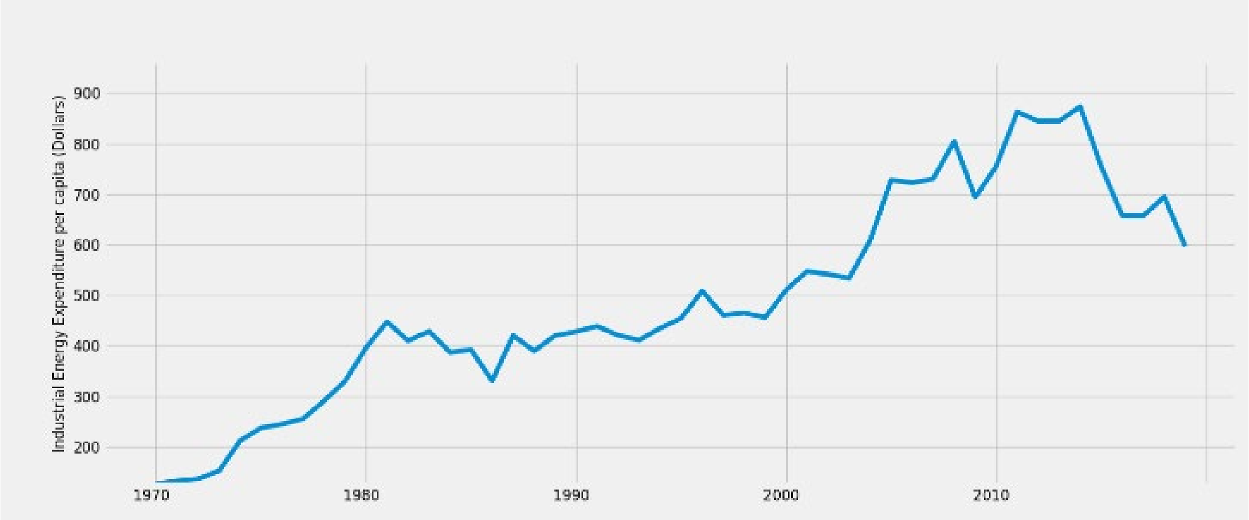
Figure 10: Idaho CO2 emissions for commercial and industrial sector (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.2.3 Expenditures

Overall consumption in both the commercial and industrial sectors has fallen; however, controlling for population, expenditures display an increasing trend. Recalling from Figure 5e, the increasing trend in Idaho energy consumption corresponds with the increase in energy expenditures shown in Figure 11. During the period 2008-2018, commercial expenditures peaked at $740 million in 2018 and industrial expenditures peaked at $1,412 million in 2014. Industrial expenditures have continued to fall since the peak, reaching $1,067 million in 2019.



(a) Idaho commercial energy expenditures per capita.



(b) Idaho industrial energy expenditures per capita.

Figure 11: Idaho commercial and industrial energy expenditures, controlling for population growth (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.2.4 Economic Impacts – Residential, Commercial, Industrial Sectors

One key climatic change impacting residential, commercial, and industrial sectors is increasing temperature. In each sector, heating and cooling buildings involves financial and physical risks to residents and business owners, along with cascading price fluctuations often passed to consumers.

A degree day compares the mean outdoor temperature for a specific location to a standard temperature. Degree days are a way to measure energy demand to heat or cool buildings. As climate change contributes to an increase in average temperatures, including an increase in unusually hot days and a decrease in unusually cold days, overall demand for heating is expected to decline and the demand for cooling is expected to increase (EPA, 2021).

4.3 Transportation Sector – Idaho

4.3.1 Consumption

Consumption in the transportation sector in Idaho is divided into four major fuel types: petroleum, biodiesel, ethanol, and natural gas. As shown in Figure 12, petroleum accounts for 96% of total energy use in the sector, with consistent increases in consumption over the past decade. Total energy consumption in 2008 stood at 124,004 billion BTUs,[7] increasing 34% by 2018 to 166,625 billion BTUs. While limited at this time, there is an increasing use of electric power in the transportation sector.

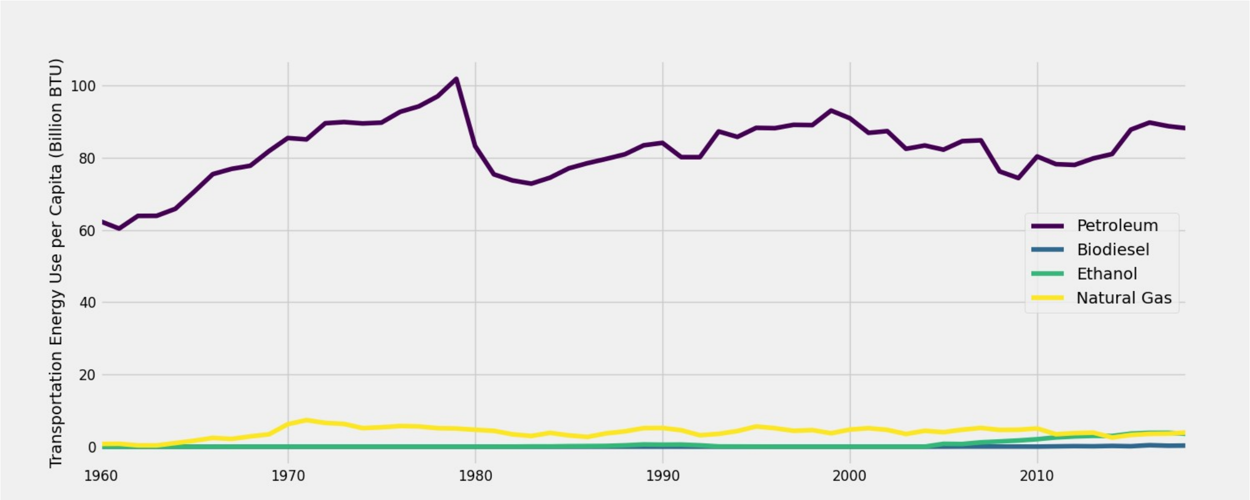


Figure 12: Idaho energy use per capita, transportation sector (1960-2018) (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.3.2 Carbon Emissions

Figure 13a displays carbon emissions in the transportation sector, showing an increasing trend over time. While the electric power sector often garners attention, the transportation sector also contributes to carbon emissions. Of the 18.55 million metric tons of CO_2 emitted in Idaho in 2017, the transportation sector accounted for 10.8 million metric tons, or 58% of the total.

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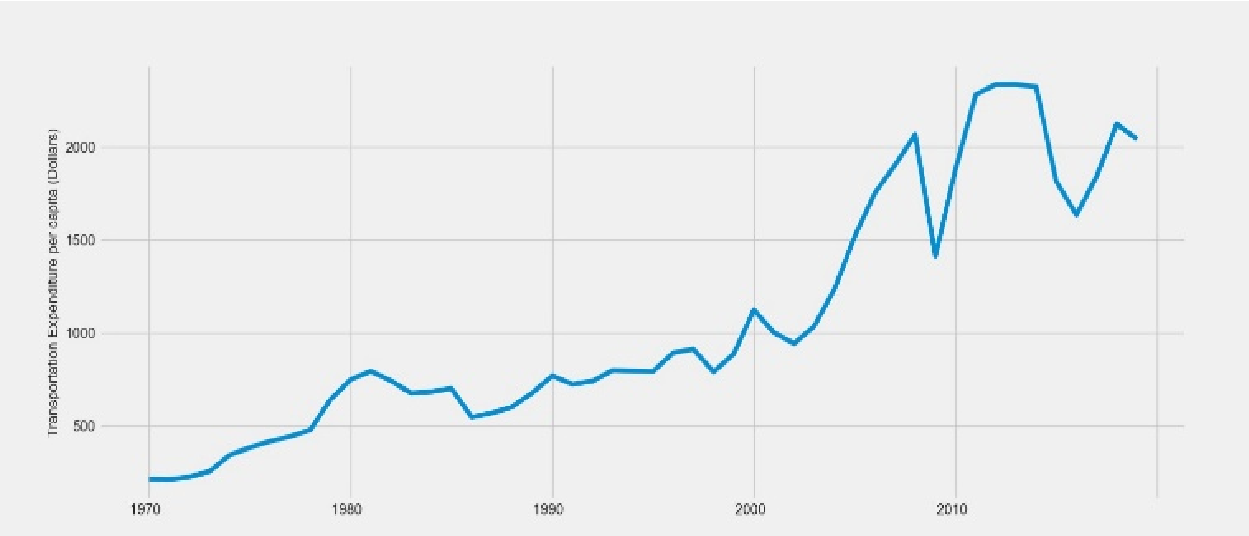
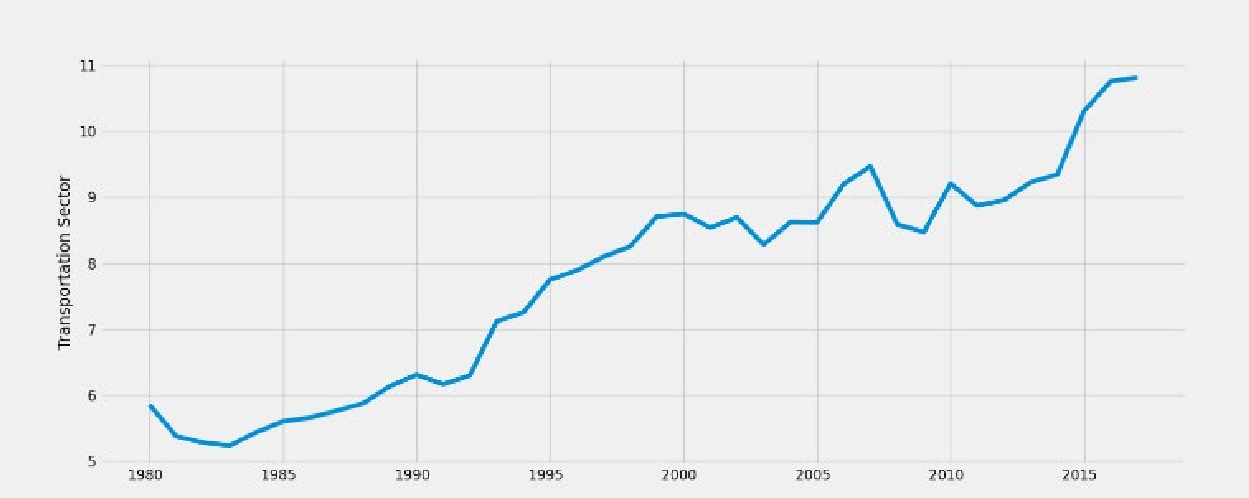
[7] A unit of heat defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. Heat is known to be the equivalent of energy.



(a) Idaho carbon emissions (million metric tons of CO_2), transportation sector (1960-2018).



(b) Idaho expenditures per capita (million metric tons of CO_2), transportation sector (1960-2018).

Figure 13: Idaho emissions and expenditures in the transportation sector (1960-2018) (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.3.3 Expenditures

Expenditures per capita in the transportation sector (Figure 13b) follow the volatility of fuel prices, ranging from \$2,066 in 2008 to \$2,112 in 2018, with a high of \$2,336 in 2013.

4.3.4 Economic Impacts – Transportation

Increasing transportation costs are often the leading factor in short-term sectoral inflation. Transportation, like the other sectors, plays a direct role in the economic livelihood of most consumers.

4.4 Electric Power Sector – Idaho

4.4.1 Consumption

Intrinsically embedded in the primary energy use of each of the preceding sectors is the primary energy mix used to deliver the electricity that makes up the majority of energy consumed by each sector. Of the 156,904 billion BTUs of primary energy used to generate electricity for Idaho in 2018, 24,228 billion BTUs were from fossil fuels. As shown in Figure 14, 64% of electrical energy was derived from hydropower dams (92 trillion BTUs), solar energy accounted for 3% (5,061 billion BTUs), and wind contributed 15% (24,172 billion BTUs) of the total Idaho electric energy mix. Idaho's electric utilities have been out in front of the clean energy transition, utilizing Idaho's natural availability of hydropower (Avista Utilities, 2019; Idaho Power, 2019; Rocky Mountain Power, 2021). As discussed further in Section 6, increasing electric transportation will increase electrical demand.

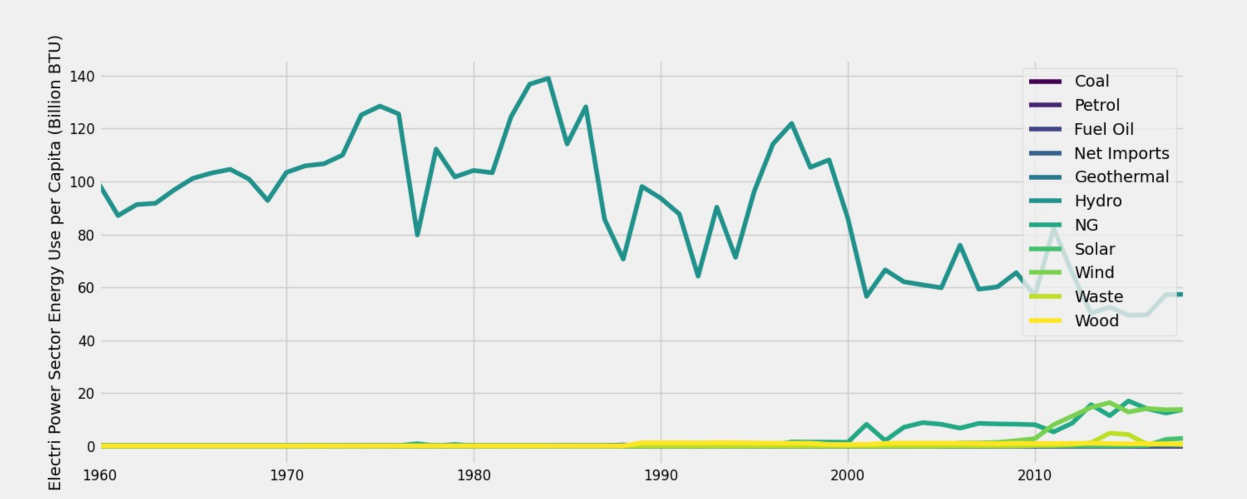


Figure 14: Idaho primary energy consumption per capita, electric power sector, by source (1960-2018) (EIA, 2021). Author's calculations using data from (EIA, 2021).

4.4.2 Carbon Emissions

The trends in carbon emissions generated in Idaho from the electric power sector indicate that while emissions were below 0.1 million metric tons from 1980 to 1995, they have trended generally upward since 1995 and have increased over the past decade (author's calculations using data from EIA, 2021). As variable energy sources have been integrated into Idaho's energy mix, natural gas peaking – at plants in Idaho – has been used for energy generation to supplement intermittent sources (e.g., Avista Utilities, 2021a; OMER, 2021b).

4.4.3 Economic Impacts – Electric Power Sector

As discussed in Sections 4.1 and 4.2, electric power makes up 36% of the average energy consumed in the Idaho residential, industrial, and commercial sectors. Table 2 further shows the contribution of hydropower to the electricity generation mix and highlights the decreasing percentage of net generation provided by hydropower over the past decade.[8] Uncertainty in streamflow trends in the Snake River, the major source of Idaho's hydropower production, is one of the concerns facing Idaho Power, as is noted in the 2019 Idaho Power Integrated Resource Plan (Idaho Power, 2019).

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[8] The decreased reliance on hydropower may well be related to the increased of availability of wind during that period.

	Geothermal	Hydro	Nat Gas	Solar	Wind	Waste	Wood
2008	1.0	85.0	12.0	0.0	2.0	0.0	1.0
2009	1.0	85.0	11.0	0.0	3.0	0.0	1.0
2010	1.0	82.0	12.0	0.0	4.0	0.0	1.0
2011	0.0	85.0	5.0	0.0	8.0	0.0	1.0
2012	1.0	75.0	10.0	0.0	13.0	1.0	1.0
2013	0.0	61.0	19.0	0.0	18.0	1.0	1.0
2014	1.0	61.0	13.0	0.0	19.0	6.0	1.0
2015	1.0	58.0	20.0	0.0	15.0	5.0	1.0
2016	1.0	62.0	18.0	0.0	18.0	1.0	1.0
2017	1.0	65.0	14.0	3.0	16.0	1.0	1.0
2018	0.0	64.0	15.0	3.0	15.0	1.0	1.0

Table 2: Electrical power sector energy consumption–percentage of total sector consumption. Author's calculations using data from (EIA, 2021).

Increasing spring flows and decreasing summer flows are projected to continue, which will impact hydro-dependent energy providers. This may affect water levels, water storage, and more (Barnett et al., 2008). For more details, see the assessment's Water Report. Carbon emissions may be impacted, based on energy choices. Without additional generation or transmission capacity, an increasing demand coupled with possible decreasing capacity for hydropower are likely to be compounded by the transition to electric-powered transportation, discussed in Section 5.

5. Electrification[9]

The conversion of transportation and heating to electrification holds enormous opportunity – both economic and net carbon-reduction – and is one of the most anticipated, but also challenging changes to the modern energy system. Electrification can allow for cleaner (an even zero-carbon) transportation and heating; it also has the potential to lower the long-term costs compared to technologies using other types of fuels. Despite the opportunities that it offers, there are several challenges to electrification in Idaho that present possibilities for innovation. The first challenge is planning for increasing electricity demands for electric equipment, especially if that demand happens at one time of day. Charging electric vehicles during non-peak times, such as at night, likely will be needed in order to not strain the grid. However, intermittent electricity sources, like solar and wind, are not at their optimum levels during this time. Alternative low- and non-carbon sources with firm baseload capacity, such as pump storage or nuclear, may need to be considered to meet demand. Additionally, expansion of batteries and improved storage potential will likely assist with meeting demand. Another challenge is electrification investment, which may offer an opportunity for innovative financial approaches. Recently, private companies have been the greatest investors in the necessary infrastructure for electrification.[10]

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[9] This section was provided by Dr. Veronika Vazhnik, Sustainability Consultant.

[10] Two examples (1) Clean Energy Buyers Alliance: several Idaho companies are members https://cebuyers.org/blog/americas-largest-energy-customers-set-a-bold-new-ambition-to-achieve-a-90-carbon-free-u-s-electricity-system-by-2030-and-accelerate-clean-energy-globally/
and (2) large national energy companies have been investing in wind and solar development across southern Idaho (e.g., LS Power is developing two 1,000 MW wind projects).

6. Transitioning Transportation

As described in Section 4.3, the transportation sector shows an increasing emissions trend, generating more than 58% of the total carbon emissions in Idaho in 2018 (Figure 13a). As market forces work to integrate electric vehicles and hydrogen-powered vehicles into the transportation mix (Car and Driver, 2021), this appears to be the shortest path to reducing carbon emissions in the transportation sector. Researchers in INL's Advanced Transportation group are working towards this transition with a focus on energy storage from advanced vehicle technology and real-time electric grid simulation, including hydrogen[11] (INL, 2021a). Vehicle electrification will be an important dimension to meeting just-announced US 2050 emissions targets (The White House, 2021). True carbon emission reductions will likely not be realized until at least 2030 due to embedded CO_2 in production processes and slow vehicle stock turnover (Hill et al., 2019). These findings likely would be similar for Idaho.

To replace the energy density of gasoline in internal combustion engines with electric motors is a challenge. Electric vehicles are able to provide power directly at the wheels, avoiding energy losses experienced in the internal combustion drive train; where gasoline-powered engines are 25%-30% efficient, electric motors are close to 90% efficient (Markowitz, 2013). These efficiency gains, along with regenerative braking, push the efficiency coefficient of electric cars to +5 (McKenzie, 2014). Due to the increased efficiency of electric vehicles, 86,906 billion BTUs of petroleum-based fuels could be replaced by 17,381 billion BTUs of electrical power. This represents an additional 11% increase in electricity production over current Idaho net generation.

7. Clean Energy Goals

Integrated Resource Plans (IRPs) for the major IOUs in Idaho propose various clean energy goals. These include:

- 100% clean energy by 2045 (Idaho Power, 2019; 2021 IRP in development)
- 100% clean energy by 2045 (Avista Utilities, 2021b)
- Carbon-neutral supply of electricity by the end of 2027 (Avista, 2021b)
- Carbon neutral by 2045 (natural gas), with a near-term goal of 30% reduction in greenhouse gas emissions by 2030 (Avista, 2021b)
- Reduction in greenhouse gas emissions 74% by 2030 from 2005 levels and 98% by 2050 (Rocky Mountain Power, 2021b).

The shift to carbon-free energy sources may require additional baseload capacity, hydropower, pump storage, or nuclear, as well as additional energy storage to meet energy demand. This presents challenges, but also affords opportunities. (Opportunities are detailed in Section 9).

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[11] Other national laboratories are engaged in hydrogen research, including the National Renewable Energy Laboratory (NREL).

Idaho’s Energy Sector and Jobs

Dr. Kathleen Araújo, Associate Professor of Sustainable Energy Systems, Innovation, and Policy, School of Public Service, Boise State University

The economic impacts of a changing climate on Idaho’s energy sector represent another area for consideration. To date, limited analysis has been done that comprehensively assesses projected economic effects of climate change on the state’s energy industry and research hubs. More broadly, studies have considered workforce gaps (Idaho Department of Labor, 2014), industry overviews (OEMR, 2021a), potential economic impacts from small modular development in eastern Idaho (Black and Peterson, 2019), and potential impacts for local tax revenue from a proposed wind project (Tiernan, 2021). The following outlines the energy sector’s general economic contribution and jobs profile within the state, key employers and their focus on low carbon energy, plus the outlook for Idaho’s energy sector amidst a changing climate, with additional research potential.

In 2020, the Idaho Department of Commerce reported that the state’s energy industry contributed up to $6.3 billion toward the Idaho’s GDP (Idaho Department of Commerce, 2020). Specific to energy jobs, analysis of the status and outlook for the state’s energy workforce and industrial hub (Araújo et al, forthcoming) indicates that, Idaho had 11,286 energy workers or 1.8% of total state employment, accounting for energy jobs across electric power generation, fuels, and transmission; distribution; and storage as of 2020 (Araújo et al, forthcoming, citing USEER, 2021). If energy efficiency jobs (8,319) and energy-related motor vehicle jobs (11,238) are taken into account, the total nearly triples to 30,843 (Ibid). The energy efficiency workforce, an important subgroup for sustainable energy and climate-centered priorities, represents a substantial area of the current Idaho energy jobs, with the largest subsector found in high efficiency heating, ventilation, and air conditioning (HVAC) plus renewable heating and cooling, at 4,418 jobs (Araújo et al, forthcoming). In power generation, which employed a total of 2,157 people in 2020, wind power (990) and solar power (693) jobs represent the largest shares of the workforce (Araújo et al, forthcoming). Across additional fuels, namely fossil fuel, ethanol, biomass, and other fuels, which totaled 2,036 employees, prominent areas of jobs are in oil and other petroleum (423), natural gas (517), corn ethanol (332), woody biomass (345), and other fuels (317) (Araújo et al, forthcoming).

Closer inspection of the state’s energy workforce employers finds that major employers include Idaho National Laboratory (INL) (5,359 employees), Power Engineers (820 employees), and Idaho Power (1,943 employees), with technology strengths/priorities in net zero carbon systems or energy-environmental planning (Idaho Power, 2019; INL, 2021b; Power Engineers, 2021). Another critical energy workforce employer in Idaho is the Center for Advanced Energy Studies (CAES), an energy-based consortium consisting of INL plus Idaho universities that focuses on research, education, and innovation. CAES contributes to economic and workforce development across the energy technology spectrum and sectors with 7,200 researchers, 50,000 students, and $1.5 billion in annual research funding (CAES, 2021a). Among CAES’ areas of focus is clean, resilient energy (CAES, 2021b), which has strong relevance to climate considerations.

Looking ahead at the changing climate and how it may affect Idaho’s energy sector, a number of critical areas are worth highlighting. First, public and private sector priorities within and beyond Idaho’s borders to shift to net zero carbon energy can position the state in a favorable light to attract new investment that is designed to leverage Idaho’s low carbon and relatively inexpensive power (EIA, 2021). Second, environmental conditions associated with climate change, including extended wildfire seasons and drought, as well as altered snowpack, may carry over to the economy or workforce in terms of disruption to normal energy infrastructure operations (Araújo and Banks, forthcoming) and, as noted elsewhere in this report, in altering the hydropower potential. Third, the state's technology leadership in nuclear energy, geothermal energy, and hydropower, among other areas, allows its industries, universities, and collaborative CAES consortium to be sources of expertise for other regions seeking to build out capacity.

In line with the aims of this report, as well as broader interests to understand the state's energy sector and future economic opportunities, additional research is warranted to more fully understand what energy employer needs are for jobs skills as the state's energy sector evolves with the changing climate and economic needs.

8. Overall Economic Impacts

Climate change is increasing extreme weather events, which can impact energy infrastructure (see assessment's Climate Report and Infrastructure Report). In 2021, there were sizable challenges to the grid and a cascading infrastructure emergency in Texas (Hogan, 2021), major stress placed on the grid in California and the Pacific Northwest due to extreme heat, and routine brownouts in California (Conca, 2021). They appear to be100-year or even 10-year events; they are increasing in frequency and magnitude. While it may be difficult to quantify all economic impacts of climate change in the energy sector, the effects will likely not only be substantial, but also unpredictable. Preparing energy infrastructure to better withstand these events could assist with decreasing the costly impacts of these extreme weather events. Table 3 shows Idaho energy expenditures as a percentage of Idaho GDP over the past decade. In aggregate, expenditures have fallen from a high of 12% in 2011-2012 to 8% in 2016, before increasing to 9% in 2018. With increasing climate effects disrupting energy distribution and supply, expenditures could return to their ten-year highs or increase as hydropower output might diminish due to reduced streamflow. Variable cost energy sources may need to be increased or baseload generation power will need to be created.

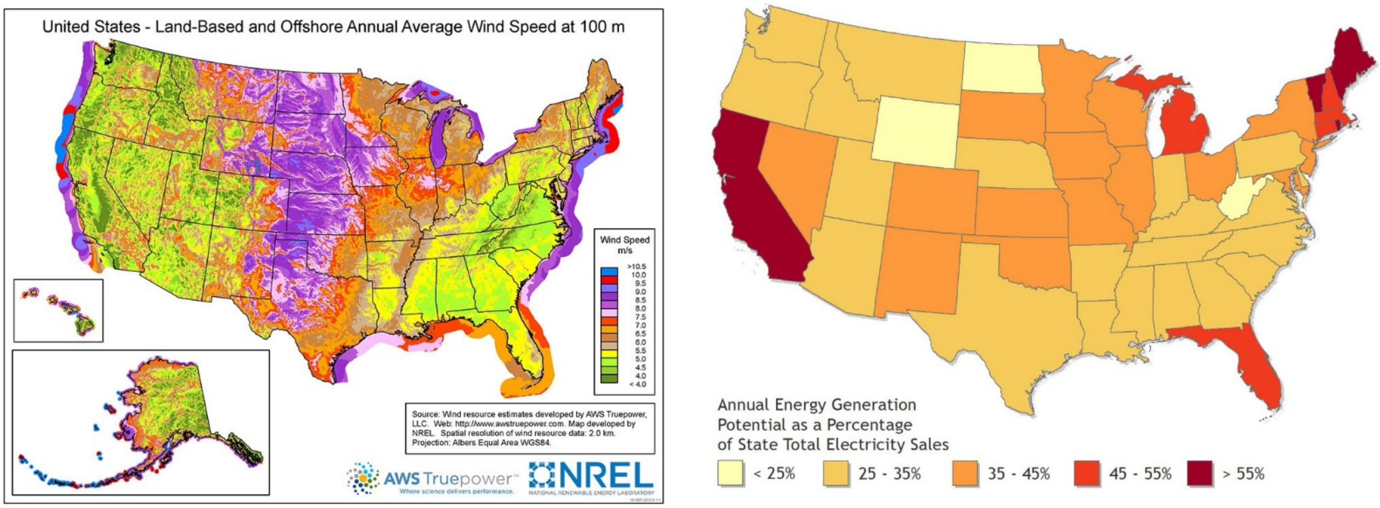
	Total GDP	Elect GDP	NatGas GDP	MtrGas GDP	Petrol GDP
2008	0.11	0.02	0.01	0.04	0.03
2009	0.09	0.03	0.01	0.03	0.02
2010	0.10	0.03	0.01	0.04	0.03
2011	0.12	0.03	0.01	0.04	0.04
2012	0.12	0.03	0.01	0.04	0.03
2013	0.11	0.03	0.01	0.04	0.03
2014	0.11	0.03	0.01	0.04	0.03
2015	0.09	0.03	0.01	0.03	0.03
2016	0.08	0.03	0.01	0.03	0.02
2017	0.09	0.03	0.01	0.03	0.02
2018	0.09	0.03	0.01	0.03	0.03

Table 3: Idaho energy expenditures as a percentage of GDP. Author's calculations using data from (EIA, 2021).

9. Opportunities

When moving toward carbon-neutral and carbon-free goals, there will be a need to decrease use of gas and coal peaking facilities, which are used when there is a high demand for electricity that intermittent renewable sources cannot meet. Finding alternatives to coal for firm baseload sources likely will be necessary to fill that gap and support challenges mentioned earlier with respect to hydropower generation.

Increasing generation through renewable, intermittent resources like solar and wind would not only reduce carbon emissions and reduce the feedback from energy to the climate, but also can create jobs and economic growth. By one estimate, nearly 1 billion machines need to be rebuilt and re-purposed in order to make a viable transition to electrification from transportation and heating (Griffith et al, 2020). A study conducted by Northern Arizona University found that wind and solar development create jobs and increase local direct and indirect spending (Acker, 2013). A 2013 study by the National Renewable Energy Lab (NREL) found Idaho to be a suitable area for increased wind power, shown in Figure 15a, while two studies from 2016 and 2019 found Idaho to be a better than average area for solar photovoltaic (PV) farms and distributed solar rooftop networks, as shown in Figure 15b (Gagon, et al., 2016; Hall, 2020). Using a case study of the mid-Atlantic region, NREL researchers suggest that moderate development of wind technology supports an additional 8,000 full-time jobs during construction and approximately 31,000 full-time jobs regionally, including development, construction, and supply chain (Tegan et al., 2015).



(a) United States' wind capacity, 2011.

(b) Potential rooftop PV annual generation from all buildings as a percentage of each state's total electricity sales in 2013.

Figure 15: Wind and solar potential, United States (Tegan, 2015).

INL and other national laboratories are exploring the development of clean and economically competitive nuclear energy options. As well, INL and several other national laboratories are researching enhanced energy storage capabilities. Increased storage and battery options would relieve some of the major challenges associated with increased electrification.

Other opportunities for jobs and economic growth exist. Research on and installation of energy transmission improvements can expand capacity and address energy demand. Strengthening energy grid cybersecurity through research and pilot programs is another emerging area.

Another opportunity is utilizing the energy market as a resource for diversity of energy sources. Increased flexibility reduces the need for additional power generation when such resources are available from the grid.

The energy sector in Idaho is well-positioned for mitigation and can contribute to economic growth with energy, industry, and transportation transitions to a low-carbon future.

An Opportunity for Resiliency: Microgrids

Dr. Stephanie Lenhart, Senior Research Associate, Center for Advanced Energy Studies, Energy Policy Institute and School of Public Service, Boise State University

In the electricity sector, distributed energy resources (DERs) are emerging technologies that allow energy generation and demand to be managed closer to end users. These resources include onsite and community-scale solar photovoltaic (PV) generation, small-scale storage, electric vehicles, and demand management approaches, as well as conventional backup diesel or gas-fired generation and combined heat and power systems (Perez-Arriaga, 2016; Schwartz et al., 2017). These resources are typically connected to the distribution system, rather than the transmission system.

Microgrids are networking platforms that can incorporate many DERs and serve multiple end-users (Lasseter, 2002; Piagi and Lasseter, 2006). These systems can operate independently or connected with the larger regional power grid. In recent years, microgrid capacity in the U.S. has grown rapidly and has diversified from traditional campus or institutional microgrids anchored by a combined-heat and power system to include applications for commercial businesses, industry, and communities that incorporate clean resources and storage. In Idaho, the municipal utility in Idaho Falls and INL successfully tested the ability to restart systems when disconnected from the centralized grid (Richards, 2021). This experiment was an important step in understanding the utility's capabilities to operate as a microgrid. The approach in Idaho Falls is consistent with research findings that highlight how emerging community microgrids are leveraging existing assets and considering a range of learning opportunities in efforts to address objectives that include resilience, renewable energy integration, grid modernization, economic development, and economic benefits (Lenhart and Araújo, 2021).

References

Acker, T. 2013. The Future of Electricity: Embracing Transition. Center for a Better Life. http://livebettermagazine.com/?article=the-future-of-electricity-embracing-transition (16 March 2013). Accessed November 2021.

Araujo, K. and Banks, E. Forthcoming. Regional Resilience Planning for Wildfire Hazard with Critical Infrastructure, INL Report for the Department of Homeland Security.

Araújo, K., Garn, K., Olson, M. and Henken, L. Forthcoming. The Status and Outlook for Energy Jobs and the Associated Hub within Idaho. *CAES Energy Policy Institute*.

Avista Utilities. 2019. Energy goals. https://www.myavista.com/about-us/our-commitment. Accessed November 2021.

Avista Utilities. 2021a. Avista declares natural gas emission reduction goal. https://www.globenewswire.com/en/news-release/2021/04/22/2215584/0/en/Avista-declares-natural-gas-emission-reduction-goal.html. Accessed November 2021.

Avista Utilities. 2021b. Electric Integrated Resources Plan. https://www.myavista.com/about-us/integrated-resource-planning. Accessed December 2021.

Aydin C., and Esen, Ö. 2018. Does the Level of Energy Intensity Matter in the Effect of Energy Consumption on the Growth of Transition Economies? Evidence from Dynamic Panel Threshold Analysis. *Energy Economics*, 69: 185-195. https://doi.org/10.1016/j.eneco.2017.11.010.

Barnett, T. P., Pierce, D. W., Hidalgo, H. G., Bonfils, C., et al. 2008. Human-Induced Changes in the Hydrology of the Western United States. *Science*, 319(5866): 1080-1083. DOI: 10.1126/science.1152538

Black, G. and Peterson, S. 2019. Economic Impact Report: Construction and Operation of a Small Modular Reactor Electric Power Generation Facility at the Idaho National Laboratory Site, Butte County, Idaho. *McClure Center for Public Policy Research* and *Idaho Policy Institute*. https://www.uidaho.edu/-/media/UIdaho-Responsive/Files/president/direct-reports/mcclure center/Research-Reports/redi-economic-impact-report-pdf.pdf. Accessed November 2021.

Bonneville Power Administration (BPA). 2021. Energy Imbalance Market. https://www.bpa.gov/Projects/Initiatives/EIM/Pages/Energy-Imbalance-Market.aspx. Accessed November 2021.

Bureau of Economic Analysis (BEA). 2021. Gross Domestic Product: All Industry Total in Idaho [IDNQGSP], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IDNQGSP. Accessed November 2021.

Car and Driver. 2021. Every electric vehicle that's expected in the next five years. https://www.caranddriver.com/news/g29994375/future-electric-cars-trucks/ (7 September 2021). Accessed November 2021.

Center for Advanced Energy Studies (CAES). 2021a. Our Mission. https://caesenergy.org/. Accessed September 2021.

CAES. 2021b**.** Strategy. https://caesenergy.org/strategy**.** Accessed September 2021.

Conca, J. 2021. Can the Pacific Northwest power grid handle the stress? Forbes. https://www.forbes.com/sites/jamesconca/2021/07/07/heat-wildfires-and-power-grid-challenges--even-the-pacific-northwest-begins-to-worry/?sh=187e51931d84 (7 July 2021). Accessed November 2021.

Energy Information Administration (EIA). 2021. State Energy Data System. https://www.eia.gov/state/seds/. Accessed November 2021.

EPA. 2021. Climate Change Indicators: Heating and Cooling Degree Days. https://www.epa.gov/climateindicators/climate-change-indicators-heating-and-cooling-degree-days. Accessed December 2021.

Gagnon, P., Margolis, R., Melius, J., Phillips, C., Elmore, R. 2016. Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy16osti/65298.pdf. Accessed November 2021.

Griffith, S., Calisch, S., Fraser, L. 2020. The Rewiring America Handbook. https://www.rewiringamerica.org/policy/rewiring-america-handbook. Accessed November 2021.

Hall, S. M. 2020. Opportunities and Obstacles in the Transition to a Distributed Network of Rooftop Solar: A Multi-Method Approach. *Boise State University Theses and Dissertations*. 1661. 10.18122/td/1661/boisestate

Hill, G., Heidrich, O., Creutzig, F., Blythe, P. 2019. The Tole of Electric Vehicles in Near-Term Mitigation Pathways and Achieving the UK's Carbon Budget. *Applied Energy* 251: 113111. https://doi.org/10.1016/j.apenergy.2019.04.107

Hogan, B. 2021. Understand Texas' energy grid failure. Policy Topics, Harvard Kennedy School. https://www.hks.harvard.edu/faculty-research/policy-topics/environment-energy/understanding-texas-energy-grid-failure (23 February 2021). Accessed November 2021.

Idaho Department of Commerce. 2020. Idaho's Expanding Energy Economy. https://commerce.idaho.gov/content/uploads/2020/08/Idahos-Expanding-Energy-Economy.pdf. Accessed September 2021.

Idaho Department of Labor. 2014. Idaho Projects Workforce Gap in Energy Industry. https://idahoatwork.com/2014/09/27/idaho-projects-workforce-gap-in-energy-industry/. Accessed September 2021.

Idaho National Laboratory (INL). 2020. Economic Impact Study. https://inl.gov/wp content/uploads/2021/05/FY20_Economic-Impact-report.pdf. Accessed November 2021.

INL. 2021a. Accelerating Development of Advanced Transportation Systems. https://inl.gov/research program/transportation-transformation/. Accessed November 2021.

INL. 2021b. Sustainable INL. https://inl.gov/about-inl/inl safety/sustainability/. Accessed September 2021.

Idaho Power. 2019. 2019 Integrated Resource Plan. https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/2019/SecondAmended2019IRP.pdf. Accessed November 2021.

King, C. W. 2021. The Economic Superorganism: Beyond the Competing Narratives on Energy, Growth, and Policy. Springer, Cham. DOI: 10.1007/978-3-030-50295-9

Lasseter, R. H. 2002. MicroGrids. IEEE Power Engineering Society Winter Meeting. Conference Proceedings: 305–8.

Lenhart, S. and Araújo, K. 2021. Microgrid Decision-Making by Public Power Utilities in the United States: A Critical Assessment of Adoption and Technological Profiles. *Renewable and Sustainable Energy Reviews,* 139(May 2020): 110692. https://doi.org/10.1016/j.rser.2020.110692

Markowitz, M. 2013. Wells to wheels: electric car efficiency. Energy Matters. https://matter2energy.wordpress.com/2013/02/22/wells-to-wheels-electric-car-efficiency/. Accessed November 2021.

McKenzie, D. 2014. Comparing Emissions and Efficiency in Electric Cars and Gasoline Cars. Lights on Solar. http://www.lightsonsolar.com/emissions-and-efficiency-in-electric-cars-versus-gasoline-cars/. Accessed November 2021.

NAICS Associations. 2018. NAICS and SIC Identification Tools. https://www.naics.com/search/. Accessed November 2021

Office of Energy and Mineral Resources (OMER). 2021a. Idaho Energy Landscape. 2021. https://oemr.idaho.gov/wp-content/uploads/Idaho-Energy-Landscape-2021.pdf. Accessed November 2021.

OMER. 2021b. Natural Gas. https://oemr.idaho.gov/sources/natural-gas/. Accessed November 2021.

Office of Nuclear Energy. 2020. NRC Approves First U.S. Small Modular Reactor Design. https://www.energy.gov/ne/articles/nrc-approves-first-us-small-modular-reactor-design (2 September 2020). Accessed November 2021.

Perez-Arriaga, I. J. 2016. The Transmission of the Future: The Impact of Distributed Energy Resources on the Network. *IEEE Power and Energy Magazine,* 14(4): 41–53. http://ieeexplore.ieee.org.ezproxy.lib.uwm.edu/document/7491385/%5Cnhttp://ieeexplore.ieee.or g.ezproxy.lib.uwm.edu/ielx7/8014/7491377/07491385.pdf?tp=&arnumber=7491385&isnumber=7491377.

Piagi, P. and Lasseter, R. H. 2006. Autonomous Control of Microgrids. IEEE Power Engineering Society General Meeting: 1–8.

Power Engineers. 2021. Company Profile. https://www.dnb.com/business-directory/company profiles.power_engineers_incorporated.16ed9b13845abbd0ac6e20fb15246d19.html, Accessed September 30, 2021.

Richards, T. 2021. Idaho Falls Power Successfully Conducts ‘microgrid’ Experiment with INL. East Idaho News.

Rocky Mountain Power. 2021a. Feasibility Studies Anticipated on 11 Pumped Storage Projects. The News Examiner. https://www.hjnews.com/montpelier/feasibility-studies-anticipated-on-11-pumped-storage- projects/article_0aa8733b-7cea-5164-9c42-983a4a8a9691.htm (15 October 2021). Accessed November 2021.

Rocky Mountain Power. 2021b. Striving to Achieve Net Zero. https://www.rockymountainpower.net/about/innovation-environment.html. Accessed November 2021.

Schwartz, L., Wei, M., Morrow, W. R. III, Deason, S. R., et al. 2017. Electricity End Uses, Energy Efficiency, and Distributed Energy Resources Baseline. In LBNL- 1006983: Energy Analysis and Environmental Impacts Division Lawrence Berkeley National Laboratory, 77.

Sharma, N., Smeets, B., Tryggestad, C. 2019. Decoupling of GDP and Energy Growth: A CEO Guide. McKinsey and Company. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-decoupling-of-gdp-and-energy-growth-a-ceo-guide. Accessed July 2021.

Tegen, S., Keyser, D., Flores-Espino, F., Miles, J., Zammit, D., Loomis, D. 2015. Offshore Wind Jobs and Economic Development Impacts in the United States: Four Regional Scenarios. *National Renewable Energy Laboratory*. https://www.nrel.gov/docs/fy15osti/61315.pdf. Accessed November 2021.

Tiernan, C. 2021. The Windy Windfall: LS Power releases timeline, economic projections for $1 billion wind farm. January 27, 2021, https://magicvalley.com/business/the-windy-windfall-ls-power-releases-timeline-economic-projections-for-1-billion-wind-farm/article_aa64d264-83f3-59f3-9dcd-ff139a2fac37.html (27 January 2021). Accessed November 2021.

The White House. 2021. Executive Order on Catalyzing Clean Energy Industries and Jobs through Federal Sustainability. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/ (8 December 2021). Accessed December 2021.